



Climate Change Risk Analysis

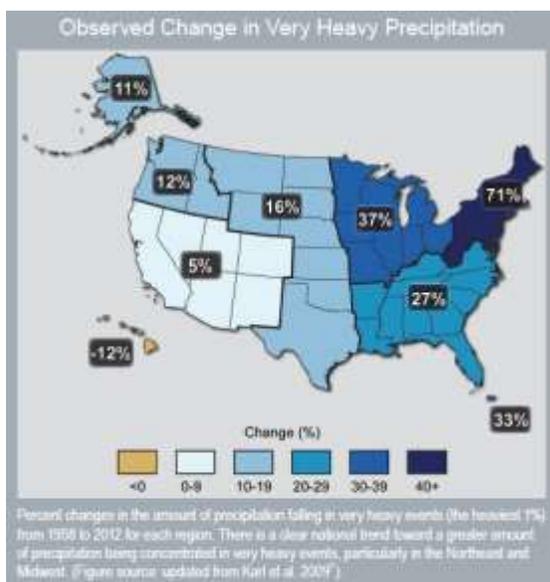
Assessment of Future Natural Disaster Threats and Impact on Springfield

Prepared for
City of Springfield, MA
Phase 1 Application for the
National Disaster Resilience Competition
October 2015

All around the world, communities are feeling the localized effects of climate change. National assessments report that heavy precipitation and extreme heat events have increased as projected, and the risk of such events will only continue to rise (Melillo et al. 2014). Not surprisingly, regional reports echo this warning and urge residents and governmental agencies in the Northeastern United States to prepare for increased flooding and extreme heat and weather events in the coming decades (Moser et al. 2007; PVPC Climate Action and Green Energy Plan 2014). This change in climate will create risks that will threaten vulnerable populations, endangered species, and fragile infrastructure in the built environment.

Rising temperatures are expected to have cascading effects on weather patterns, the natural and built environments, and public health. With the Northeast warming at a rate of nearly 0.5 degrees F per decade, the Northeast Climate Impact Assessment estimates that by the end of the century Massachusetts's climate will be similar to that of New Jersey or Virginia depending on the rate at which the emissions that affect the increase in temperature are produced (Frumhoff et al. 2007; PVPC Climate Action and Green Energy Plan 2014). Since the 1950's, winter storms have increased in frequency and intensity and they have shifted northward on their tracks across the country (Melillo, et al. 2014). While areas out west will need to prepare for longer periods of drought, Massachusetts will prepare for wetter weather. Springfield and the Pioneer Valley will see an increase of 2.5-5.5 inches of annual precipitation over the next 75-100 years, most of which will come in the form of winter rain (PVPC Climate Action and Green Energy Plan 2014). There is also likely to be an increase in extreme weather events as the increase in precipitation will not fall gently, but rather it will come in concentrated events. In fact, since the late 1950's, the Northeast has seen a 71% increase in very heavy precipitation, the largest increase in the nation as can be seen in Figure 1 (Melillo et al. 2014). For Springfield, this increase may bring flooding which can damage homes, interrupt utility service, overwhelm the water treatment facilities, and pollute waterways.

Figure 1. Observed Changes in Heavy Precipitation from 1958 to 2012 in the U.S.



EVIDENCE-BASED MODEL TO ASSESS RISK

This assessment was completed using an approach adapted from United Nations Disaster Programme Disaster Risk Assessment (UNDP). This five-step approach relied on local and regional scientific literature to provide the foundation of data collection. The steps include, 1) understanding the current situation including the needs and gaps, 2) identifying the likelihood of major hazards prevailing in Springfield, 3) identifying the population and assets at risk and delineating disaster-prone areas, 4) determining the capacity (or lack of it) of elements at risk to withstand the given hazard scenarios, and 5) estimating the potential losses and their potential impacts on Springfield.

THREATS AND HAZARDS

Based on the above assessment, the following are the natural disaster threats and hazards that are likely to occur in Springfield as a result of climate change: **1) rising temperatures and heat waves, 2) increased precipitation and flooding, and 3) extreme storm events** (which would also result in flooding). They were identified through the unmet need assessment, review of scientific literature, and local and regional planning reports. Data was drawn from a variety of available data sources, including the U.S. Census Bureau, the Massachusetts Department of Public Health data sets, and housing data sources. Information from the Pioneer Valley Planning Commission's "Climate Action and Clean Energy Plan" was utilized as part of this process. Regional Planning agencies understand the needs and vulnerabilities of the residents. Local governments work directly with residents impacted by disasters. Regionally specific scientific data is more useful than the less-focused national data.

Rising Temperatures and Heat Waves: While rising temperatures and heat waves affect both rural and urban areas, residents of urban areas are likely to feel the most impact. Heat island effect describes the tendency for urban areas to be warmer than surrounding rural areas (PVPC Green Infrastructure Plan 2013). In many urban areas vegetation is found scattered across the landscape creating pockets of green space. However, the urban landscape is dominated by contiguous sections of concrete and asphalt with clusters of large buildings that absorb heat, resulting in slightly warmer days and sustained warmth at night. In fact, an increase of temperature of 2 to 5 degrees F during the day, and up to 22 degrees F at night can be felt in cities (PVPC Green Infrastructure Plan 2013). The cities that are most vulnerable are not those located in a warm climate, rather cities that experience a wide range of temperature change will feel the greatest impact. Therefore, projections show that cities in the Northeast, like Springfield, and cities in the Midwest will see the largest increases in heat-related deaths (Congressional Black Caucus Foundation, 2004). Urban trees play an important role in regulating the temperature of the city in many ways including creating shade. Shaded areas are often 20 to 40 degrees cooler than non-shaded areas (PVPC Green Infrastructure Plan 2013). Strategically placed trees can shade buildings and parks which reduces indoor cooling costs and creates comfortable outdoor spaces. Rising temperatures will also likely lead to increased ozone pollution, which would affect a number of health conditions, including asthma (NRDC).

Increased Precipitation and Flooding: As Springfield sees an increase in heavy precipitation events, potential flooding will threaten homes, businesses, water quality, and public health. A study of the last 50 years reveals an increase in total precipitation by approximately 10% in Massachusetts (PVPC Climate Action and Green Energy Plan 2014). Scientists advise communities that it is insufficient to prepare only for an increased amount of precipitation in the Northeast. Rather, communities should prepare to be inundated with precipitation during concentrated events. The Northeast Climate Impacts Assessment projects that the number of thunderstorms that produce more than 2 inches of rain during a 48-hour period will increase by 8% in the Northeast by mid-century (Frumhoff et al. 2007). Therefore, we should

expect that the increased amount of heavy precipitation events and overall increase in rainfall will likely result in more flooding in Springfield and the region (PVPC Climate Action and Green Energy Plan 2014). Other projections include an increase in the occurrence of 100-year floods to one every 2 to 3 years (PVPC Climate Action and Green Energy Plan 2014). Though Springfield as a whole does not experience large-scale flooding, some neighborhoods are more vulnerable than others. Brightwood, a neighborhood in the North End, and the South End neighborhood are both located in the 500-year flood zone (Oliver).

Extreme Weather Events

- **Tornadoes:** Tornadoes can cause a great deal of damage on any landscape, but they are especially dangerous in a dense, urban environment. Many lives, homes and much of the urban infrastructure are at risk when a tornado strikes a city or greater metropolitan area, as evidenced by the June 2011 tornadoes in Springfield. Those EF3 tornadoes, categorized by having wind speeds from 136 to 165 miles per hour, were the region's worst outbreak of tornadoes in a century, causing \$90 million in damages in Hampden County alone (PVPC Climate Action and Green Energy Plan 2014; NOAA). As NOAA reported, the tornado that ravaged Springfield will be noted not only for its intensity, but also for the length of the continuous damage path extending for 39 miles (NOAA). The tornadoes cut a mile swath as it tore through eight Springfield neighborhoods. The path of the storm, coupled with the city's development patterns resulted in the vast majority of residential damage occurring in just five neighborhoods: South End, Six Corners, Old Hill, East Forest Park, and Sixteen Acres (Springfield CDBG – Disaster Recovery Partial Action Plan A).
- **Snowstorms:** Heavy precipitation, taking the form of late-fall snowstorms, can wreak havoc on communities. Just months after the tornadoes ravaged Springfield, a record early snowstorm pummeled the region causing \$3 billion in damages across the Northeast (PVPC Climate Action and Green Energy Plan 2014). Many trees still had their leaves as the snow began to fall. In Springfield, the snowfall totals exceeding 14 inches snapped branches and downed power lines causing \$30 million in damages and recovery for Springfield (Springfield CDBG – Disaster Recovery Partial Action Plan A). Across the state, more than 700,000 people were without power, many for more than a week (PVPC Climate Action and Green Energy Plan 2014). In addition the power outages and expensive recovery, the death of one Springfield resident was attributed to the storm.

What are knowns and unknowns?

Knowns

- There will likely be an increase in precipitation and extreme weather events that may result in flooding. The effects of flooding can be predicted by collecting data to render models that contribute to projections. A community's topography, development patterns, stormwater capacity, water table, and historical storm data can inform disaster response plans so that residents and municipal leaders can identify the most vulnerable populations, assets, and environments.
- Temperatures will continue to rise which will increase risk for some vulnerable populations, particularly in the City.

Unknowns

- Severe weather events such as tornadoes, hurricanes and atypical snow storms are more difficult to predict. For example, when specific weather conditions are met, tornadoes can form quickly and with little warning. Though the trends of severe storms are being studied intensively, the literature shows there is insufficient data to directly connect climate change to increased

tornadic activity. However, many scientists agree that rising temperatures and increased greenhouse gasses encourage meteorological conditions that are favorable for tornado formation (Hoerling et al. 2011; Melillo et al. 2014). Some projections show that the number of days during which such conditions are met are likely to increase (Hoerling et al. 2011). Therefore, while climate change projections lack evidence to prove causation, they provide significant data on the frequency of days during which tornadoes are likely to form. Tornadoes occur less frequently in the Northeast than in other parts of the country. Residents in Tornado Alley are exposed to more frequent tornado warnings and drills than in Massachusetts. Though the National Weather Service broadcasts tornado warnings across television and radio stations in the Northeast, the efficacy of such warnings is unclear in a region that experiences so few tornados. Massachusetts state and local agencies provide tornado preparedness information their websites, including instructions on how to shelter in place (Commonwealth of Massachusetts Commonwealth of Massachusetts, Public Safety: Tornadoes), but it's unclear if Springfield residents are prepared.

VULNERABILITIES

A variety of factors make communities vulnerable to the impacts of natural disasters and climate change, including the social, economic and health status of the community, as well as the built environment and infrastructure (Lynn 2011). Below is a description of vulnerabilities of the Springfield community. Springfield residents are particularly vulnerable to the effects of climate change, and the resulting flooding, heat waves, and extreme weather events that will occur. Factors that increase their susceptibility to negative impacts are described below and include: current housing status, economy and businesses, infrastructure status, existing health disparities and environmental risk factors, and the large number of vulnerable residents at increased risk for health and socioeconomic impacts.

Housing

Owner-Occupied Housing: Damaged or destroyed housing creates an urgent need for individuals and the community at large. In Springfield, 615 residential units were condemned as a result of the damages sustained during the 2011 tornadoes (Springfield CDBG – Disaster Recovery Partial Action Plan A). By the fall of 2013, most of owner-occupied homes damaged in 2011 have been repaired. These homeowners tapped into the resources available to them such as homeowners' insurance, Small Business Association (SBA) disaster loans, bank loans, homeowner savings, and donated resources, including volunteer labor. (Springfield CDBG – Disaster Recovery Partial Action Plan A).

As stated in the Disaster Recovery Partial Action Plan A, the City estimates “the total amount of real property damage for owner-occupants to be \$70,755,000. The total amount of insurance claims plus SBA loans paid out is estimated to be \$27,146,708. The remaining total unmet housing need is **\$43,608,292**, (Springfield CDBG – Disaster Recovery Partial Action Plan A).”

Rental Properties: Unlike homeowners, many renters don't have access to the same resources to assist them during and after a disaster. Renters have little control over maintenance, and this includes protective measures that can be taken (e.g. air conditioners used during extreme heat waves). Additionally, even if renters are supplied with units such as air conditioners, they may have limited financial resources to pay for the extra energy costs associated with running them (Cox, et al. 2006).

Following the June 2011 tornadoes, Springfield has permanently lost a total of 110 rental units, for which there is no indication or intent to rebuild. Many of these units were one-, two- and three-family homes which are not being rebuilt and are now vacant or abandoned lots (Springfield CDBG – Disaster

Recovery Partial Action Plan A). In addition, 74 units of public and subsidized low-income housing were destroyed.

Hundreds of households became homeless in the immediate aftermath of the tornado. Neighborhoods, like Six Corners and Old Hill with a higher percentage of renters felt this impact the strongest because as renter households, they were less likely to have insurance that might cover interim housing.

Table 1. Home Ownership, Age of Housing Units and Number of Subsidized Units

	Home Ownership	Housing Units Built Before 1940*	Subsidized Housing Units**
South End	5.9%	73.7%	460
Metro Center	4.0%	66.4%	1374
Six Corners	15.3%	63.2%	552
Old Hill	36.1%	73.5%	170
Forest Park	45.6%	75.2%	200
East Forest Park	89.5%	22.5%	0
Brightwood	17.5%	30.8%	975
Memorial Square	10.3%	50.1%	743
Springfield	49.8%	38.9%	9080

*ACS 5-Year Estimates 2005-2009; ACS 2013 1-Year Estimate

**ACS 5-Year Estimates 2008-2012; ACS 2013 1-Year Estimate

*2014- MA DHCD

FUTURE RISKS:

- Low home ownership in Six Corners (15.3%) and Old Hill (36.1%) are both well below the Springfield (49.8%) and Massachusetts (63.7%) averages and are vulnerable to future extreme weather events that can impact or destroy housing (Table 1) (PVPC Data Atlas by Neighborhood, City of Springfield, MA).
- Older housing in Springfield increases risk for lead exposure if damaged. All but one of the neighborhoods impacted by the tornado have more than 50% of their housing units built before 1940 (Table 1).
- Property abandonment throughout tornado-impacted neighborhoods has left buildings vacant creating safety hazards in the neighborhoods (Springfield CDBG – Disaster Recovery Partial Action Plan A).
- Neighborhoods with a higher amount of vacant lots and of vacant housing like Six Corners and Old Hill, could see future delayed cleanup and increased blight after another tornado or extreme storm event.
- Two years following the tornadoes, the City noted that most middle-class families were able to repair or rebuild, while lower-income neighborhoods were slower to recover. Therefore, lower income residents face greater risks with future storms.
- Climate change will continue to affect the price, affordability and availability of insurance coverage (PVPC Climate Action and Green Energy Plan 2014).

Economy and Businesses

In the immediate aftermath of the storm, the most significant issues were damaged buildings, power outages, closed roads, closed transit services, delivery challenges, and access to work for staff. Some businesses were affected for weeks following the storm. Some businesses that were able to reopen resulted in some long-term job loss (Springfield CDBG – Disaster Recovery Partial Action Plan A).

As stated in the Disaster Recovery Partial Action Plan A, the unmet needs assessment conservatively assumes that each of the 100 impacted businesses incurred an average of \$22,500 for a total of \$2,250,000. In total, \$20,614,503 of recovery funds has been disbursed, including SBA loans of \$2,755,500 and commercial insurance of \$17,859,003. This leaves **\$20,167,130** in current unmet need (Springfield CDBG – Disaster Recovery Partial Action Plan A).

FUTURE RISK:

- While some businesses may recover fully after an extreme weather event, those that are the most vulnerable are located in communities that are already faced with economic struggles.

Springfield Development Patterns

Springfield's urban center is located on the western edge of the city at the bend of the Connecticut River. Several of the surrounding neighborhoods, including the South End, Six Corners, Old Hill, and Upper Hill are densely developed with small parcels. When a disaster strikes a densely developed area, the impacts on the environment and the community are exacerbated during extreme weather events. In the Northeast, two extreme events include heavy precipitation and heat waves (Cox et al. 2006). When heavy precipitation falls, it needs somewhere to go. Smaller lot sizes can mean there are fewer parks and vegetated areas that have the capacity to recharge the groundwater after a rain event. A landscape dominated by buildings, roads, sidewalks, and parking lots, offers a reduced amount of opportunities for stormwater infiltration. This is critical for Springfield which is nestled in the bend of the Connecticut River because an impact on the River will affect communities and wildlife downstream. Numerous studies show a direct correlation between the amount of impervious surfaces and the quality of water in rivers, streams, and lakes receiving discharges from these areas. According to the Pioneer Valley Green Infrastructure Plan, Springfield has 34% directly connected impervious surfaces, the most in the Pioneer Valley. Urban street trees can offset the impacts of impervious surfaces by facilitating stormwater infiltration. A study conducted by the Urban Forest Coalition showed that the existing tree cover in the City of Boston reduces stormwater runoff by 314 million gallons per year (PVPC Green Infrastructure Plan 2013). As Springfield sees an increase in heavy rain events stormwater infiltration strategies, such as strategically planting more trees, will be necessary.

FUTURE RISKS:

- As both annual and concentrated precipitation totals increase, Springfield will likely see the impact of polluted waterways. Stormwater infiltration strategies will reduce the pollution impact on the Connecticut River and surrounding waterways. Such strategies include installing rain gardens, developing parks and open space, and building green roofs, all of which will be critical in the densely populated sections of Springfield.

- The South End, Old Hill and Six Corners neighborhoods have three of the lowest tree canopy cover percentages in the city (Bloniarz 2014). Therefore, these neighborhoods have a lower natural capacity for intercepting stormwater runoff, which may lead to polluted waterways, localized flooding and other health risks during future heavy precipitation events.

Infrastructure:

A city’s operational infrastructure is essential to the healthy functioning of the city. Roads, sewers, utilities, water supplies, and transportation systems are the framework on which cities are built. Scientists warn that this framework may become increasingly compromised by climate-related hazards, including sea level rise, coastal flooding, and heavy precipitation events (Melillo et al. 2015). In a city like Springfield with 34% impervious surfaces, increased precipitation will lead to increased stormwater runoff which will create risk for polluted waterways, flooding, and erosion unless mitigation strategies are implemented.

Combined Sewer: Springfield, like many older cities in the Northeast, has a combined sewer system, where sewage and stormwater are carried through the same pipes to a treatment facility. During heavy rain events, the system is overwhelmed and untreated sewage mixed with stormwater runoff is discharged directly into the Connecticut River at combined sewer outfalls (CSOs). This has significant health consequences indicated by the issuance of health safety alerts to advise that people avoid contact with the water for 48 hours. Springfield is working to separate its sewer system and reduce the number of CSOs. As of 2010, \$170 million was still needed for Springfield to realize its goal of cleaning up the CSOs (PVPC Climate Action and Green Energy Plan 2014).

Dams: Massachusetts Department of Conservation and Recreation’s Office of Dam Safety (ODS) inspects dams and classifies dams based on what impact a dam failure would have on the surrounding population. There are 2 dams in Springfield that are listed as High Hazard Areas. High Hazard Areas are those that where failure will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways, or railroads (PVPC Climate Action and Green Energy Plan 2014). One is the Watershops Pond Dam, which sits less than a quarter mile from the Elias Brookings School, one of the schools badly damaged in the tornado. The Lower Van Horn Reservoir Dam in the North End is also listed as a High Hazard Area and is in poor condition. Because dams were constructed and sized based on historic weather data, they are not equipped to handle the increased flows and volumes that Springfield and other communities will see as a result of climate change (PVPC Climate Action and Green Energy Plan 2014).

Roads: Roads are the arteries of the city, transporting people and goods from place to place. During the 2011 tornadoes downed power lines, toppled trees, and debris clogged the roadways. Interstate 91 is a major highway that bisects that state and connects Springfield to the greater region. Most sections of I-91 are generally at a higher roadway elevation and are expected to be usable during floods. However, there are a number of ramps at a lower elevation in downtown Springfield that are at risk of flooding from the Connecticut River. The most vulnerable of which are ramps Ramps 3 through 8 – a stretch of the interstate that carries approximately 70,000 cars and trucks per day (PVPC Climate Action and Green Energy Plan 2014).

The delivery of core utility services was substantially impaired, and thousands of residents lost power as powerful wind and falling trees downed power lines. In addition to the transportation damage and utilities interruptions, the City sustained extensive damage to other public infrastructure, including

schools, a community center, and parks. The storm created multiple public health issues, including unsafe structures, environmental hazards (e.g., mold, lead and asbestos) and extensive amounts of building and vegetative debris (Springfield CDBG – Disaster Recovery Partial Action Plan A).

FUTURE RISKS:

- Runoff from heavy precipitation events increases the risk of flooding, landslides, erosion—which may expose buried pipelines, or reduce the stability of dams. With two dams in the High Hazard Areas and 146 culverts roadway stream crossings, Springfield is vulnerable when floods disconnect residents from evacuation routes, food access, safety, etc. (PVPC Climate Action and Green Energy Plan 2014)
- Stormwater runoff can pollute the Connecticut River and other waterways that are tributary to water supply reservoirs. Surface water reservoirs provide 100% of the water supply for Springfield (PVPC Climate Action and Green Energy Plan 2014). Therefore, it's in the City's best interest to reduce stormwater runoff.
- Utility facilities may be more susceptible to flooding, as some components are located in flood zones. Two examples are Putts Bridge, a hydroelectric facility, is located in the 100-year floodplain (bordering Springfield and Ludlow) and Consolidated Energy at Indian Orchard is in the 500-year flood zone (Oliver).

Schools

Springfield is the home of 57 public and charter schools which are distributed across the city (Massachusetts Department of Elementary and Secondary Education). As the tornadoes tore across the city two such public schools, Dryden Elementary and Elias Brookings Elementary, sustained serious damages. These damages resulted in an estimated \$51,809,588 in damage. While some funding and been obtained, the city estimates that there is still \$10,893,279 in unmet need (Springfield CDBG – Disaster Recovery Partial Action Plan A).

FUTURE RISK:

- The areas affected by the 2011 tornadoes are home to 28 schools, 13,781 students, and 1483 teachers (Massachusetts Department of Elementary and Secondary Education).
- The South End Middle school is in 500-year flood plain and may be at risk in extreme flooding events (Oliver).
- 3 schools in the North End (Chestnut Street Middle School, Garena School and Brightwood School) are located in 500-year flood plain and may be at risk in extreme flooding events. (Oliver).

Health

Springfield residents experience large health disparities when compared to the state and the nation. Residents are disproportionately impacted by high rates of asthma, stroke, chronic obstructive pulmonary disease (COPD), obesity, hypertension, childhood lead poisoning, and diabetes, all of which are impacted by the environment and will be impacted by climate change. Some neighborhoods that were impacted by the tornado and continue to have unmet needs experience even larger inequities (see Table 2).

- Respiratory Disease
 - Asthma – An estimated 18% of Springfield residents have asthma, which is 60% higher than the state prevalence (MDPH, Behavioral Risk Factor Surveillance Survey [BRFSS] 2012). Residents experience high morbidity due to asthma with ER visit rates 3 times higher than that of the state and more than double the national rate (Table 2). Residents in zip codes that include large portions of Metro Center, Six Corners, the South End and the North End are particularly impacted with rates 40-75% higher than that of the City.
 - COPD – Springfield residents experience this disease that typically affects older adults at an ER visit rate double that of the state (Table 2). Residents in zip codes that include large portions of Metro Center, Six Corners, the South End and the North End are particularly impacted with ER visit rates 40-60% higher than that of the city overall.
- Stroke and Hypertension – Springfield residents experience over double the rate of hypertension emergency room visits than the state, with zip codes that include Six Corners, South End, Old Hill, and North End disproportionately impacted (Table 2). Springfield hospitalization rates for stroke are 15% higher than the state, with residents of zip codes that include large portions of Old Hill, and Six Corners zip codes disproportionately impacted.
- Mental health – Springfield residents have high rates of depression (MDPH BRFSS) and mental health hospitalizations (Table 2) with both more than double the state rates.
- Obesity – An estimated 67% of Springfield adults (MDPH BRFSS) and 42% of Springfield children are overweight or obese (MDPH, Status of Childhood Weight in Massachusetts, 2011).
- Lead poisoning – Springfield has been designated a high-risk community for childhood lead poisoning in Massachusetts with the 3rd highest adjusted rate in the state in 2012 (MDPH, Childhood Lead Poisoning Prevention Program).

Table 2. Emergency Room and Hospitalization Rates

zip code*	Neighborhood	Emergency Room Visit Rates**				Hospitalization Rates***
		Asthma	Hypertension	Mental Health	COPD	Stroke
01109	Old Hill	1590	444	3493	1998	340
01103	Metro Center	2225	#	5359	2818	#
01105	Six Corners & South End	2740	436	9172	3276	267
01108	Forest Park	1476	273	3584	1826	297
01118	East Forest Park	566	108	1829	724	233
01107	North End	2640	361	4675	3207	369
	Springfield	1593	301	4017	1976	281
	Massachusetts	586	131	2150	894	246

* Neighborhoods may have more than one zip code. Zip codes were identified that included the largest portion of the neighborhood or that were entirely for a given neighborhood.

** 2009-2011 Emergency Room Visit Dataset, MDPH; Age-adjusted per 100,000

*** 2009-2011 Inpatient Hospitalization Discharge Dataset, MDPH; Age-adjusted per 100,000

Suppressed due to too few numbers

Increases in temperature, increased precipitation and flooding may create even greater disparities and negatively impact individuals with pre-existing conditions and other vulnerable populations as follows:

- Increases in temperature and heat waves– Individuals with diabetes, obese individuals, children, elderly, hypertension, stroke, and depression are all at risk for negative effects of increases in temperature (Kovatz 2008). In some cases, such as children and older adults, bodies have a difficult time adjusting to the increased temperature, particularly in the absence of air conditioning. Elderly adults in assisted living institutions have been found to be at particular risk. Heat stress can also increase strain on the cardiovascular system which would negatively impact those with existing cardiac disease (e.g. stroke). Also, some common medications may prevent the body from adjusting to increased heat (e.g. diuretics used to treat hypertension). The increase in temperature may also increase ozone pollution levels which would potentially adversely affect all residents but particularly vulnerable populations which include the elderly, children, and individuals with asthma, COPD, stroke, and diabetes (Eze 2014)(Anderson 2012; Brooke 2004).
- Flooding or extreme weather conditions would have the potential to destroy or cause damage to houses – Damage sustained from these conditions would lead to exposure to hazards in the home, including lead, asbestos and mold. Disrepair could also create opportunity for pest infestation, which is a trigger for asthma morbidity, in addition to mold exposure. It is estimated that 21% of asthma cases can be attributable to mold and moisture exposure in housing and buildings (Mudarri & Fisk 2007).
- Extreme weather events Such events may negatively impact mental health due to the stress and strain of homelessness, loss of property, etc.

FUTURE RISK:

- Rising temperatures, increased precipitation and flooding, and extreme weather events that will likely occur as a result of climate change may negatively affect the health of a large number of at-risk Springfield residents, including those with asthma, COPD, stroke, hypertension, diabetes, obesity, depression.
- ***These negative effects may exacerbate large existing health disparities if measures are not taken to increase resiliency of the city and its residents.***

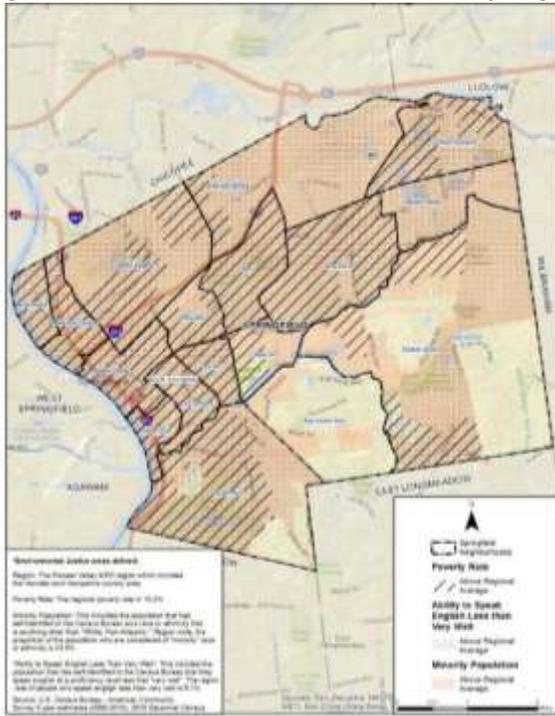
Environmental Conditions Exacerbated by Climate Change

Springfield struggles with high levels of outdoor air pollution with most years experiencing some exceedences for ozone and fine particulate matter (PM_{2.5}) based on data from the EPA Air Quality Index (EPA AirData). This is likely due to several factors, including the I-91 interstate that runs along the city and over some neighborhoods, several point sources, including factories and power plants, and the fact that the city is in a valley and that pollution travels from other sources and settles. Ozone, PM_{2.5} and outdoor air pollution have been shown to lead to morbidity for several chronic diseases including asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disease, with recent studies also suggesting an association with diabetes (Anderson 2012, Brook 2004, Ko 2009, Rajagopalan 2012). Increasing temperatures that would occur with climate change would increase the production of ozone and number of “unhealthy” days thereby increasing morbidity for people with these health conditions and thereby exacerbate existing health disparities (NRDC, Air Pollution, Smoke, Smog and Pollen).

Springfield has also been identified by the Massachusetts Office of Energy of Environmental Affairs as an Environmental Justice(EJ) community. EJ communities often experience disproportionate exposure to environmental hazards and are identified so that care can be taken when the potential for additional environmental exposures occurs. A more recent analysis that was conducted using the Pioneer Valley

Metropolitan Planning Organizations definition of environmental justice, which includes those neighborhoods that have rates of poverty or racial/ethnic minorities above the regional average, found that large parts of Springfield meet the criteria for Environmental Justice communities as can be seen in Figure 2.

Figure 2. Environmental Justice Areas in Springfield



Springfield residents also struggle with limited access to affordable, healthy food with most neighborhoods having limited access based on USDA’s Food Access Research Atlas (Partners for a Healthier Community, Health Equity Report). In particular, among the neighborhoods impacted by the tornado with unmet need, Six Corners, Old Hill and parts of Metro Center, Forest Park and Memorial Square are described as having limited access. Climate change and rising temperatures are projected to increase food costs and decrease food availability which would create more disparities (Lynn 2011; Melillo et al. 2014).

FUTURE RISK:

- Existing environmental injustices in Springfield have the potential to be worsened as a result of climate change. Increased air pollution that may occur would increase morbidity for the many people with asthma and COPD and other vulnerable populations in Springfield.

Vulnerable Populations

Low income populations, communities of color, and immigrants have been identified as vulnerable to negative impacts of natural disasters and climate change as these group often face numerous challenges which decrease their ability “to anticipate, cope with, resist and recover from the impact of a natural hazard” (Wisner 2004; Lynn 2011). These groups also experience many health disparities in Springfield and thus would be disproportionately impacted as well.

- Springfield residents struggle with economic insecurity with a median household income of \$31,356, half that of the state, and 33% of residents living in poverty (Table 2) with children

particularly impacted as almost half live in poverty (48%)(U.S. Census, ACS, 2012). Rates of poverty are almost 50% in all but two of the neighborhoods with unmet need from the tornado (Table 2). These residents also struggle with high rates of unemployment and lower levels of education (Table 2).

- Springfield is a diverse, multi-ethnic city with people of color accounting for the majority (66%) of its population. Among people of color, an estimated 43% of Springfield’s population is Latino, 19% is Black, and 2% is Asian (U.S. Census Bureau, ACS, 2012). Latino and Black Springfield residents experience large health disparities for many health conditions, including asthma, COPD, stroke and mental health (Partners for a Healthier Community, Health Equity Report 2014). Among impacted neighborhoods with unmet needs from the tornado, people of color—particularly Blacks and Latinos - make up more 90% of the population in Old Hill and between 50-90 % of the population in South End, Metro Center and Forest Park with Latinos having the largest population in these neighborhoods.
- Springfield has a substantial immigrant and migrant population with an estimated 10% of Springfield’s population foreign-born (largest group Vietnamese and significant Central and South America, Eastern Europe, and Eastern African populations) and 18% migrants from Puerto Rico (U.S. Census Bureau, ACS, 2012). Forty-one percent of the Springfield population speaks a language other than English, and 17% speak English “less than well,” with the majority of those facing language barriers being primarily Spanish speaking (81%) (U.S. Census Bureau, ACS, 2012).

Table 2. Sociodemographic Data

	Median Household Income	Poverty Rate	Poverty Rates Age 65+	Unemployment	Bachelor's Degree or More
South End	\$17,441	63.6%	58.5%	19.2%	4.0%
Metro Center	\$16,114	48.9%	25.5%	20.6%	12.7%
Six Corners	\$18,763	49.3%	24.7%	18.5%	14.3%
Old Hill	\$23,021	46.2%	26.4%	29.5%	6.9%
Forest Park	\$40,513	24.7%	8.2%	17.7%	22.6%
East Forest Park	\$64,362	4.8%	3.0%	6.3%	28.2%
Brightwood	\$15,495	47.5%	51.0%	16.6%	6.0%
Memorial Square	\$16,974	49.3%	18.3%	30.8%	6.9%
Springfield	\$31,356	33.3%	13.7%	10.9%	17.6%
Massachusetts	\$65,339	11.9%	9.3%	6.7%	39.3%

Data Source: U.S. Census Bureau ACS 5-Year Estimates 2008-2012

Children and older adults age 65 and over are also vulnerable to the negative effects of climate change and natural disasters as they are at increased risk for numerous negative health impacts related to climate change as discussed in the health section. For example, households comprised of older adults may be on a fixed income and have fewer resources available to assist in their recovery. They may have had greater difficulty in undertaking cleanup tasks. In Springfield, there are an estimated 20,951 children age 9 and under and 17,461 adults age 65 and over that would be at risk (U.S. Census Bureau, ACS, 2013). As poverty rates among children and adults 65 and older are high in Springfield (Table 2), they would experience even greater risk of negative impacts of climate change and natural disasters.

FUTURE RISK:

- Springfield has a large number of low-income residents, residents of color, and immigrants, who experience socioeconomic and health disparities that will be exacerbated by heat waves, flooding and extreme weather events that will occur more frequently as a result of climate change.
- Residents in the tornado impacted areas of the South End, Metro Center, Old Hill and Six Corners experience many socioeconomic challenges, have not fully recovered from the impacts of the tornado, and are vulnerable to the effects of future natural disasters and climate change effects.
- Children and elderly are susceptible to the negative health effects of climate change natural disasters and also experience high rates of poverty and face other socioeconomic challenges that place them at particular risk.

Climate change adaptation and mitigation actions may buffer residents from the effects of future extreme events. Following the 2011 tornadoes and snowstorm, the city and its residents are still in need to assistance to reach full disaster recovery.

Residents and City officials are committed to addressing climate change and its effects on Springfield.

- More than 3,000 residents participated in setting redevelopment priorities during the ReBuild Springfield planning process (DevelopSpringfield).
- Springfield city government and residents are ready to take action to reduce the impact of climate change. On October 20, 2014, the city Council unanimously passed Resolution 2810 that calls for Mayor Domenic Sarno to create and implement a climate change action plan (City of Springfield).

Sustainable communities are those that are resilient in the face of disaster and look towards the future to plan for today. The city believes that Springfield can become a sustainable community by providing more transportation choices, promoting equitable and affordable housing, enhancing economic competitiveness, supporting existing communities, coordinating and leveraging federal policies and investment, and valuing communities and neighborhoods. (Springfield CDBG – Disaster Recovery Partial Action Plan A)

REFERENCES

Anderson J, Thundiyil J, Stolbach A. Clearing the air: A review of the effects of particulate matter air pollution on human health. *Journal of Medical Toxicology* 2012;8(2):166-175.

Bloniarz D, Beals T, Sovoie D. i-Tree Canopy Assessment of Springfield Neighborhoods. *ReGreen Springfield*. August 2014. Web. February 2015. <<http://regreenspringfield.com>>.

Brook R, Franklin B, Cascio W, Hong Y, Howard G, Lipsett M, Luepker R, Mittleman M, Samet J, Smith S, Tager I. Air pollution and cardiovascular disease: A statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association. *Circulation* 2004;109(21):2655-2671.

City of Springfield. "Community Development Block Grant – Disaster Recovery Partial Action Plan A." November 2013. Web. February 2015. <<http://www3.springfield-ma.gov/>>.

- City of Springfield. "Resolution 2810, IV. Climate Change." *City of Springfield*. October 2014. Web. February 2015. <<http://springfieldcityma.iqm2.com>>.
- Commonwealth of Massachusetts. "Public Safety: Tornadoes." *Mass.gov*. 2015. Web. February 2015. <<http://www.mass.gov>>.
- CBCF (Congressional Black Caucus Foundation). "African Americans and climate change: An unequal burden." *Redefining Progress*. July 2004. Web. February 2015 <<http://rprogress.org/>>.
- Cox, Jennifer et al. "Social Vulnerability to Climate Change: A Neighborhood Analysis of the Northeast U.S. Megaregion." *Union of Concerned Scientists, Northeast Climate Change Impact Study*. November 15, 2006.
- Eze I et al. Long-term air pollution exposure and diabetes in a population-based Swiss cohort. *Environmental International* 2014;70:94-105.
- Environmental Protection Agency (EPA). AirData. Web. February 2015. <<http://www.epa.gov/airdata/>>.
- Frumhoff, Peter C., et al. "Confronting Climate Change in the Northeast: Science, Impacts and Solutions." Synthesis report of the Northeast Climate Impacts Assessment (NECIA). *Union of Concerned Scientists*. 2007. Web. February 2015. <<http://www.ucsusa.org>>.
- Hoerling, Martin. "Preliminary Assessment of Climate Factors Contributing to the Extreme 2011 Tornadoes." *Earth System Research Laboratory: Physical Science Division*. July 2011. Web. February 2015. <<http://www.esrl.noaa.gov>>.
- Ko F, Hui D. Outdoor air pollution: impact on chronic obstructive pulmonary disease patients. *Curr Opin Pulm Med* 2009; 15:150–157.
- Kovats RS, Hajat S. Heat stress and public health: A critical review. *Annual Review of Public Health* 2008; 29: 41-55.
- Lynn K, MacKendrick K, Donoghue E. Social Vulnerability and Climate Change: Synthesis of Literature. *USDA* 2011.
- Massachusetts Department of Elementary and Secondary Education (ESE). n.p. n.d. Web. February 2015. <<http://profiles.doe.mass.edu>>.
- Massachusetts Department of Public Health. "Status of Childhood Weight in Massachusetts, 2011." December 2012.
- Massachusetts Department of Public Health. "High-Risk Communities for Childhood Lead Poisoning, 2005-2010." Web. <<http://www.mass.gov/eohhs/researcher/community-health/environment-health/lead/childhood-lead-poisoning-screening-and-statistics.html>>.
- Melillo, Jerry M., et al. "Climate Change Impacts in the United States: The Third National Climate Assessment." *U.S. Global Change Research Program*. 2014. Web. February 2015. <<http://www.globalchange.gov/downloads>>.

- Moser, Susanne C, et al. "Adaptation to Climate Change in the Northeast United States: Opportunities, Processes, Constraints." *Mitigation and Adaptation Strategies for Global Change*. 2007.
- Mudarri D, Fisk W. Public health and economic impact of dampness and mold. *Indoor Air* 2007;3:226-35.
- National Oceanic and Atmospheric Administration (NOAA). "Massachusetts Tornado Outbreak: June 1, 2011." *National Weather Service Forecast Office*. June 2011. Web. February 2015. <<http://www.erh.noaa.gov>>
- National Resources Defense Council (NRDC). "Air Pollution: Smoke, Smog and Pollen." Web. February 2015. <http://www.nrdc.org/health/climate/airpollution.asp>.
- Oliver. *MassGIS's Online Mapping Tool*. n.p.n.d. Web. February 2015. <<http://maps.massgis.state.ma.us>>.
- Partners for a Healthier Community (PHC). Springfield health equity report: Looking at health through race and ethnicity. *Partners for a Healthier Community*. October 2014.
- Pioneer Valley Planning Commission (PVPC). "Data Atlas by Neighborhood. City of Springfield, MA." *Pioneer Valley Planning Commission*. September 2014. <<http://www.pvpc.org>>.
- Pioneer Valley Planning Commission (PVPC). "Pioneer Valley Climate Action and Clean Energy Plan." *Pioneer Valley Planning Commission*. February 2014. Web. February 2015. <<http://www.pvpc.org>>.
- Pioneer Valley Planning Commission (PVPC). "Pioneer Valley Green Infrastructure Plan." *Pioneer Valley Planning Commission*. January 2013. Web. February 2015. <<http://www.pvpc.org>>.
- Rajagopalan S, Brook R. Air Pollution and Type 2 Diabetes Mechanistic Insights. *Diabetes* 2012;61: 3037-45.
- United Nations Development Programme (UNDP). "Disaster Risk Assessment." October 2010. Web. February 2015. <<http://www.undp.org>>.
- U.S. Census Bureau. American Communities Survey. < <http://www.census.gov/acs/www/> >.
- Wisner B et al. At risk: Natural hazards, people's vulnerability and disasters. London; New York: Routledge. 2nd ed p.134.