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Massachusetts Residents' Proximity to Bridges

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Background

This report was prepared during the Capstone Project in partial fulfillment of Salem State University's Master of Science in Geo-Information Science. The analysis was performed in spring and summer of 2022 for MassBudget, a public policy think tank researching and advocating for racial and economic justice in Massachusetts.

Contents

Introduction

The state of infrastructure across the United States has received increasing scrutiny over the past decade. Bridges are of considerable concern because of their critical role in supporting our reliance on vehicular transportation for moving people and goods across short and long distances. As the nation's stock of bridges ages, a systematic program for preservation and investment is needed. Periodic bridge inspections are conducted to identify and prioritize the rehabilitation of bridges in poor condition; these bridges are referred to as structurally deficient. "While structurally deficient bridges are not inherently unsafe, they require substantial investment in the form of replacement or significant rehabilitation, and they present higher risk for future closure or weight restrictions" (2021 Report Card for America's Infrastructure for bridges). The following report offers a deeper understanding of the state of bridges, with a focus on structurally deficient bridges, and their connection to the residents of Massachusetts. It presents an equity analysis to determine if certain populations of people reside closer to bridges with structural deficiency. We consider how minority, low-income, and English-isolated populations fare in comparison to the general population regarding proximity to five different categories of bridges—three structural conditions and two operational conditions.

Key Findings

Of the 7,862 bridges in Massachusetts, 636 (8%) have a structural deficiency and 219 (3%) have a structural condition of unknown. Structurally deficient bridges carry more than their fair share of the traffic volume statewide (see Table 4). When considering the concentration of structurally deficient bridges by different geographic boundaries, we gain nuance from the data. Connecticut River Valley contains the highest percentage of structurally deficient bridges (22%) and Southeast contains the lowest percentage of structurally deficient bridges (10%) (see Table 2). Urban and rural areas of the state contain the same percentage of structurally deficient bridges (8%) when calculated as a proportion of all bridges within their boundaries (see Table 5). Connecticut River Valley also contains the highest concentration of bridges for the two operational conditions we analyze: closed (28%) and load/capacity restriction (22%). While Central has the lowest percentage of closed bridges (5%), and Northeast has the lowest percentage of load/capacity restriction bridges (10%) (see Table 3). Population-weighted average distances show that some population groups live closer to these bridges than the general population. In Massachusetts, minorities and English-isolated households reside closer to a bridge, regardless of its structural condition, than the general population (see Table 8). Across all regions of the state, English-isolated households consistently live closer to a structurally deficient bridge than any other group (see Table 12). By contrast, individuals of low-income are approximately equidistant to a structurally deficient bridge compared to the general population (see Table 15). In urban areas, minorities and English-isolated households reside nearer to a structurally deficient bridge than the general population. Conversely, these subgroups reside farther away compared to the general population in rural areas (see Table 21). In Massachusetts, English-isolated households reside nearest to a bridge with a load/capacity restriction and farthest from a closed bridge than the other populations (see Table 22). Regardless of the region in which individuals of low-income reside, they are equidistant to a bridge that is load/capacity restricted or closed compared to the general population (see Table 25). While minorities and English-isolated households are nearer to a bridge with a load/capacity restriction in urban areas, they are farther away from the same type of bridge in rural areas (see Table 31).

Data & Methodology

Bridge data used for our analysis was obtained in January 2022 from the Massachusetts Department of Transportation Highway Division (massDOT) website and reflects a snapshot of a database that is updated regularly. In addition to location data, the massDOT Bridges dataset offers numerous categorical values from the massDOT Bridge Inspection Management System. Bridge data does not include structures under the jurisdiction of federal, other state entities, or those in private ownership.

Bridges are categorized into three different types of structural conditions: no structural deficiency; structural deficiency; and unknown structural deficiency. According to the 2021 Report Card for America's Infrastructure for bridges, structural deficiency is defined as a key structural element of a bridge, which includes the deck, superstructure, substructure, or culvert, having a rating of “poor” or worse. While a confirmed absence or presence of structural deficiency for a bridge is clear for our analysis, a bridge condition of ‘unknown’ structural deficiency is unclear; the massDOT database provides no detail or explanation for ‘unknown’ status. This report will not include explanations for this bridge category, as our information is insufficient to reach a conclusion on this subset of bridges. Instead, we present the findings as is and recognize the opportunity to clarify this structural condition as an area for further research.

Additionally, two operational categories of bridges were selected for analysis—closed and load/capacity restriction. An operational condition of closed indicates a bridge is closed to all traffic; the duration of its closure is unspecified in the massDOT database on bridges. Load/capacity restriction combines two separate categories in the database: posted for load and posted for other load-capacity restriction. There was insufficient information to determine a meaningful difference between these categories and so they were combined for analysis. This operational condition indicates a bridge has a restriction on its use which may include, but is not limited to, number of vehicles, speed, and weight. Operational categories are independent of their structural category; a bridge can be both closed and not structurally deficient as an example.

Traffic volume for each bridge was calculated by identifying the closest road and attributing its Annual Average Daily Traffic (AADT) data, acquired from the massDOT Road Inventory 2020 dataset, to the bridge. AADT is the total volume of vehicle traffic of a highway or road for a year divided by 365 days. Null and zero values for AADT were not used to calculate averages for each structural category of bridge (see Table 4 for more details).

Population data from the American Community Survey 5-Year Estimate for 2016-2020 at the geographic unit of the blockgroup was obtained from the Census Bureau. A blockgroup is generally defined to contain between 600 and 3,000 people and is the smallest unit for which the Census Bureau reports a full range of demographic statistics. The three census tables used are: B02001 Race; C17002 Ratio of Income to Poverty Level in the Past 12 Months; and C16002 Household Language by Household Limited English Speaking Status. Calculations on these data used to derive population statistics on minorities, low-income individuals, and English-isolated households are adopted from the Environmental Protection Agency's EJSCREEN Technical Documentation. This report matches the definitional qualities used to determine the subsets of the population under examination with that of the Environmental Justice Mapping and Screening Tool. Further analysis to parse data by a specific racial identity, as an example, can be conducted to offer more nuance. For our initial review, however, we focus on these three high-level subsets of the population. Demographic data was apportioned to areas within a block group that contained residential parcels. This method offers greater accuracy when calculating average distances to bridges because it considers where people reside within a block group. Residential parcels were identified using the Metropolitan Area Planning Council's Land Parcel Database.

Proximity to bridges was calculated based on three different geographic regions: Massachusetts (MA) state; municipal vulnerability preparedness (MVP) regions (see APPENDIX A.); and urban areas (see APPENDIX B.). It was important for us to measure proximity from multiple angles because we wanted to compare similar populations of people regarding their proximity to structurally deficient bridges based on where they lived, e.g. are low-income residents of urban areas on average closer to structurally deficient bridges than low-income residents of rural areas in the state? We selected the MVP regions, as used for the Massachusetts Vulnerability Preparedness program by the Massachusetts Office of Energy and Environmental Affairs, to provide the basis for dividing the state into six exclusive areas for our analysis. Urban areas, designated by the Census Bureau, represent densely developed territory, and encompass residential, commercial, and other non-residential urban land uses. Rural areas encompass all population, housing, and territory not included within an urban area. Each type of geographic boundary used for our analysis offers a different lens through which to view the findings.

We use population-weighted averages to calculate distances to a bridge. Weighted averages are used to give different groups proportional representation; it removes biased overrepresentation of large groups and underrepresentation of small groups. To do this, each data point value is multiplied by the assigned weight, which is then divided by the number of data points. For our analysis, the calculation is (population*average distance to bridge)/population. A ratio comparing the average distance to a bridge for a particular demographic to the general population [of its respective demographic] is calculated for every combination of demographic, bridge category, and geographic boundary analyzed. A value below 1 indicates a demographic is closer to a bridge on average than the general population, and a value above 1 indicates a demographic is farther away from a bridge on average than the general population. The difference between the value and 1 is the percentage of how close or far the demographic compared to the general population. For example, the ratio of average distance to a structurally deficient bridge in urban areas for minorities compared to the general population is .79; this ratio can be interpreted by taking the difference from 1. Therefore, minorities are 21% closer to a structurally deficient bridge than the general population in urban areas.

I. Massachusetts Bridge Characteristics

In this section, an overview of the bridge data is offered to gain a foundational understanding of the sum, age, and distribution by bridge type among different geographic boundaries. For a visual representation of all bridges by MVP region, see APPENDIX C. The renovation year of a bridge, when applicable, supplants its build year in the calculation for bridge age (2021 - Bridge Build Year = Bridge Age); values of zero were excluded. We also calculate traffic volume by bridge type. While this insight is purposefully not applied to our analysis, it merits further examination. Each table is accompanied by insights that put its data into perspective.

Table 1: Bridge counts and percentages by structural and operational condition.

	Structurally Deficient			Total
	No	Unknown	Yes	
Closed Bridge Total	23 (40%)	2 (4%)	32 (56%)	57 (.07%)
Open Bridge Total	6,984 (89%)	217 (3%)	604 (8%)	7805 (99.3%)
Bridge Total	**7,007 (89%)**	**219 (3%)**	**636 (8%)**	**7,862 (100%)**

There are a total of 7,862 bridges in Massachusetts, 8% of which are structurally deficient (see Table 1). This proportion is slightly greater than the national average at 7.5% (2021 Report Card for America's Infrastructure for bridges). Most closed bridges (56%) have a structural deficiency, and the duration of their closure is unknown (see Table 1).

Table 2: Bridge counts by structural condition by MVP region.

Region Name	Structurally Deficient			Percentage of Structurally Deficient Bridges (%)
	No	Unknown	Yes	
Berkshires & Hilltowns	1,116	8	91	14
Central	1,351	40	102	16
Connecticut River Valley	1,406	111	141	22
Greater Boston	1,319	20	115	18
Northeast	878	14	124	19
Southeast	937	26	63	10
Bridge Total (Count)	**7,007**	**219**	**636**	100

The MVP region with the greatest percentage of the state's structurally deficient bridges is Connecticut River Valley (22%), while Southeast boasts the lowest percentage of structurally deficient bridges (10%) (see Table 2 above). Although Connecticut River Valley has the highest count of structurally deficient bridges, Northeast has the highest proportion of within-region bridges that are structurally deficient ((124/1,016)*100 = 12%). A map visualizing the density of structurally deficient bridges across the state is included in APPENDIX D.

Table 3: Bridge counts and percentages by operational condition by MVP region.

Region	Closed	Load/Capacity Restriction
Berkshires & Hilltowns	16 (28%)	123 (21%)
Central	3 (5%)	79 (13%)
Connecticut River Valley	16 (28%)	131 (22%)
Greater Boston	7 (12%)	125 (21%)
Northeast	8 (14%)	60 (10%)
Southeast	7 (12%)	78 (13%)
Bridge Total (Count)	57 (100%)	596 (100%)

Connecticut River Valley has the highest count of both closed and load/capacity restriction bridges.

Table 4: AADT count and percentage for each structural bridge condition.

	Structurally Deficient			Total
	No	Unknown	Yes	
Average Annual Daily Traffic (Count)	110,564,873 (87%)	1,851,055 (2%)	14,339,702 (11%)	126,755,630 (100%)

Structurally deficient bridges are relied on to carry a disproportionate amount of traffic; while only 8% of all bridges, they bore 11% of the traffic volume handled by all bridges in the state in 2019 (see Table 4).

Table 5: Bridge counts and percentages by urban and rural designation.

Urban/Rural Classification	Structurally Deficient			Bridge Total (Count)
	No	Unknown	Yes	
Urban	5,205 (90%)	117 (2%)	467 (8%)	5,789 (74%)
Rural	1,802 (87%)	102 (5%)	169 (8%)	2,073 (26%)

Most of the state's bridges (74%) are in Census-designated urban areas (see Table 5). However, urban and rural areas share similar percentages of structurally deficient bridges - 8%. Rural areas have more than twice the proportion of its bridges with a structural condition of unknown.

Table 6: Bridge counts and percentages by urban and rural designation.

Urban/Rural Classification	Structurally Deficient		
	No	Unknown	Yes
Urban	5,205 (74%)	117 (53%)	467 (73%)
Rural	1,802 (26%)	102 (47%)	169 (26%)
Bridge Total (Count)	7007	219	636

Most bridges with no structural deficiency, structural deficiency, and unknown structural deficiency are in urban areas.

Table 7: Average build year and age of bridges by structural condition.

	Structurally Deficient		
	No	Unknown	Yes
Unknown Year Built (Count)	67	1	2
Average Year Built	1967	1945	1949
Average Age of Bridge (Years)	54	76	73

The average year of bridge construction or reconstruction is 1965. The average age of all bridges is 56 years old. The average age of bridges of unknown and known structural deficiency (76 and 73 years, respectively) are almost 30 years older than the nationwide average of 44 years old (2021 Report Card for America's Infrastructure for bridges). Irrespective of structural condition, however, bridges in Massachusetts are older than the average national bridge age (see Table 7). There are 778 bridges over the age of 100 years old.

Table 8 Bridge counts and average age of bridges by MVP region.

Region Name	Bridge Total	Average Age of Bridges
Berkshires & Hilltowns	1,205	57
Central	1,483	59
Connecticut River Valley	1,645	56
Greater Boston	1,449	51
Northeast	999	52
Southeast	1,011	59

Table 8 (above) offers bridge counts and the average age of bridges within MVP regions after removing bridges with no build year data. On average, Greater Boston has the newest bridges (lowest average age) in Massachusetts. Conversely, Central and Southeast are tied for having the oldest bridges (highest average age).

II. Population-Weighted Average Distances to Bridges of Different Structural Conditions

In this section, we examine population-weighted average distances to bridges with a structural deficiency and an unknown structural condition by demographic; also included as a reference is population-weighted average distances to any bridge (see Table 10 and Table 11). The demographic populations considered are minority, low-income, and English-isolated households. Population-weighted average distances by demographic account for differences in the relative proportions of each population group that are nearer or further away from each bridge type. Each table is accompanied by one or more insights, but there is more to glean from these data than what is written here.

Table 9: Population-weighted average distances to bridges of different structural conditions by demographic for MA.

	General Population*	Minority	Low-Income	English Isolation
Population-Weighted Average Distance to a Bridge	913 m (0.6 mi)	755 m (0.5 mi)	922 m (0.6 mi)	666 m (0.4 mi)
Population-Weighted Average Distance to a Structurally Deficient Bridge	2,720 m (1.7 mi)	2,120 m (1.3 mi)	2,732 (1.7 mi)	1,875 m (1.2 mi)
Population-Weighted Average Distance to a Bridge with an Unknown Structural Status	7,844 m (4.9 mi)	7,111 m (4.4 mi)	7,809 m (4.9 mi)	7,271 m (4.5 mi)

While English-isolated households reside closer to structurally deficient bridges across the state compared to the general population (see Table 8), they are farther from bridges with an unknown structural condition than minorities and individuals of low-income. Since there are fewer bridges with an unknown structural condition, the average distance to this bridge type is greater than that of other structural conditions, regardless of demographic.

*Throughout the report, tables that provide population-weighted average distances by demographic contain a general population category that is included as a reference only. It was derived using population statistics from the Race Census table. Tables that provide the ratio of distances by demographic compared to the general population were derived using the respective subgroup's population statistics and, thus, offer an accurate comparison to the general population.

Table 10: Ratio of distances to bridges of different structural conditions by demographic compared to the general population for MA.

	Minority	Low-Income	English Isolation
Ratio of Distances to a Bridge Compared with General Population	0.83	1.00	0.74
Ratio of Distances to a Structurally Deficient Bridge Compared with General Population	0.78	1.00	0.69
Ratio of Distances to a Bridge with an Unknown Structural Status Compared with General Population	0.91	0.99	0.91

Table 10 (above) shows ratios of population-weighted distances for each subgroup to the general population. Values below 1 indicate that a group is closer than the general population; values above 1 indicate greater distance. Minorities and English-isolated households reside closer to a bridge, regardless of its structural condition, than the general population. When compared to the general population, minorities and English-isolated households reside equidistant to a bridge with an unknown structural condition.

Table 11: Population-weighted average distances to a bridge by demographic within each MVP region.

Region Name	General Population*	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	736 m (0.5 mi)	620 m (0.4 mi)	748 m (0.5 mi)	540 m (0.3 mi)
Central	898 m (0.6 mi)	814 m (0.5 mi)	906 m (0.6 mi)	794 m (0.5 mi)
Connecticut River Valley	876 m (0.5 mi)	790 m (0.5 mi)	877 m (0.5 mi)	615 m (0.4 mi)
Greater Boston	726 m (0.5 mi)	660 m (0.4 mi)	737 m (0.5 mi)	592 m (0.4 mi)
Northeast	951 m (0.6 mi)	781 m (0.5 mi)	958 m (0.6 mi)	628 m (0.4 mi)
Southeast	1,378 m (0.9 mi)	1,202 m (0.7 mi)	1,376 m (0.9 mi)	1,065 m (0.7 mi)

Minorities and English-isolated households are equidistant to a bridge in Central, Greater Boston, and Southeast.

Table 12: Ratio of distances to a bridge by demographic compared to the general population within each MVP region.

Region Name	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	0.84	1.02	0.75
Central	0.91	1.01	0.89
Connecticut River Valley	0.90	1.00	0.72
Greater Boston	0.91	1.00	0.83
Northeast	0.82	1.01	0.67
Southeast	0.87	1.00	0.77

In every region, English-isolated households reside nearer to a bridge, regardless of its structural condition, than the general population; the largest difference between these households and the general population is in the Northeast. Minorities in every region reside at least 9% closer to a bridge than the general population. On average, individuals of low-income reside as near to a bridge as the general population.

Table 13: Population-weighted average distances to a structurally deficient bridge by demographic within each MVP region.

Region Name	General Population*	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	2,508 m (1.6 mi)	1,900 m (1.2 mi)	2,578 m (1.6 mi)	1,715 m (1.1 mi)
Central	2,633 m (1.6 mi)	2,361 m (1.5 mi)	2,658 m (1.7 mi)	2,090 m (1.3 mi)
Connecticut River Valley	2,450 m (1.5 mi)	2,159 m (1.3 mi)	2,482 m (1.5 mi)	1,690 m (1.1 mi)
Greater Boston	1,964 m (1.2 mi)	1,768 m (1.1 mi)	1,986 m (1.2 mi)	1,676 m (1 mi)
Northeast	2,436 m (1.5 mi)	2,022 m (1.3 mi)	2,466 m (1.5 mi)	1,643 m (1 mi)
Southeast	5,178 m (3.2 mi)	4,240 m (2.6 mi)	5,080 m (3.2 mi)	3,405 m (2.1 mi)

Minorities reside farther away from a structurally deficient bridge than English-isolated households in every region.

Table 14: Ratio of distances to a structurally deficient bridge by demographic compared to the general population within each MVP region.

Region Name	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	0.76	1.02	0.68
Central	0.90	1.01	0.80
Connecticut River Valley	0.88	1.01	0.70
Greater Boston	0.90	1.00	0.87
Northeast	0.83	1.01	0.68
Southeast	0.82	0.98	0.65

Minorities reside closest to a structurally deficient bridge in Berkshires & Hilltowns, followed by Southeast, Northeast, and Connecticut River Valley compared to the general population; for perspective, minorities are 24% closer to this bridge type than the general population of the Berkshires & Hilltowns region. English-isolated households are closest to a structurally deficient bridge in Southeast, followed by Berkshires & Hilltowns, Northeast, and Connecticut River Valley; for perspective, English-isolated households are 35% closer to this bridge type than the general population of the Southeast region.

Table 15: Population-weighted average distances to a bridge with an unknown structural condition by demographic within each MVP region.

Region Name	General Population*	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	13,970 m (8.7 mi)	13,013 m (8.1 mi)	13,855 m (8.6 mi)	11,941 m (7.4 mi)
Central	5,495 m (3.4 mi)	4,831 m (3 mi)	5,498 m (3.4 mi)	4,159 m (2.6 mi)
Connecticut River Valley	9,625 m (6 mi)	11,097 m (6.9 mi)	9,634 m (6 mi)	12,162 m (7.6 mi)
Greater Boston	6,582 m (4.1 mi)	6,470 m (4 mi)	6,579 m (4.1 mi)	6,884 m (4.3 mi)
Northeast	8,319 m (5.2 mi)	7,801 m (4.8 mi)	8,283 m (5.1 mi)	8,024 m (5 mi)
Southeast	10,066 m (6.3 mi)	8,049 m (5 mi)	9,874 m (6.1 mi)	6,293 m (3.9 mi)

Individuals of low-income mostly reside farther away from bridges with unknown structural condition, except in Connecticut River Valley. English-isolated households reside nearer to bridges with unknown structural condition in Berkshires & Hilltowns, Central, and Southeast. Minorities reside nearer to bridges with unknown structural condition in Greater Boston and Northeast.

Table 16: Ratio of distances to a bridge with unknown structural condition by demographic compared to the general population within each MVP region.

Region Name	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	0.93	0.99	0.86
Central	0.88	1.00	0.77
Connecticut River Valley	1.15	1.00	1.27
Greater Boston	0.98	0.99	1.04
Northeast	0.94	1.00	0.94
Southeast	0.80	0.98	0.60

While minorities and English-isolated households reside farther away from a bridge with unknown structural condition in Connecticut River Valley, they are nearer to the same type of bridge in Southeast. The region with the greatest parity when comparing each demographic to the general population is Greater Boston—minorities, individuals of low-income, and English-isolated households reside nearly the same distance from a bridge with an unknown structural condition as the general population.

Table 17: Population-weighted average distances to a bridge by demographic within urban and rural areas.

Classification	General Population*	Minority	Low-Income	English Isolation
Urban	897 m (.0.6 mi)	748 m (0.5 mi)	905 m (0.6 mi)	663 m (0.4 mi)
Rural	1,274 m (0.8 mi)	1,348 m (0.8 mi)	1,261 m (0.8 mi)	1,288 m (0.8 mi)

In rural areas, every demographic resides approximately the same distance to a bridge.

Table 18: Ratio of distances to a bridge by demographic compared to the general population within urban and rural areas.

Classification	Minority	Low-Income	English Isolation
Urban	0.83	1.00	0.75
Rural	1.06	0.99	1.01

While individuals of low-income reside the same distance to a bridge of any structural and operational condition in both urban and rural areas, minorities are 17% and English-isolated households are 25% closer to a bridge than the general population in urban areas (see Table 17 above).

Table 19: Population-weighted average distances to a structurally deficient bridge by demographic within urban and rural areas.

Classification	General Population*	Minority	Low-Income	English Isolation
Urban	2,635 m (1.6 mi)	2,086 m (1.3 mi)	2,644 m (1.6 mi)	1,861 m (1.2 mi)
Rural	4,552 m (2.8 mi)	5,133 m (3.2 mi)	4,501 m (2.8 mi)	5,425 m (3.4 mi)

While English-isolated households reside nearer to a structurally deficient bridge in urban areas, they are farthest from the same type of bridge when compared to other demographics in rural areas.

Table 20: Ratio of distances to a structurally deficient bridge compared to the general population within urban and rural areas.

Classification	Minority	Low-Income	English Isolation
Urban	0.79	1.00	0.71
Rural	1.13	0.99	1.18

Minorities are 21% and English-isolated households are 29% closer to a structurally deficient bridge compared to the general population in urban areas. Conversely, minorities are 13% and English-isolated households are 18% farther away from a structurally deficient bridge than the general population in rural areas.

Table 21: Population-weighted average distances to a bridge with an unknown structural condition by demographic within urban and rural areas.

Classification	General Population*	Minority	Low-Income	English Isolation
Urban	7,715 m (4.8 mi)	7,057 m (4.4 mi)	7,684 m (4.8 mi)	7,250 m (4.5 mi)
Rural	10,631 m (6.6 mi)	11,858 m (7.4 mi)	10,328 m (6.4 mi)	15,521 m (7.8 mi)

English-isolated households in rural areas reside the farthest away from a bridge with an unknown structural condition than any other demographic in both urban and rural areas.

Table 22: Ratio of distances to a bridge with an unknown structural condition by demographic within urban and rural areas.

Classification	Minority	Low-Income	English Isolation
Urban	0.91	1.00	0.93
Rural	1.12	0.98	1.15

While minorities and English-isolated households reside nearer to a bridge with an unknown structural condition in urban areas, they are farther away from the same bridge type in rural areas.

II. Population-Weighted Average Distances to Bridges of Different Operational Conditions

While the focus of this report is on the proximity of residents to structurally deficient bridges, it is not the only bridge condition that may be of concern. More information on bridges classified with the operational conditions of closed or load/capacity restriction is needed. In the meantime, we provide statistics to these bridge types by demographic and geographic boundary in a similar fashion to what was provided previously for bridges of different structural conditions.

Table 23: Population-weighted average distances to different operational conditions of bridges by demographic for MA.

	General Population*	Minority	Low-Income	English Isolation
Population-Weighted Average Distance to a Closed Bridge	11,295 m (7 mi)	10,564 m (6.6 mi)	11,306 m (7 mi)	10,100 m (6.3 mi)
Population-Weighted Average Distance to a Load Capacity/Restriction Bridge	2,898 m (1.8 mi)	2,307 m (1.4 mi)	2,919 (1.8 mi)	2,059 m (1.3 mi)

While English-isolated households reside farthest away from a closed bridge than the other demographic populations, they reside nearer to a bridge with a load/capacity restriction.

Table 24: Ratio of distances to different operational conditions of bridges by demographic for MA.

	Minority	Low-Income	English Isolation
Ratio of Distances to a Closed Bridge Compared with General Population	0.94	1.00	0.89
Ratio of Distances to a Load Capacity/Restriction Bridge Compared with General Population	0.80	1.00	0.72

Minorities and English-isolated households are on average closer to closed and load/capacity restriction bridges than the general population.

Table 25: Population-weighted average distances to a closed bridge by demographic within each MVP region.

Region Name	General Population*	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	7,972 m (5 mi)	8,209 m (5.1 mi)	8,017 m (5 mi)	7,346 m (4.6 mi)
Central	18,514 m (11.5 mi)	19,594 m (12.2 mi)	18,462 m (11.5 mi)	20,371 m (12.7 mi)
Connecticut River Valley	9,009 m (5.6 mi)	9,577 m (6 mi)	8,949 m (5.6 mi)	7,851 m (4.9 mi)
Greater Boston	7,595 m (4.7 mi)	8,333 m (5.2 mi)	7,599 m (4.7 mi)	7,865 m (4.9 mi)
Northeast	10,171 m (6.3 mi)	9,649 m (6 mi)	10,222 m (6.4 mi)	9,388 m (5.8 mi)
Southeast	17,486 m (10.9 mi)	17,025 m (10.6 mi)	17,304 m (10.8 mi)	14,485 m (9 mi)

English-isolated households reside farther away from a closed bridge than minorities and individuals of low-income only in Central. Individuals of low-income reside nearer to a closed bridge than minorities and English-isolated households only in Greater Boston.

Table 26: Ratio of distances to a closed bridge compared to the general population within each MVP region.

Region Name	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	1.03	1.01	0.93
Central	1.06	1.00	1.10
Connecticut River Valley	1.06	1.00	0.89
Greater Boston	1.10	0.99	1.05
Northeast	0.95	1.00	0.92
Southeast	0.97	0.99	0.81

Regardless of where individuals of low-income reside in the state, they are approximately equidistant to a closed bridge compared to the general population. There is considerable variation in proximity to a closed bridge by region. In Central and Greater Boston, minorities and English-isolated households are farther from a closed bridge than the general population. In Connecticut River Valley and Southeast, English-isolated households are closer to a closed bridge than the general population.

Table 27: Population-weighted average distances to a bridge with a load/capacity restriction compared to the general population by demographic within each MVP region.

Region Name	General Population*	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	2,312 m (1.4 mi)	1,933 m (1.2 mi)	2,352 m (1.5 mi)	1,523 m (1 mi)
Central	3,278 m (2 mi)	3,102 m (1.9 mi)	3,274 m (2 mi)	2,614 m (1.6 mi)
Connecticut River Valley	3,187 m (2 mi)	3,015 m (1.9 mi)	3,186 m (2 mi)	2,294 m (1.4 mi)
Greater Boston	2,181 m (1.4 mi)	1,894 m (1.2 mi)	2,215 m (1.4 mi)	1,767 m (1.1 mi)
Northeast	2,948 m (1.8 mi)	2,237 m (1.4 mi)	2,980 m (1.9 mi)	1,809 m (1.1 mi)
Southeast	4,081 m (2.5 mi)	3,491 m (2.2 mi)	4,056 m (2.5 mi)	3,343 m (2.1 mi)

English-isolated households reside closer to a bridge with a load/capacity restriction than minorities and individuals of low-income in every MVP region.

Table 28: Ratio of distances to a bridge with a load/capacity restriction compared to the general population by demographic within each MVP region.

Region Name	Minority	Low-Income	English Isolation
Berkshires & Hilltowns	0.84	1.01	0.67
Central	0.95	1.00	0.81
Connecticut River Valley	0.95	1.00	0.73
Greater Boston	0.87	1.00	0.83
Northeast	0.76	1.01	0.61
Southeast	0.86	0.99	0.81

While individuals of low-income are approximately equidistant to a bridge with a load/capacity restriction compared to the general population in every MVP region, minorities and English-isolated households are nearer to the same type of bridge in every MVP region.

Table 29: Population-weighted average distances to a closed bridge compared to the general population by demographic for urban and rural areas.

Classification	General Population*	Minority	Low-Income	English Isolation
Urban	2,845 m (1.8 mi)	2,284 m (1.4 mi)	2,865 m (1.8 mi)	2,051 m (1.3 mi)
Rural	4,042 m (2.5 mi)	4,342 m (2.7 mi)	4,011 m (2.5 mi)	4,039 m (2.5 mi)

While individuals of low-income reside nearer to closed bridges than minorities and English-isolated households in rural areas, they are farther away from this type of bridge compared with the other demographics in urban areas.

Table 30: Ratio of distances to a closed bridge compared to the general population by demographic for urban and rural areas.

Classification	Minority	Low-Income	English Isolation
Urban	0.94	1.00	0.89
Rural	1.09	0.98	1.10

While minorities and English-isolated households reside nearer to a closed bridge in urban areas, they are farther from a closed bridge in rural areas.

Table 31: Population-weighted average distances to a bridge with a load/capacity restriction compared to the general population by demographic for urban and rural areas.

Classification	General Population*	Minority	Low-Income	English Isolation
Urban	2,845 m (1.8 mi)	2,284 m (1.4 mi)	2,865 m (1.8 mi)	2,051 m (1.3 mi)
Rural	4,042 m (2.5 mi)	4,342 m (2.7 mi)	4,011 m (2.5 mi)	4,039 m (2.5 mi)

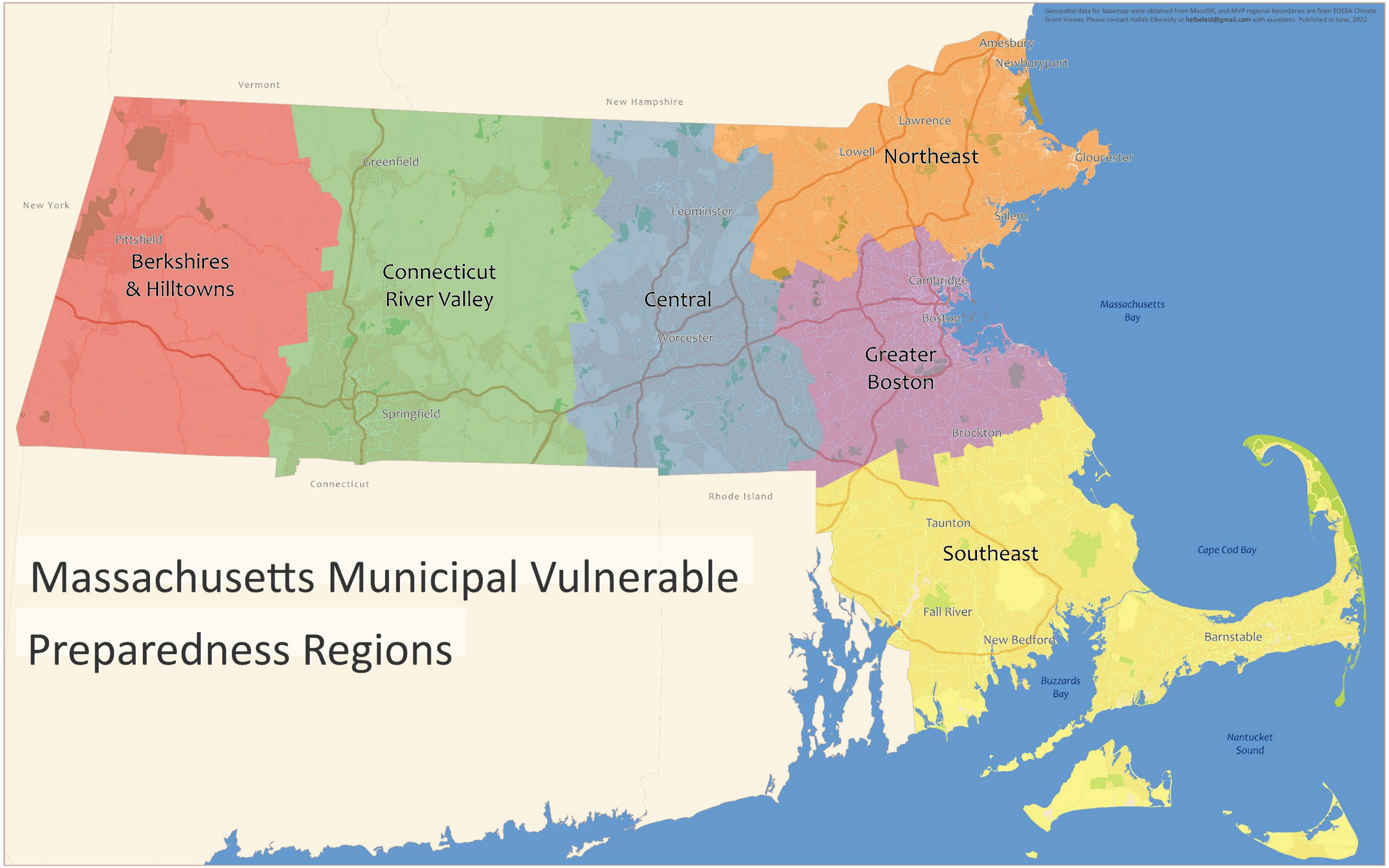
In urban areas, individuals of low-income reside farther away from a bridge with a load/capacity restriction than minorities and English-isolated households. In rural areas, minorities reside farther away from a bridge with a load/capacity restriction than individuals of low-income and English-isolated households.

Table 32: Ratio of distances to a bridge with a load/capacity restriction compared to the general population by demographic for urban and rural areas.

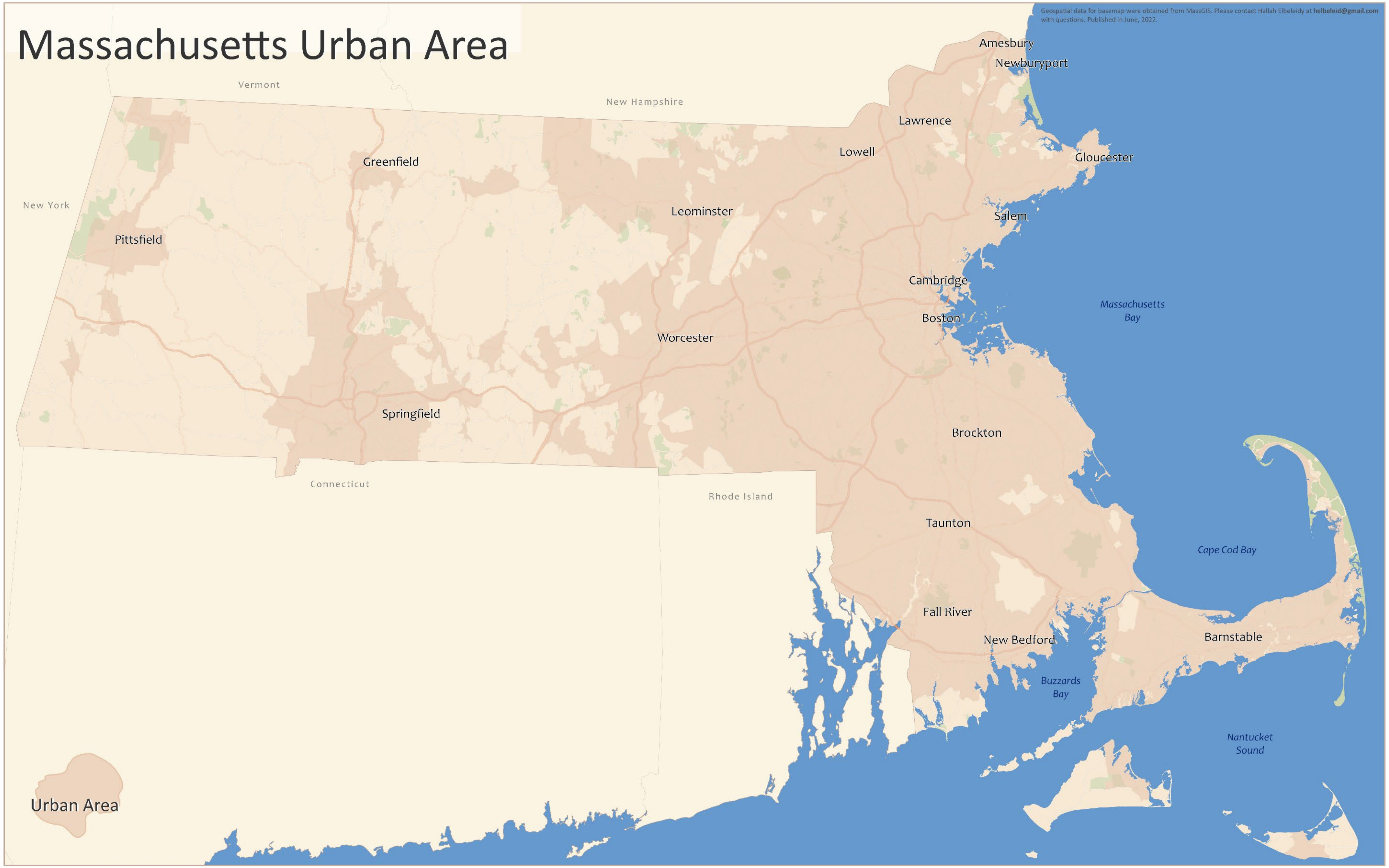
Classification	Minority	Low-Income	English Isolation
Urban	0.80	1.00	0.73
Rural	1.07	0.99	1.01

Minorities are 20% and English-isolated households are 27% nearer to a bridge with a load/capacity restriction in urban areas. Conversely, these demographics are on average farther from a bridge with a load-capacity restriction in rural areas.

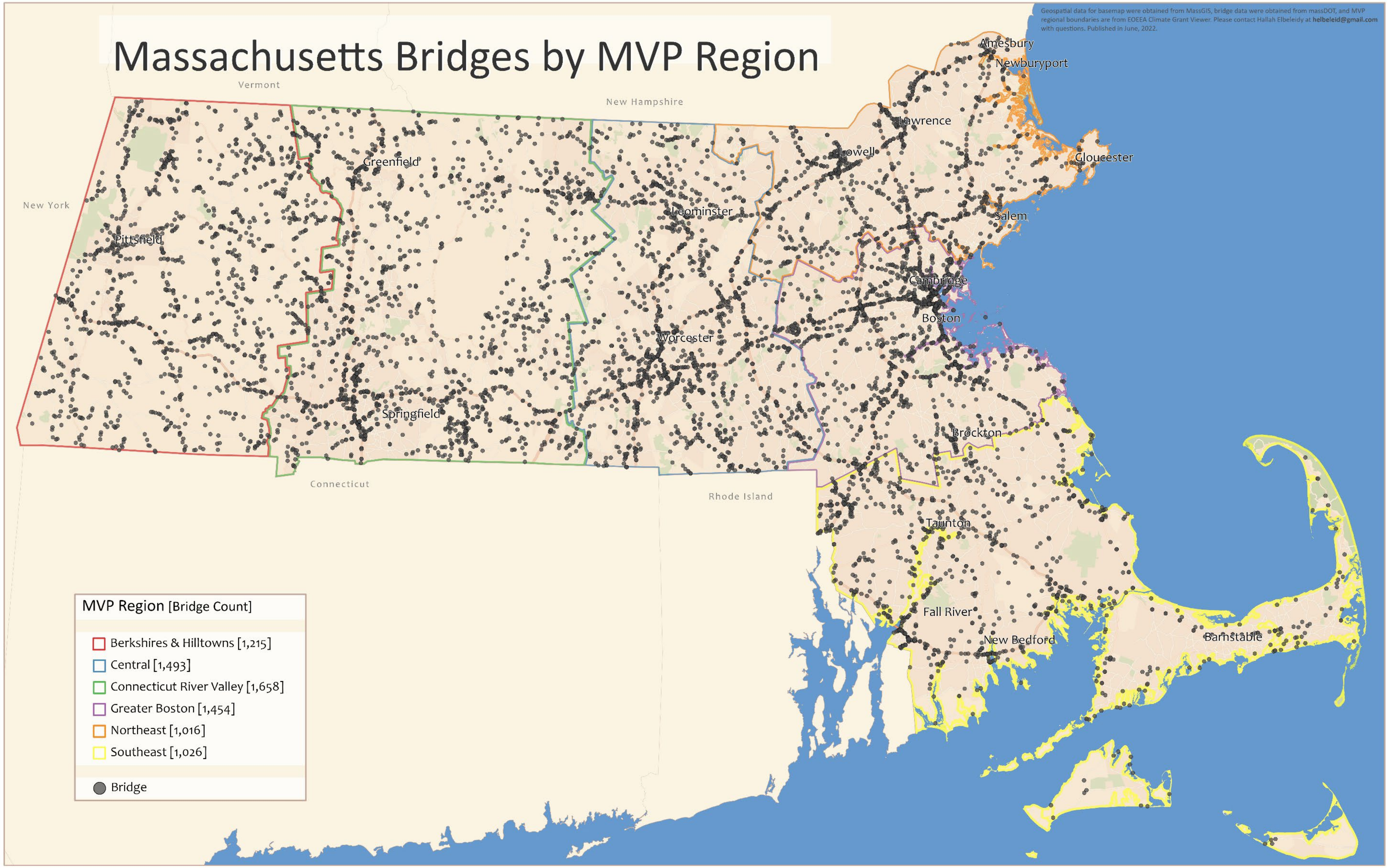
APPENDIX A. Massachusetts Municipal Vulnerability Preparedness Regions



APPENDIX B. Massachusetts Urban Area



APPENDIX C. Massachusetts Bridges by MVP Region



APPENDIX D. Density of Structurally Deficient Bridges in Massachusetts