Climate Change Vulnerability Assessment

February 2017

City of Cambridge, Massachusetts

The CCVA Report

Part 2

ADDITIONAL RESOURCES

The following reports were produced as part of this project and will provide more information on the topics covered in this report:

- ***Climate Change Vulnerability Assessment (CCVA) Part 2***
- ***Sea Level Rise and Costal Storm Surge Vulnerability Assessment***
    - *Executive Summary*
    - *Appendix 1: Infrastructure & Community Resources Ranking Reports*
    - *Appendix 2: Vulnerable Populations Memorandum*
- ***Sea Level Rise and Costal Storm Surge Projections***
    - *Executive Summary*
    - *Appendix 1: Flooding Maps*
    - *Appendix 2: SLR/SS (BH-FRM) Memorandum*
    - *Appendix 3: Propagated Flooding (ICM-2D) Memorandum*

These technical reports are available online at:

http://www.cambridgema.gov/climateprep

February 2017

Dear Members of the Cambridge Community,

The City of Cambridge undertook its first ever Climate Change Vulnerability Assessment (CCVA) to understand the physical and social implications of our changing climate and to establish a technical foundation to make our community more resilient. The CCVA Part 1 Report, which focused on the risks posed by increasing temperatures and precipitation and this report, CCVA Part 2, which focuses on the risks from rising sea levels and coastal storm surges, together provide a comprehensive picture of our vulnerabilities to climate change if we do not act.

The City of Cambridge accepts the scientific consensus that climate change is unequivocally happening and that our planet is warming. Therefore, Cambridge is incorporating this knowledge into our planning and decision-making to reduce our vulnerabilities and ensure that the city's residents, economy, and quality of life are sustained in the future. While the vulnerability assessment has been completed, it will be a continuous process to update the findings of the assessment with new observations and scientific understanding. The City is committed to using the best available information as we move forward.

We are already seeing progress in our efforts to prepare for climate change. The findings and information from the CCVA Report are being applied to public infrastructure projects and development planning. The Envision Cambridge Plan is incorporating the CCVA results. And the CCVA Report has been a valuable tool in the city's engagement with key stakeholders and property owners in Cambridge and furthered regional cooperation on resiliency. As with CCVA Part 1, the City will continue to publicly share data and analyses with stakeholders and others to help foster efforts in preparing for climate change.

This project would not be possible without the strong support of the City Council through its approval of funding and policy direction. I appreciate the support of the community's residents, businesses, and institutions, which has enhanced the CCVA.

While climate change is a daunting challenge, I am encouraged to see the response of the community and the region. We will continue to treat this matter with urgency and keep working to make Cambridge a resilient city.

Very truly yours,

Louis A. DePasquale
City Manager

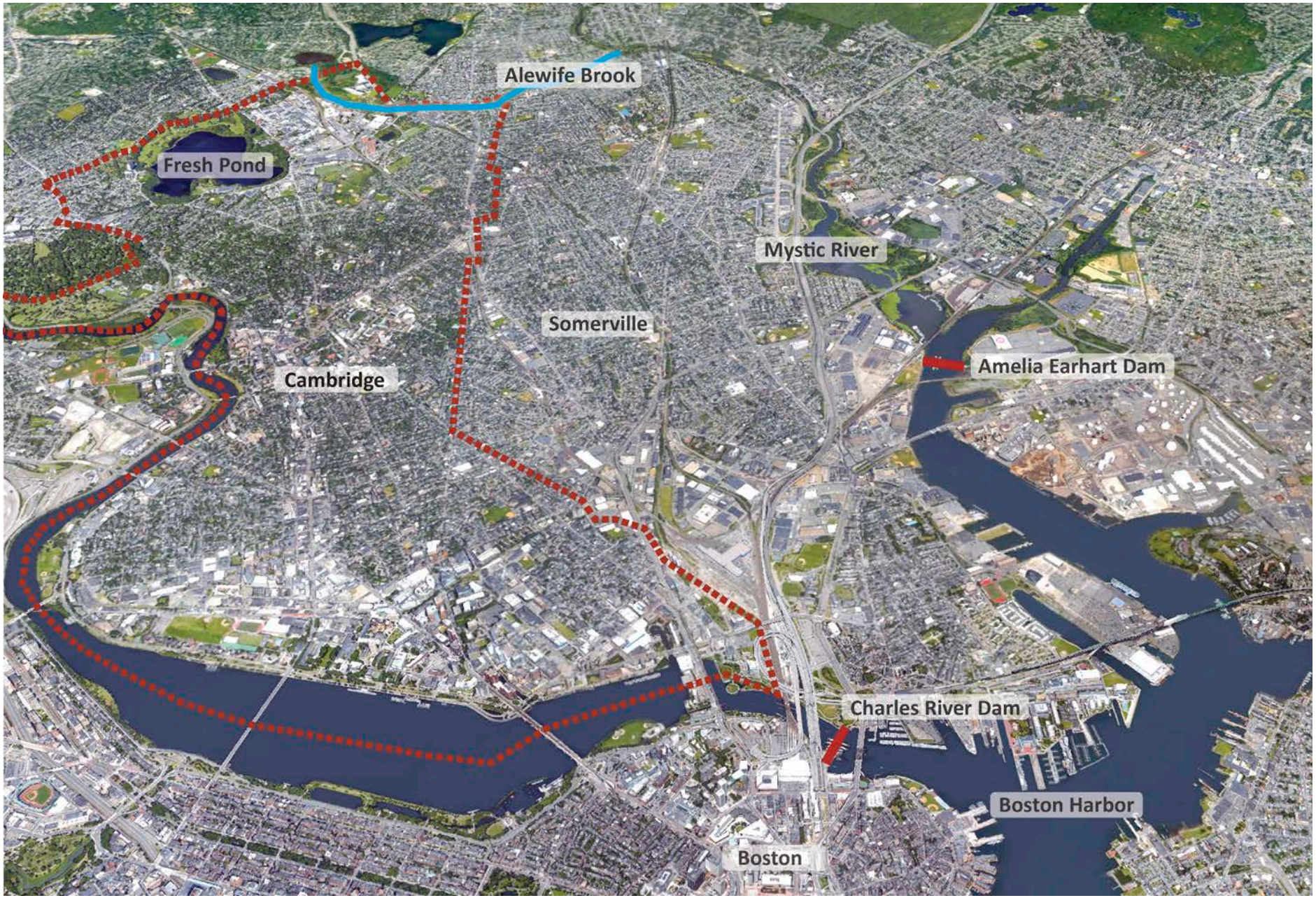

Fig. 1 **Cambridge's relationship to rivers and Boston Harbor.** (Source: Google Maps)

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PURPOSE

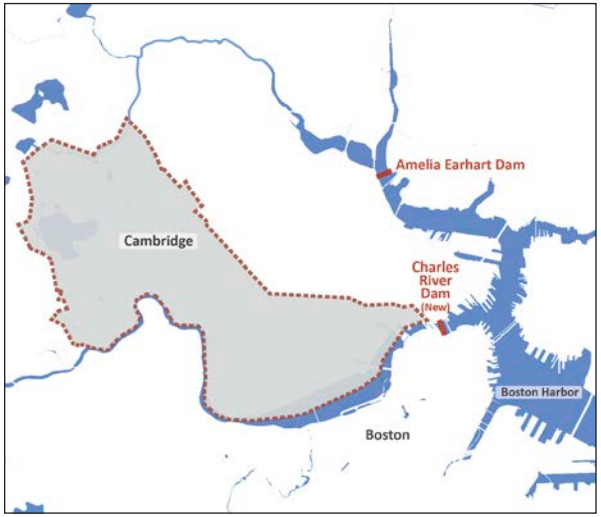

Fig. 2 **Amelia Earhart and Charles River Dams** (Source: Kleinfelder 2017)

As a community located in New England and near the Atlantic Ocean, Cantabridgians have come to expect a certain type of climate and long-term weather patterns. Cold, snowy winters, crisp autumns, wet springs, and summers with some hot and humid days are considered normal for our area. However, emissions of greenhouse gases to the atmosphere from human activities are causing our climate to shift to warmer and wetter conditions. Some changes have already become noticeable as average temperatures have increased, heavy rain and snow fall events have become more intensive, and the ocean is starting to creep inland. The City of Cambridge (City) is conducting a cutting-edge climate change vulnerability assessment (CCVA) to understand the effects of these shifting conditions.

Sea level rise and storm surges (SLR/SS) due to climate change may not pose a direct existential threat to Cambridge in this century. However, as sea level rises, the risk of periodic flooding from storm surges created by major coastal storms such as hurricanes and nor'easters will become significant. There are several factors that contribute to sea level rise including expansion of the water as its temperature rises, changing water currents, and melting of land ice. In Massachusetts, these factors are amplified by local land subsidence, or sinking of the land, at a greater rate than global averages. Large storms, such as hurricanes, can produce storm surges, with higher than normal amounts of water generated and pushed inland. Although Cambridge is connected to Boston Harbor and the ocean by the Charles River and the Alewife Brook, a tributary to the Mystic River, the Charles River Dam and the Amelia Earhart Dam (on the Mystic River) have been able to block surges from coming up rivers. However, as the ocean rises, the protection provided by the dams will diminish over time. This report discusses how SLR/SS can affect flooding in Cambridge. It follows the CCVA Report – Part 1 that addresses the risks posed by increasing temperatures and precipitation. Parts 1 and 2 of the CCVA Report are intended to be complementary.

A central challenge of climate change is that we can no longer look to the weather patterns of the past to guide us in planning for the future. We need to plan for different circumstances, since weather patterns will continuously change. There is not one set of conditions that we can accurately predict. Therefore, the City conducted a "climate stress test" on Cambridge in its present state to find out what might happen in physical and social terms. This assessment on SLR/SS enables us to understand more clearly where action is most needed, and will serve as a part of the technical foundation or baseline for the Climate Change Preparedness and Resilience Plan. The plan will guide the City's response to climate change as we work to reduce our vulnerability and increase our preparedness.

Although the science of climate change gives us strong indications of the direction and range of possible climate shifts, future climate depends on a number of variables. As a result, the City will need to monitor changing conditions and new information, and update the CCVA and the Climate Change Preparedness and Resilience Plan periodically to ensure that the steps to create a more resilient and prepared community are effective.

Key Findings

- The dams will likely protect Cambridge from storm surge flooding until at least 2030. It is projected that the Amelia Earhart Dam will likely be bypassed around 2045 and the Charles River Dam around 2055.
- The City's Alewife-Fresh Pond area will be the most impacted area by flooding from SLR/SS. Flooding may involve salt water, which if it reaches Fresh Pond, could contaminate the City's drinking water supply.
- Storm surge flooding, particularly in the Alewife-Fresh Pond area, will pose risks to populations, buildings, and infrastructure.
- By 2070, storm surge modeling shows that large swaths of the Alewife-Fresh Pond area could be subject to annual probabilities of flooding up to 20 percent or once every five years.
- The volume of flood water associated with a storm surge would be immense. Conventional flood management techniques, such as storage basins and tanks, would be insufficient to deal with the problem.
- Overland flooding from a storm surge into the Charles River appears to be a generally low probability through 2070. However, the raised river level could cause river water to back up through the storm drainage pipes and discharge onto some streets. This is called propagated flooding.
- Cambridge's exposure to SLR/SS is a regional problem. There are regional systems that Cambridge relies on, such as public transit and energy, which could be disrupted in neighboring communities and, thereby, affect Cambridge.

Fig. 3 **Charles River Dam** (Source: New England District, US Army Corps of Engineers, 2015)

Fig. 4 **Amelia Earhart Dam** (Source: MaUSHarbors.com)

KEY FINDINGS

Sea level rise will likely continue for centuries as a result of climate change, therefore, the assumed heights of sea level rise are more a question of timing.

THE "BIG PICTURE"

The threat posed to Cambridge in this century by sea level rise is periodic flooding associated with storm surges caused by major coastal storms such as hurricanes and nor'easters.

Risks from increasing temperatures and precipitation are more imminent than sea level rise and storm surge (SLR/SS). However, flooding caused by SLR/SS is a major concern for the City as it poses a new threat that could cause unprecedented levels of flooding--mostly in the Alewife-Fresh Pond area, East Cambridge and Kendall Square, and low-lying areas of Riverside. (Figure 5). As this occurs, the whole region will be impacted and regional infrastructure will likely fail. Consequently, the City of Cambridge wishes to identify its infrastructure and critical services most vulnerable to SLR/SS in order to develop a resiliency plan which protects its population and businesses, and allows for rapid post-storm recovery.

The Alewife-Fresh Pond area is most impacted since key infrastructure assets of local and regional importance, such as the MBTA Red Line, will likely fail assuming no actions are taken. Key electrical substations, telecom facilities, and major state roadways, mainly the Alewife Brook Parkway and access to Route 2 are also at risk. East Cambridge and Kendall Square areas are also seriously impacted by possible failure of the Red Line, key energy infrastructure, the stormwater system, and roadway infrastructure such as Broadway and access to the Longfellow Bridge. As in Alewife, failure of major infrastructure will impact the abutting population and businesses with negative public safety and economic consequences.

The low-lying areas of Riverside are susceptible to SLR/SS flooding when stormwater backs up in the pipes, because it cannot be discharged to the river by gravity flow as designed. The vulnerable population in this neighborhood is at risk as well as a key electric substation.

Flood events physically damage buildings by disrupting operating systems and damaging infrastructure that they depend on, as well as making areas inaccessible and creating an immediate public safety hazard. This includes blocked access to first responders caused by flood debris. There are also public health consequences associated with flood events as water carries contaminants into buildings and creates conditions for indoor mold growth. Salt water flooding from SLR/SS also has the potential to cause long-term impacts, such as corrosion, to vulnerable local and regional infrastructure including the MBTA Red Line, particularly if such flooding occurs for longer durations. Contamination from salt water or hazardous pollutants could also damage water resources, such the Fresh Pond Reservoir. Further study is being conducted as a part of the City's Climate Change Preparedness and Resilience Plan to determine the potential impacts of salinity from SLR/SS flooding in Cambridge, since fresh and salt water mixing in the Charles River and Alewife Brook basins has not been analyzed in the current report in terms of salt concentration.

The impacts of flooding from SLR/SS go beyond municipal boundaries; if a major storm was to impact Cambridge and the surrounding region, it would certainly have regional consequences for energy distribution, transportation services, and food services, among others. Regional coordination among the cities of the Boston metropolitan area, State and Federal agencies, and key regional stakeholders, such as utility providers and health care organizations, is essential for effective preparedness and resilience planning and implementation.

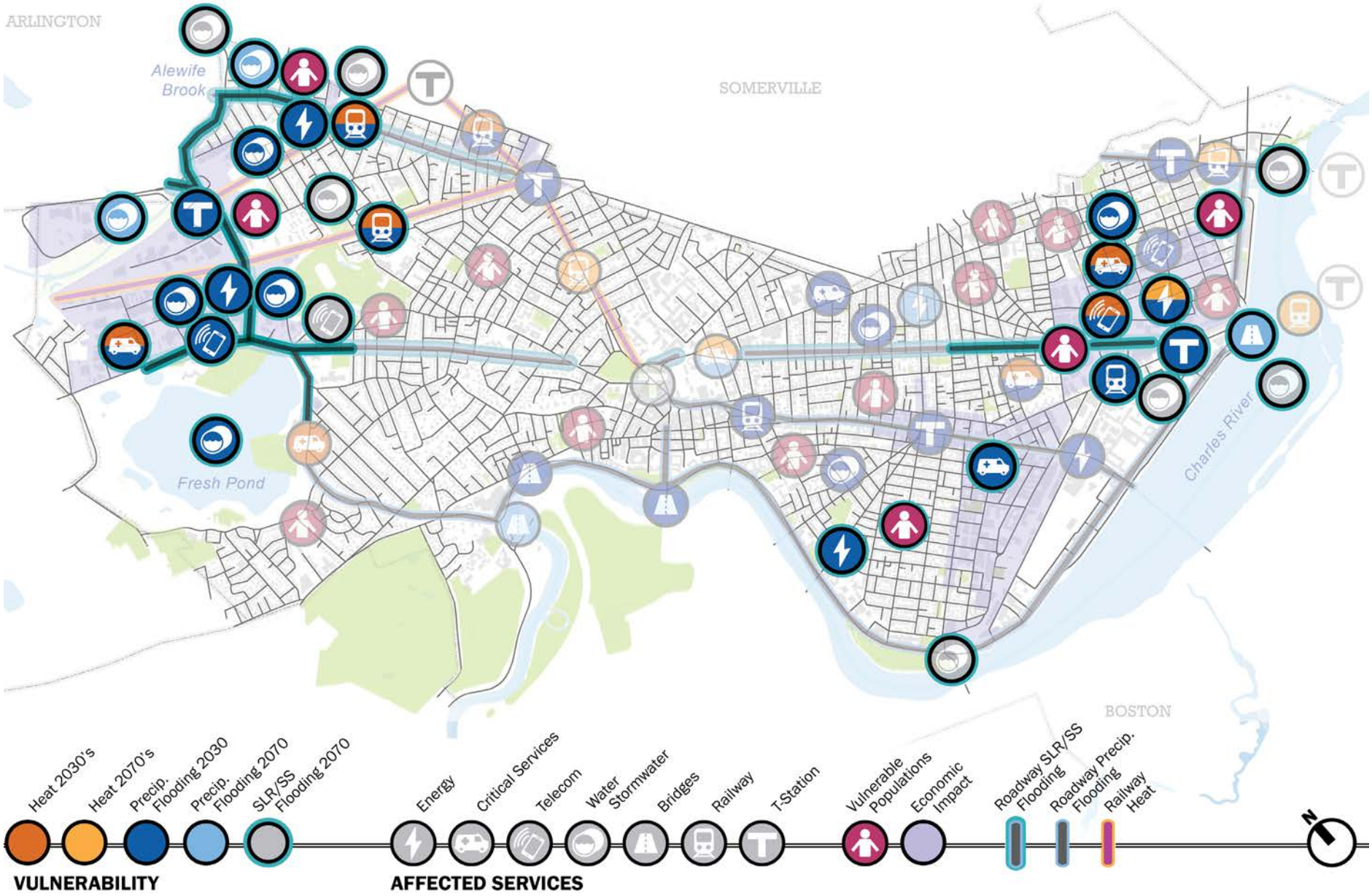

Fig. 5 **Priority Planning Areas Map**
(Source: SLR/SS Risk Assessment, February 2017, compiled with CCVA Part 1 as of November 2015. Kleinfelder for the City of Cambridge.)

CLIMATE SCENARIOS FOR SEA LEVEL RISE AND COASTAL STORM SURGE

Storm surge flooding would be a new phenomenon in the City.

Although Cambridge was once directly connected to the Atlantic Ocean by the Charles River and the Alewife Brook-Mystic River and had salt marshlands in the Alewife area and along the Charles River, the City does not have any historic experience with storm surge flooding. The construction of the Charles River Dam in 1910 and of the Amelia Earhart Dam in 1966 changed the hydrology of the region and effectively protects Cambridge from storm surges under present-day circumstances. But as sea levels rise, the dams' ability to protect the City will be gradually diminished. The combination of rising sea level over time and high-severity storms causing storm surges will increase the vulnerability of both dams.

In the latest Boston Harbor Flood Risk Model, undertaken by the Massachusetts Department of Transportation (MassDOT), the Boston Harbor area sea level is projected to rise almost one foot by 2030 and more than 3 feet by 2070 compared to present levels using 1992 as the base year. The City partnered with MassDOT to extend the model to assess the impacts of sea level rise and storm surge (SLR/SS) in Cambridge for 2030 and 2070. These projections are based on the "Highest" scenario published in the National Oceanic and Atmospheric Administration (NOAA) Technical Report "Global Sea Level Rise Scenarios for the United States National Climate Assessment" (December, 2012). Use of this scenario is a conservative approach considering that recent literature reports predict the rate of sea level rise in the Northeast to be approximately three to four times higher than the global average. The volume of flood water associated with coastal storm surges would be considerable and dwarf flows in the rivers compared to 100-year extreme storms caused by precipitation only.

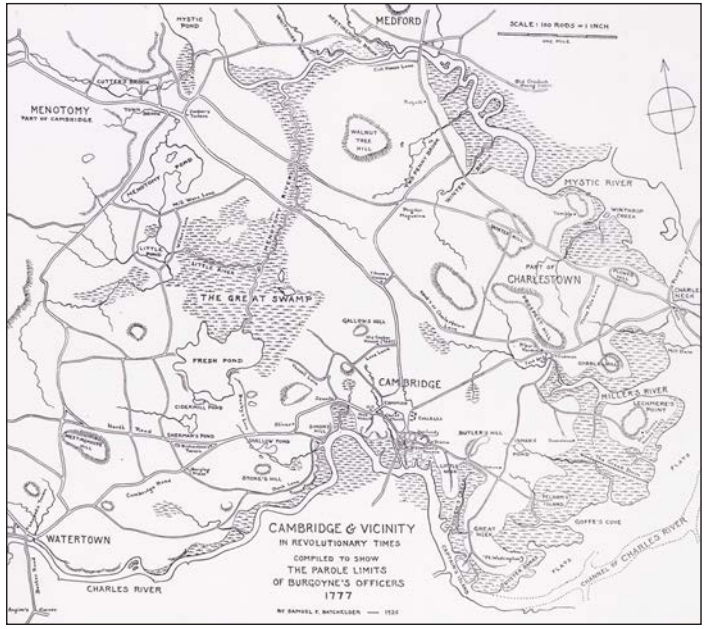

Fig. 6 (Above) **Alewife Brook Channelized in 1911** (Source: Alewife Master Plan, http://www.mass.gov/eea/docs/dcr/pe/alewife/introduction.pdf)

Fig. 7 (Left) **The Great Swamp, 1777** (Source: Samuel F. Batchelder Publisher)

IMPACTS ON DAMS

As previously mentioned, the protection the dams provide to the City from storm surges will gradually decrease depending on the rate of sea level rise. The Amelia Earhart Dam will probably be impacted sooner than the Charles River Dam due to the difference in land topography adjacent to the dams. Both dams are flanked before they are overtopped. A dam is flanked when water goes around one or both sides and is overtopped when water goes over the top of the dam. Assuming sea level rise continues on the "highest" scenario described by the National Climate Assessment, this will likely occur sometime between 2045 and 2060.

A 100-year flood event, or one that has a 1 percent annual probability, could flank the Amelia Earhart Dam by 2045 and the Charles River Dam by 2055. It is estimated that both the Amelia Earhart and the Charles River Dams may be flanked 10 to 15 years before they are likely to be overtopped. The Amelia Earhart Dam is likely to be flanked significantly on the west side of the dam near the Assembly Row area of Somerville (Flood Pathway 1 in Figure 8), as well as by a much larger flood pathway that originates from Chelsea and Everett (Flood Pathway 2 in Figure 8). The Charles River Dam is likely to be flanked directly south of the dam (Flood Pathway 3 in Figure 8), as well as via a significant flood pathway that originates from the Mystic River and advances through Somerville and the Sullivan Square area (Flood Pathway 4 in Figure 8).

The current Federal Emergency Management Administration (FEMA) flood plain map only includes precipitation-driven flooding and does not factor in SLR/SS. The FEMA map is based on historic projections for the impacts of flooding and uses a conservative value of two pumps at the Amelia Earhart Dam and two pumps at the Charles River Dams but does not factor in SLR/SS. The Boston Harbor Flood Risk Model assumed that the available pump capacity at the New Charles River Dam and at the Amelia Earhart Dam was fully utilized meaning all existing pumps at the Amelia Earhart and Charles River Dams are functioning. The extent of flood risk from a storm surge in Cambridge was modeled using projections for 2070 factoring SLR/SS and accounting for each dam to operate at maximum pumping capacity (three pumps at the Amelia Earhart Dam and six pumps at the Charles River Dam).

Results from the 2070 SLR/SS inundation analysis indicate that the flood volume associated with this coastal flooding are orders of magnitude larger than from rainfall events and will quickly overwhelm available storage and conveyance infrastructure. The

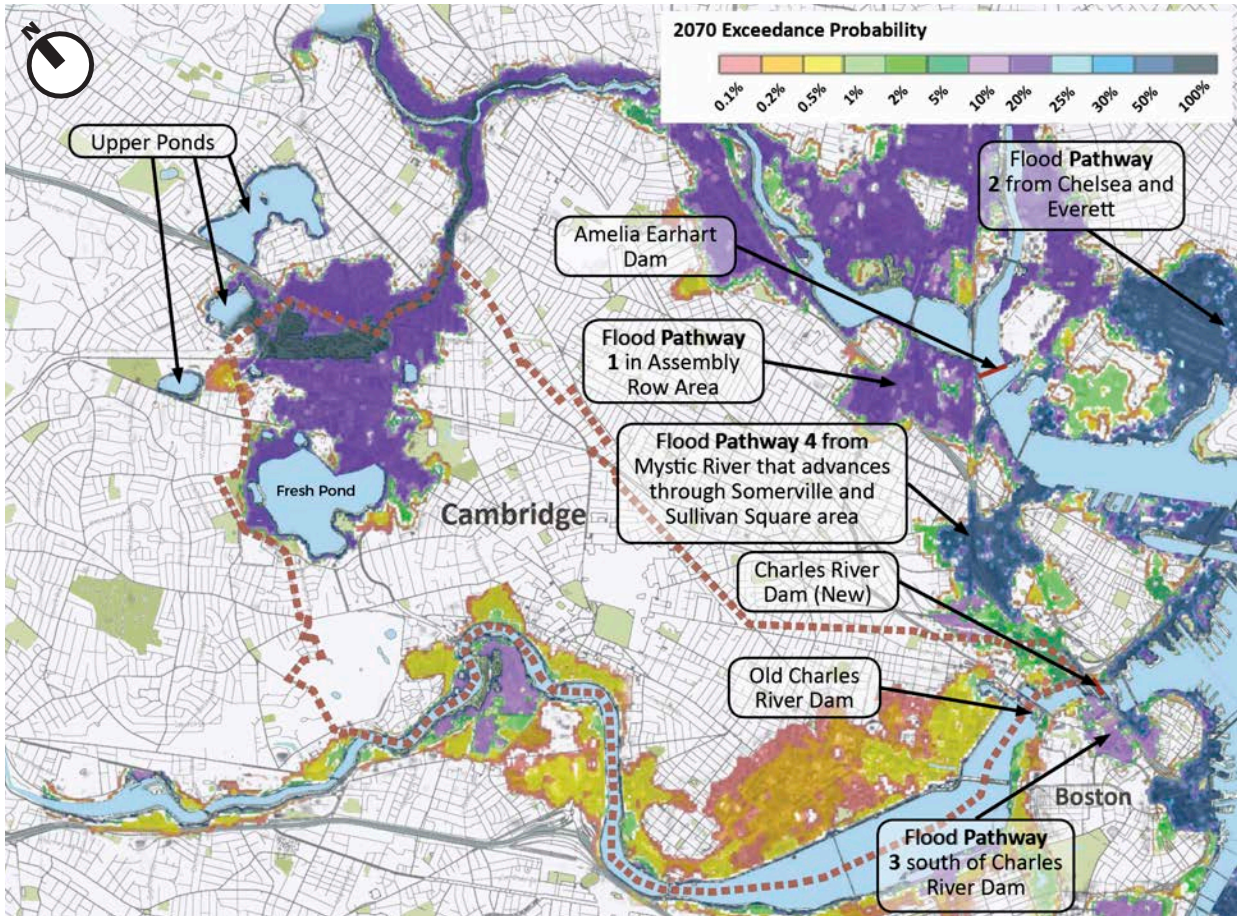

Fig. 8 **Percent probability of flooding by 2070 for City of Cambridge and surrounding areas** (Source: Kleinfelder and Woods Hole Group, February 2017)

Flood volume from coastal flooding will quickly overwhelm the City's available storage and conveyance infrastructure.

pump stations at the dams operating at full capacity will not be able to keep up with the incoming ocean flows to prevent flooding (Figure 8); their ability to pump after the storm will reduce the duration of upstream flooding in Cambridge, if they are not damaged during the event. The Massachusetts Department of Conservation and Recreation, the authority who manages the dams, is currently conducting a vulnerability assessment on the Amelia Earhart and Charles River dams and, when completed, will be factored in the City's climate change modeling.

IMPACTS ON CAMBRIDGE

The results of the Boston Harbor Flood Risk Model are represented by two types of maps in Figure 9, which show the SLR/SS impacts to Cambridge by 2070. The first map shows the extent and depth of flooding in six-inch increments above ground level for the 100-year flood event (1 percent annual probability).

The second map shows the annual percent probability of flooding ranging from 100 to 0.1 percent. The results indicate that:

- The Alewife Brook and its adjacent areas have a 10 to 20 percent annual probability of flooding once the Amelia Earhart Dam is flanked and/or overtopped by flood waters and salt water flows via its historic route; and
- The Charles River and its adjacent areas have less than a 1 percent annual probability of flooding, except in the North Point area where it would approach 5 percent. Although areas of Cambridge in the Charles River basin are not projected to experience major overbank flooding from the 100-year flood caused by SLR/SS in 2070, certain low-lying areas could experience substantial propagated flooding.

Flood risk models help understand the likelihood, extent and depth of flooding from the Charles River and the Alewife Brook/Mystic River under SLR/SS conditions and increased precipitation. The possible extent and depth of flooding in some areas of Cambridge (such as Alewife area and North Point) could be significant under joint conditions of increased precipitation and SLR/SS. This is because the rivers will not be able to discharge the increased flows from extreme precipitation to the Boston Harbor, which will also be at a higher level due to SLR/SS. These conditions could result in extensive damage to certain areas and is a cause of concern to the City.

SLR/SS AND PROPAGATED FLOODING

Sea level rise and storm surge (SLR/SS) events will likely result in a significant increase in river water levels. These increased water levels will then propagate flows upstream through existing outfalls and connected pipes to relief in low-lying areas within Cambridge via catch basins and manholes causing localized flooding even in days with no precipitation.

Increased river levels due to SLR/SS will exacerbate rainfall-derived flooding because the conveyance conduits will be partially or completely full once the rainfall occurs. For the Charles River basin in particular, the piped infrastructure is very sensitive to river water level increases due to the low slope of pipes which limits the ability to drain stormwater. Findings from the SLR/SS model integrated with the City's piped infrastructure model shows that some additional inland low-lying areas in Riverside, The Port and East Cambridge (top map in Figure 9) will be impacted due to flooding back-ups though the pipes as a result of increased water levels in the Charles River from SLR/SS.

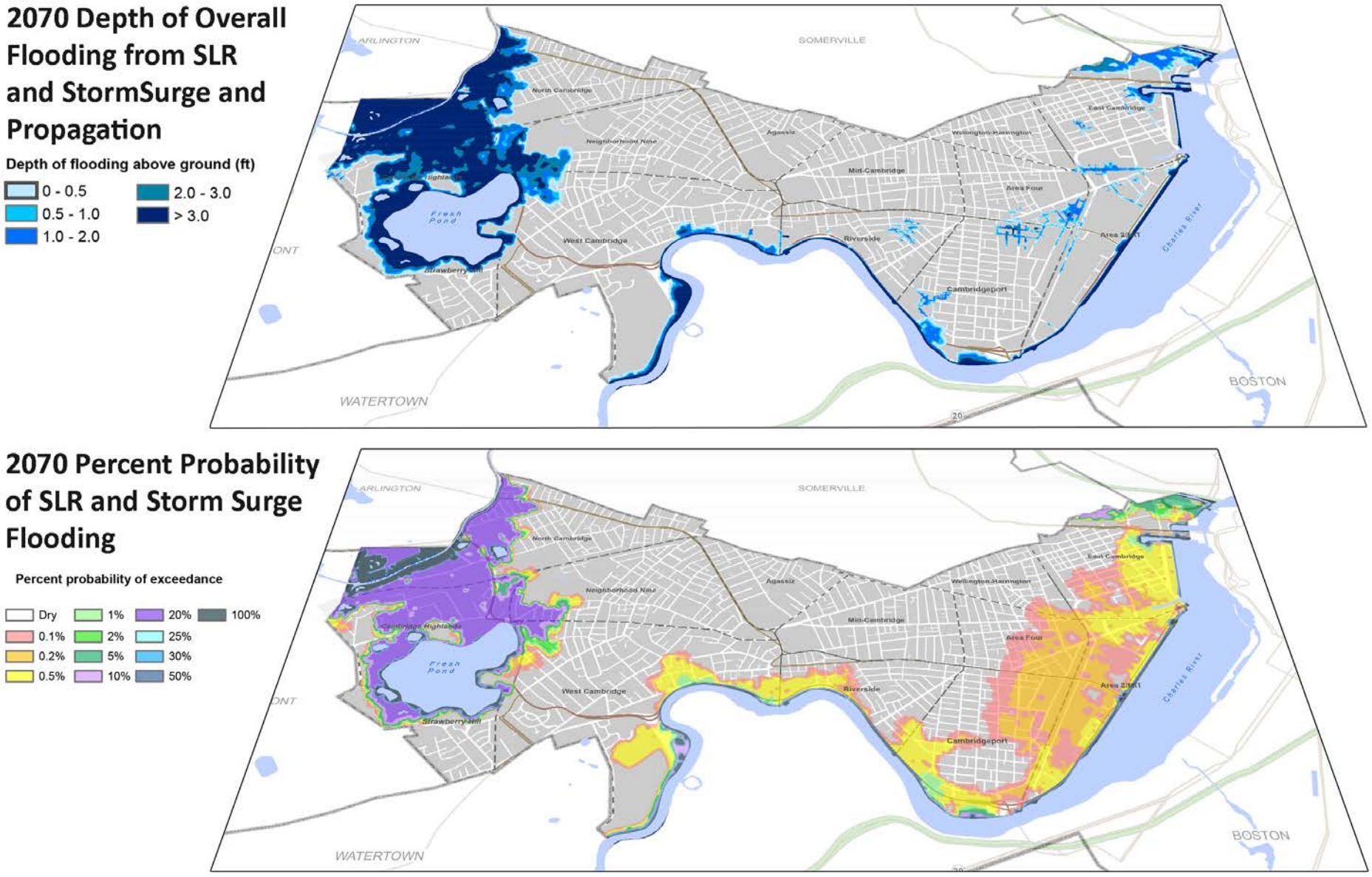

Fig. 9 Top map: **2070 Depth of Flooding from SLR and Storm Surge at 1% Probability** Bottom map: **2070 Percent Probability of Sea Level Rise and Storm Surge Flooding** (Source: Kleinfelder, February 2017, based on WHG MassDOT Boston Harbor Flood Risk Model)

SLR/SS VULNERABILITY AND RISK ASSESSMENT

Salt water flooding can cause long-term impacts to vulnerable local and regional infrastructure due to its corrosive effects.

The vulnerability and risk assessment for Cambridge allows the City to sort its numerous assets, systems, and vulnerable populations to compare the relative vulnerability of each, and identify the most critical and urgent needs. Since resources available to address the vulnerabilities are finite, prioritization is critical to mitigating impacts of sea level rise and storm surge (SLR/SS). The most at-risk elements will become the primary focus of the subsequent Climate Change Preparedness and Resilience Plan. A full description of the vulnerability assessment methods, including how vulnerability and risk were measured, was included in the CCVA Report Part 1. The same methodology was used for assessing vulnerability and risk to flooding resulting from SLR/SS.

Extent and depth of flooding informed by the 2070 SLR/SS scenarios were used in combination with information on the locations of infrastructure, community facilities, and socially vulnerable populations developed in CCVA Part 1 to determine which elements may be exposed to SLR/ SS flooding. For each exposed asset, detailed data regarding the probability and depth of flooding was obtained from the Boston Harbor Flood Risk Model. To build comparable profiles of risk, that data was analyzed based on the City's understanding of the exposed elements' sensitivities to flooding and the resulting consequences for the community if those elements were to be impacted.

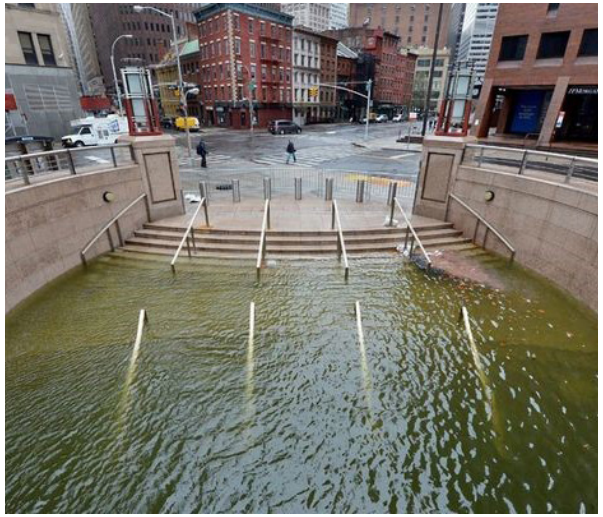

Fig. 10 **Flooded entrance to New York City subway in Sandy's aftermath** (Source: That Hartford Guy)

It is important to note that there are still many unknowns relative to potential damages caused by SLR/SS. Damages tend to increase with longer duration flooding which could occur if the pumps at the Charles River and Amelia Earhart Dams are not able to function properly during and after a storm. The corrosive effects of salt water flooding from SLR/ SS also has the potential to cause long-term impacts to vulnerable local and regional infrastructure, such as the MBTA Red Line. Contamination from salt water or hazardous pollutants could also cause damages to water resources, such the Fresh Pond Reservoir. Further study is being conducted as a part of the City's Climate Change Preparedness and Resilience Plan to determine the potential impacts of salinity from SLR/SS flooding in Cambridge.

CRITICAL INFRASTRUCTURE

Many infrastructure systems are impacted by SLR/SS. Even though it is farthest from Boston Harbor, the Alewife-Fresh Pond area is at greatest risk of storm surge flooding by 2070, and several critical infrastructure assets are located in this area. In addition, there are several critical infrastructure assets in East Cambridge that are also at high-risk from SLR/SS flooding. Most infrastructure assets identified as being at risk for SLR/SS are also at risk for flooding caused by precipitation. However, there are many additional assets including drinking water, stormwater, and combined sewer infrastructure systems that are uniquely at high-risk from SLR/SS flooding and could be completely overwhelmed (e.g. pipes) or damaged (e.g. pump stations) in impacted neighborhoods of the City.

SLR/SS flooding could present a significant challenge for the City's infrastructure and will most likely also have regional implications. Mitigating some of these flood risks will require a coordinated approach for adaptation measures at both the City-wide and regional scales.

The City's energy infrastructure, mainly the electricity and natural gas distribution systems, is at high risk from sea level rise and storm surge flooding in the Fresh Pond-Alewife area. Cambridge relies on the regional grid to be resilient as most of the electricity used in Cambridge is generated outside of the City's boundaries and transmitted into the City through one of two large substations. The North Cambridge Substation is the largest such substation by far and is at high risk of flooding. Similarly, all of the natural

Fig. 11 **Fresh Pond Reservoir** (Source: City of Cambridge)

Even though it is farthest from Boston Harbor, the Alewife-Fresh Pond area is at greatest risk of storm surge flooding by 2070.

gas used in the City is transmitted to the City through a single facility, Brookford Street Take Station, that is also at high risk from flooding. If both these facilities were flooded, the economic and social consequences of energy service disruption would be severe.

Three important critical service facilities in Cambridge are at risk of propagated flooding from SLR/SS: the Police Department Headquarters, the Professional Ambulance Services and Fire Company 2. Given that the City has all police services in the headquarters with no redundancy, this is an asset at high risk.

The telecom system is also impacted by SLR/SS with three critical assets being impacted, including the City Emergency Communication Center housed in the Police Department Headquarters.

The critical water/stormwater natural and infrastructure systems are highly vulnerable to flooding from SLR/SS. The Alewife Brook and neighboring lands, as well as the Fresh Pond Reservoir are at a high-risk of flooding from sea level rise and storm surge. The City has completed several sewer separation projects in the Alewife Brook area but a large portion still remains as a combined wastewater system and is expected to experience significant flooding by 2070. Increased flooding from the combined wastewater catchment areas can cause public health and water quality impacts from the sewage releases. The Broadway and Lechmere areas are also to experience significant flooding by 2070. The pump stations located in Cambridge, such as the New Street pump station or others outside Cambridge but servicing the City, are also at risk of flooding and, therefore, could compromise system operation.

Some of the most severely impacted systems include transportation networks such as roadway and transit systems. All modes of transportation that pass through the Fresh Pond-Alewife area are at high risk from SLR/SS flooding. High risk transit assets include the MBTA Fitchburg Commuter Rail Line, the MBTA Alewife Station, and the MBTA Red Line tunnel from Alewife to Davis and Porter T Stations. High risk roadways include Alewife Brook Parkway, Massachusetts Avenue, and Concord Turnpike. Heavily used bicycle routes are vulnerable as well, including the Minuteman Bikeway and some of those which share the roadways listed above. These vulnerabilities will be analyzed more in depth and adaptation strategies will be developed in the coming Climate Change Preparedness and Resiliency Plan.

		Asset	Heat		Precip. Flood		SLR/ SS Flood
			2030	2070	2030	2070	2070
E	Energy	E.2 North Cambridge Substation					
		E.3 Putnam Substation					
		E.5 Third Street Regulator Station – natural gas					
		E.6 Brookford Street Take Station – natural gas					
C	Critical Services	C.1 Police Department headquarters					
		C.3 Professional Ambulance Services					
		C.5 Fire Company 2					
TC	Telecom	TC.1 City Emergency Communications Center (Police HQ)					
		TC.2 BBN Technologies data hub					
		TC.5 Concord Ave Antenna Tower					
W	Water / Stormwater	W.2 New Street Pump Station					
		W.3 Fresh Pond Reservoir					
		W.4 CAM 004 (Alewife, Separated)					
		W.6 CAM 400 (Alewife, Separated)					
		W.7 Lechmere (Charles, Separated)					
		W.8 CAM 001 (Alewife, Combined)					
		W.9 D46 (Alewife, Separated)					
		W.10 Alewife Brook					
		W.11 Charles River Dam					
		W.12 Charles River					
		W.13 Ames Wadsworth (Charles, Separated)					
		W.14 CAM 002/002A (Alewife Combined)					
		W.15 CAM 401 A/B (Alewife Combined)					
		W.16 Cottage Farm Pump Station					
R	Roadways & Bridges	R.1 Alewife Brook Parkway					
		R.2 Massachusetts Ave					
		R.7 Broadway					
		R.8 Alewife Brook Parkway - intersections with Rt. 2					
		R.9 Concord Turnpike/ Route 2					
		R.13 Longfellow Bridge					
T	Transit	T.1 Alewife Station (Red Line)					
		T.3 Alewife – Davis – Porter (Red Line)					
		T.5 Central – Kendall (Red Line)					
		T.8 Kendall Station (Red Line)					
		T.9 Fitchburg Commuter Rail Line					

Fig. 12 **Most At-Risk Infrastructure Legend**
(Source: SLR/SS Risk Assessment, February 2017, compiled with CCVA Part 1 as of November 2015. Kleinfelder for the City of Cambridge.)

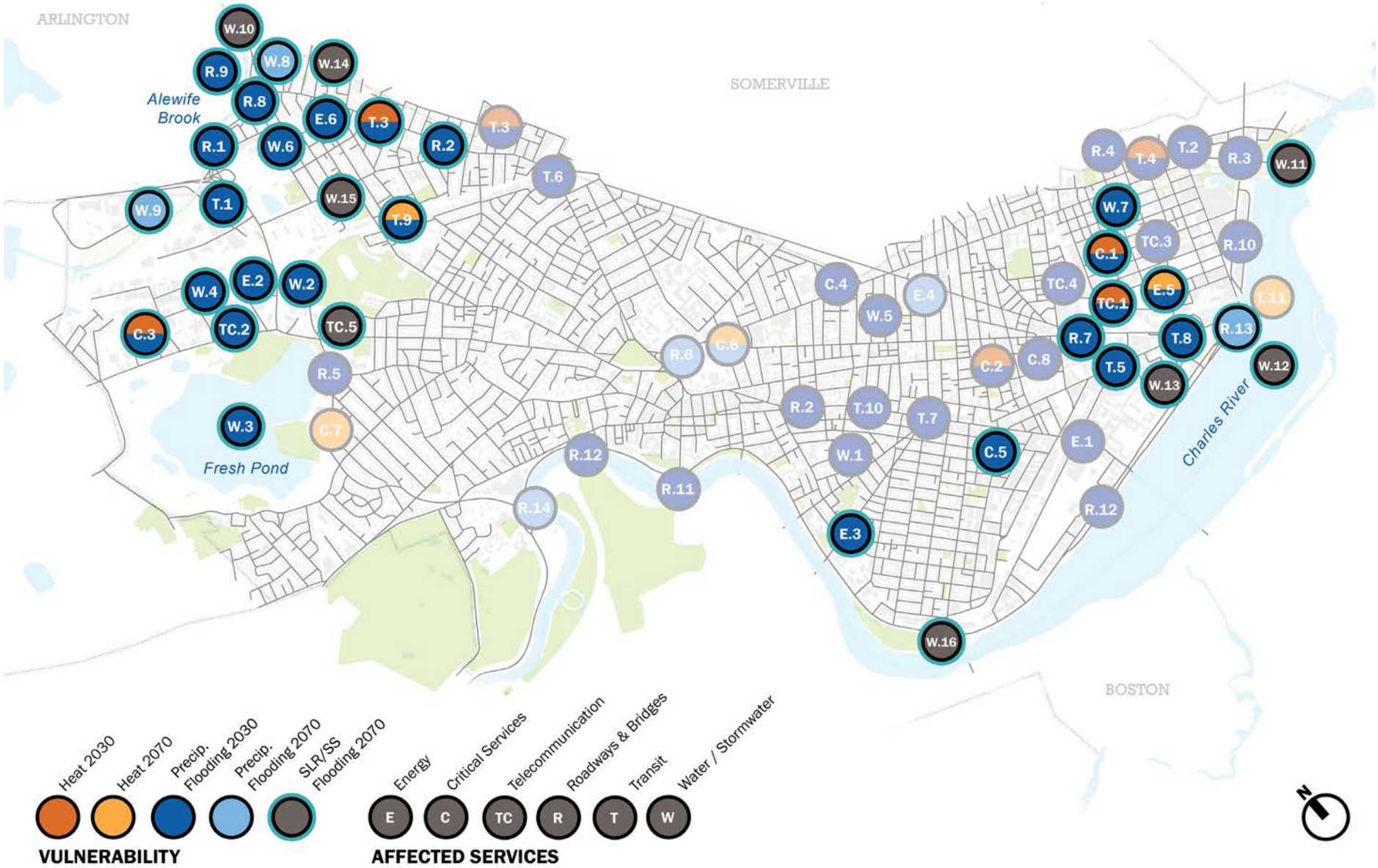

Fig. 13 **Most At-Risk Infrastructure**
(Source: SLR/SS Risk Assessment, February 2017, compiled with CCVA Part 1 as of November 2015. Kleinfelder for the City of Cambridge.)

COMMUNITY RESOURCES AND SOCIAL VULNERABILITY

SLR/SS flooding is likely to affect the entire metro-Boston region, resulting in regional scale disruptions to key services, from transit to social services.

The project team worked with public health scientists, critical service providers, and social service professionals to develop indicators from the 2010 census data for the City's vulnerable populations which are likely to be impacted by increased flooding. This approach enabled the assessment to identify areas with greater concentrations of at-risk residents, understanding that people rely on social and service networks to ensure their safety and comfort. These complex, often invisible, social networks are harder to assess than the built environment and are not completely captured by the geographic or quantitative demographic data used in this study.

Socially vulnerable residents in the Fresh Pond-Alewife area are at relatively higher risk due to the higher probability, larger extent, and higher depths of flooding in this area. Low-lying areas of the Riverside neighborhood and East Cambridge would only experience SLR/SS related flooding in extreme scenarios where water backs up through the City's drainage system.

The City examined the extent to which community resources are at risk of harm from climate stressors as a proxy for measuring harm to social support systems. Figure 14 illustrates that three key community resource facilities have a high risk of flooding impact from SLR/SS in 2070: (H.17) the Neville Center (a nursing and rehabilitation facility) on Concord Avenue, (S.3) the Tobin School and Daycare, both in the Alewife area, and (S.5) the Kennedy/ Longfellow School in East Cambridge. The Tobin School and Daycare is the only one of these facilities with a high probability of being directly exposed to high depths of flooding. Neville Center faces a high risk of becoming temporarily inaccessible due to flooding on Concord Avenue. The Kennedy/Longfellow School could be exposed to flooding due to SLR/SS flood water being propagated through the stormwater drainage system, but only in low probability 100-year storm.

It is important to report, however, that Sea Level Rise and Storm Surge (SLR/SS) flooding is likely to affect the entire metro-Boston region, resulting in regional-scale disruptions to key services, from transit to nutritional assistance. Regional-scale disruptions tend to be more significant with longer recovery time. This tends to have greater consequences for populations already coping with higher levels of social vulnerability. For these reasons and those discussed above, it will be important to prioritize support for socially vulnerable populations through the Climate Change Preparedness and Resilience Plan.

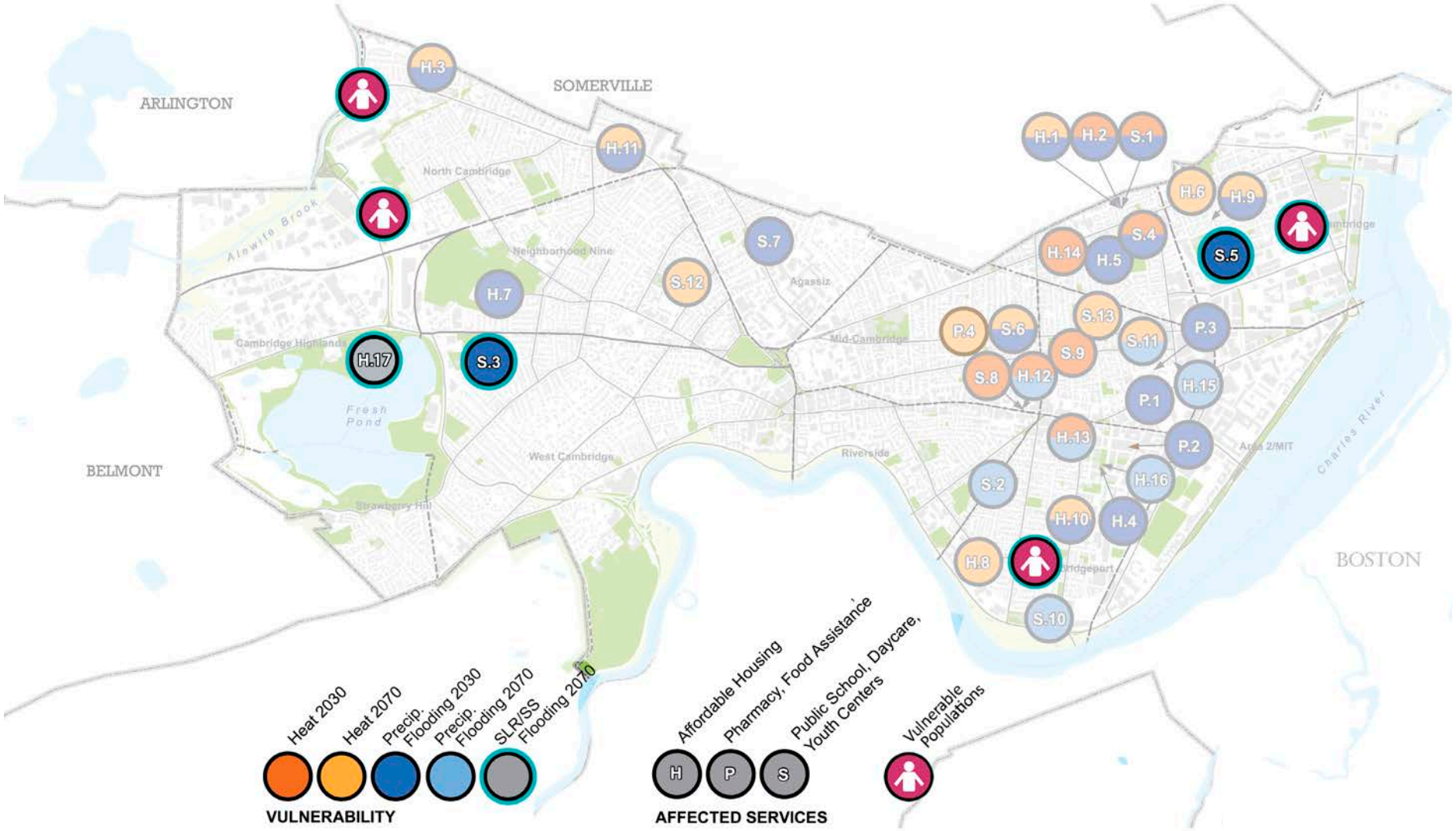

Fig. 14 **Community Resources Priority Areas**
(Source: SLR/SS Risk Assessment, February 2017, compiled with CCVA Part 1 as of November 2015. Kleinfelder for the City of Cambridge.)

NEXT STEPS

Fig. 15 **Flooding caused by King Tide - Seaport** (Source: David Weaver, Boston Globe, October 28, 2016)

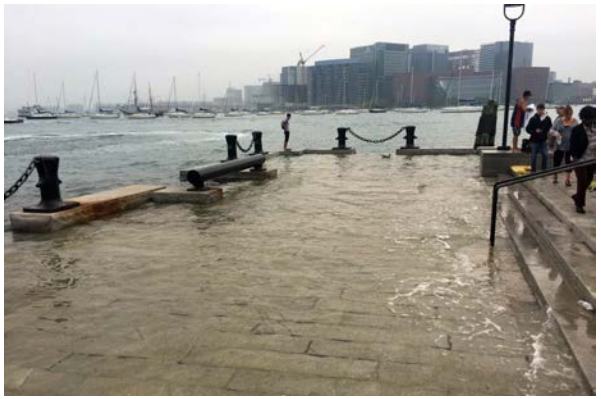

Fig. 16 **Flooding caused by King Tide - Seaport** (Source: Boston Magazine, October 2016)

The publication of this report marks the conclusion of the City's Climate Change Vulnerability Assessment. The assessment will serve as the technical foundation for the development of Cambridge Climate Change Preparedness and Resilience Plan.

The City has begun what is expected to be a two year planning process, starting with a neighborhood level plan for the Fresh Pond-Alewife area. This neighborhood pilot will then be expanded to other neighborhoods that have been identified as being at high risk from impacts of one or more climate change threats (heat, flooding from precipitation, and flooding from sea level rise and storm surge). Ultimately, these neighborhood plans will be folded up into a comprehensive Climate Change Preparedness and Resilience Plan for the City that will also address regional issues beyond the City's boundaries working with State agencies and the Metro Mayors Coalition, a groundbreaking coalition made up of 14 communities in Greater Boston.

The Climate Change Preparedness and Resilience Plan will:

- Develop objectives, strategies, implementation plans, and monitoring metrics to address the priority climate change risks identified in the CCVA;
- Be designed to influence positive change at four scales: regional, City-wide, neighborhoods, and buildings. Early actions will be programmed into the process;
- Engage City residents, agencies, businesses, and institutions so they have ownership of the plan and its implementation;
- Coordinate with other ongoing planning efforts including Envision Cambridge and the Net Zero Action Plan. Beyond Cambridge, City officials will continue to participate in regional coordination initiatives to raise issues of common concern with neighboring communities and State agency partners.

The science of climate change is evolving and the range of possible climate conditions might shift as future climate depends on a number of variables. The City is monitoring changing conditions and will integrate new information when available. The models that helped determined the Sea Level Rise and Storm Surge (SLR/SS) flooding for the City will be updated as new information is available and the CCVA and the Climate Change Preparedness and Resilience Plan will be updated periodically to ensure that the steps to create a more resilient and prepared community are effective.

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READER NOTES

The CCVA Report

Climate Change Vulnerability Assessment

City of Cambridge,
Massachusetts

Part 2