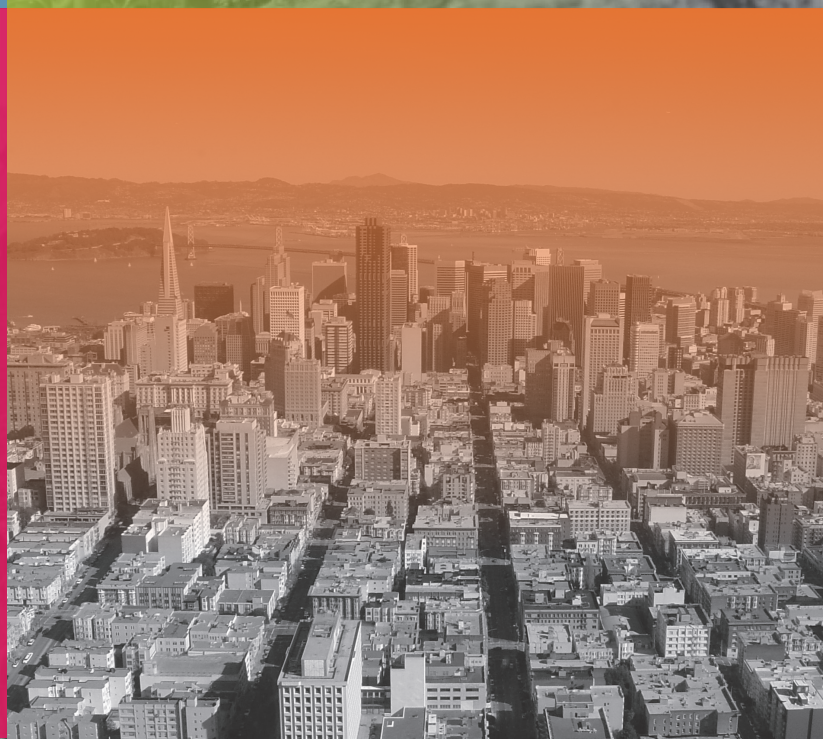


San Francisco's Climate and Health Adaptation Framework 2017

San Francisco Department of Public Health

Table of Contents

This report was prepared by
The San Francisco Department of Public Health
Office of Policy and Planning
Climate and Health Program
Director: Cynthia Comerford

Contact
Cynthia Comerford, Manager
Office of Policy and Planning
San Francisco Department of Public Health
101 Grove Street, Suite 330
San Francisco, CA 94102
Phone: 415.554.2626
cyndy.comerford@sfdph.org

Climate and Health Adaptation Framework Team

Matt Wolff,
Health Data and Geosystems Analyst

Teri Dowling,
Community Planning Manager

Tara Connor,
Community Planning Coordinator

Josh Ollinger,
Research Assistant

Max Gara,
Health Impact Assessment Project Coordinator

John Ribeiro-Broomhead,
Intern

Acknowledgments

San Francisco Department of Public Health (SFDPH) provided funding for staff to participate in this project.

The Centers for Disease Control and Prevention (CDC) provided funding for this project through a Building Resilience Against Climate Effects (BRACE) grant (CDC-RFA-EH13-1305)

Colleagues and organizations were generous with their time and ideas.

1.

Introduction

Climate and Health Adaptation Framework Introduction and Goals

Climate change affects the San Francisco Department of Public Health (SFDPH)'s ability to protect and promote health. Since 2010, SFDPH's Climate and Health Program has worked to address the public health impacts of climate change by developing assessments, outreach materials, plans, indices, and indicators for adaption and resilience efforts. This Climate and Health Adaptation Framework is a compendium of the Climate and Health Program's work over the last several years, and represents a starting point to engage San Francisco's diverse City and community stakeholders on designing solutions that reduce health disparities and climate health impacts. The Climate and Health Adaptation Framework does not represent a final plan, but rather a tool to begin conversations about how best to adapt to the health impacts of climate change.

The goals of the Climate and Health Adaptation Framework are to:

- Increase awareness of climate impacts
- Identify and assess how climate change will impact both public health in San Francisco and the Public Health Department's ability to protect and promote health
- Propose a draft framework of strategies and activities to reduce the health burden of climate change, improve health equity, and develop a culture of climate preparedness
- Propose draft indicators to measure the severity of the climate risks and associated health risks
- Collaborate with internal and external stakeholders on climate change challenges

The Use of the Climate and Health Adaptation Framework and Next Steps

Over the next year, the Climate and Health Program plans to have open discussions with San Francisco City departments and communities, especially in San Francisco's most vulnerable neighborhoods, to further refine the proposed framework and strategies. This discussion will serve as a roadmap for the Department, the City and local communities on how best to prepare the health impacts of climate change. Next steps in this process include:

- The development and implementation of a culturally competent outreach strategy to work with both internal and external stakeholders to cultivate partnerships, further develop adaptation strategies and increase awareness of climate change impacts.
- The development of an implementation and monitoring strategy to document how adaptation strategies and activities are selection, implemented, communicated, and evaluated.
- Preparing the Health Department to become informed about the health implications of climate change in order to educate clients and communities and to incorporate sustainable principles to assist with adaptation of SFDPH infrastructure and operations.

Structure of the Climate and Health Adaptation Framework

The goals and next steps are supported by the framework in this documented which is divided in three sections. The first section is a **Review of Vulnerability Assessments** that summarizes how climate change is projected to impact San Francisco, which health outcomes are associated with the projected climate impacts, and which neighborhoods and communities are most vulnerable to the anticipated health outcomes.

The second section provides a more thorough analysis of specific **Climate Health Risks and Responses**. Eight climate risks were chosen to correspond to the climate risks identified in the Obama Administration's 2016 report, *The Impacts of Climate Change on Human Health: A Scientific Assessment*. For each climate risk, the Climate and Health Adaptation Framework includes an analysis of the baseline conditions of the climate risk in San Francisco, propose draft strategies and activities to respond to that climate risk, and proposes draft climate health indicators to measure health outcomes.

The third section is an **Assessment of Public Health Preparedness** that examines the climate change preparedness of SFDPH staff, internal structure, and infrastructure. The assessment of public health preparedness includes analysis of the results of a survey of SFDPH leadership to better understand current perception of climate change impacts and capacity to implement adaptations, an assessment of SFDPH's strategic planning documents to examine how climate adaptation could be best incorporated, and a climate vulnerability analysis of San Francisco's public health facilitates.

2.

Background

2.1

Structure of the Public Health Department

The mission of *the San Francisco Department of Public Health* (SFDPH) is to *protect and promote* the health of all San Franciscans. SFDPH has long been a pioneer in advancing equity in the public health field from the fight against HIV AIDS to advancing universal health care.

SFDPH is divided into two divisions. The Population Health Division (PHD) protects the health of San Franciscans through consumer safety, health promotion, and the monitoring of threats. The San Francisco Health Network (SFHN) is the City's only complete system of care that includes primary care for all ages, dentistry, emergency and trauma treatment, medical and surgical specialties, diagnostic testing, skilled nursing and rehabilitation, and behavioral health. SFDPH's Climate and Health Program resides within the Department's Office of Policy and Planning. The Office of Policy and Planning supports both PHD and the SFHN to conduct comprehensive strategic planning and policy analysis.

2.2

The Climate and Health Program

In 2010, San Francisco was one of the first local health department's to create a Climate and Health Program in recognition that climate change is one of the biggest threats to health in the 21st century. The program has worked to assess the health impacts of climate change and understand the disproportionate burden on low-income communities and communities of color.

The guiding principles of the Climate and Health Program are:

- **Equity:** Explicitly address vulnerable populations in programs and policies focused on climate health impacts with the goal of reducing health disparities.
- **Community:** Inform and engage communities about the health impacts and health co-benefits associated with taking action to both adapt and mitigate to climate change.
- **Preparedness:** Enhance planning and preparedness for emergency response to protect the public's health against negative impacts associated with climate change-related stressors and disasters.

- **Collaboration:** Work with City departments to ensure climate change is a recognized public health issue and provide guidance to reduce health risks and create more resilient communities.
- **Capacity:** Build the capacity of Departmental staff and programs to monitor health impacts, integrate climate preparedness, and improve climate response.

Priority activities of SFDPH have focused on vulnerability assessments, outreach and education, building partnerships and community resilience, developing tools and indicators, and planning. For details about the Climate and Health Program's past initiatives, please visit www.sfclimatehealth.org. In April of 2016, the Obama Administration released a new report, *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment.* The SFDPH Climate and Health Program was one of approximately one hundred experts in the climate change and public health fields to contribute climate and health data and best practices to the Obama Administration's report. The work of the Climate and Health program has also recognized by the White House and been incorporated into the U.S. Climate Resilience Toolkit and disseminated to communities and decision makers nationally.

2.3

San Francisco Climate Change Engagement

Climate change is a complex threat with cascading impacts that affect the operations of most City departments. San Francisco's response to climate change is interdepartmental in scope and reflects the breadth of climate change's impacts. Multiple City departments are currently engaged in efforts to either minimize the greenhouse gases that cause climate change or prepare for the impacts of more frequent and intense extreme weather events. These efforts include:

- **San Francisco Department of Environment** develops, organizes, and operationalizes San Francisco's Climate Action Strategies to increase renewable energy and electric vehicles, reduce waste and toxics and facilitate environmental justice projects.
  www.sfenvironment.org

- **San Francisco Planning Department** co-chairs the Mayor's Sea Level Rise Coordinating Committee (SLRCC), which is implementing San Francisco's Sea Level Rise Action Plan as a guideline for the long-term reliability and resilience of the City's shoreline development, public spaces, communities, and infrastructure.
  www.sf-planning.org

- **Sea Level Rise Coordinating Community (SLRCC)** is an inter-agency working group comprising of the San Francisco Public Utilities Commission (SFPUC), San Francisco Planning Department, SFDPH, the Municipal Transportation Authority (MTA), Department of Parks and Recreation, City Administrators Office, the Port of San Francisco, and San Francisco International Airport. SLRCC coordinates San Francisco's response to climate change.

- **San Francisco Office of Resiliency and Recovery,** in the Office of the City Administrator developed Resilient SF, an interdepartmental strategy that sets goals, assigns actions to achieve those goals, identifies metrics to evaluate progress, and proposes supporting initiatives to increase City resiliency to earthquakes, infrastructure, climate change, social inequality, sea level rise, and unaffordability.
  sfgov.org/org

- **San Francisco Port** which maintains its own climate action plan to establish baseline carbon emissions, identify opportunities to reduce these emissions, and develop adaptations to increase resiliency. The Port focuses on waterfront resiliency and critical infrastructure such as the sea wall to protect San Francisco from sea level rise.
  sfport.com

- **San Francisco MTA** is developing the San Francisco Transportation Sector Climate Strategy to provide a framework for the reduction of emissions from the transportation sector while also increasing the resilience of the transportation system.
  www.sfmta.com

- **San Francisco PUC** provides drinking water and wastewater services to three Bay Area counties and power to San Francisco City agencies. In this capacity, the department is preparing for the impacts that climate change will have on their infrastructure and the essential services that they supply. In addition, they administer programs that promote solar power, high-efficiency toilets and washing machines, and rainwater harvesting.
  sfwater.org

- **San Francisco Mayor's Office** works to promote sound environmental policy and promote sustainable government administration and supports Citywide initiatives including the City's Climate Action Strategy and the SLRCC.

- **San Francisco International Airport (SFO)** developed a Climate Action Plan to reduce greenhouse gas emissions by developing green buildings and facilities, conserving energy and using renewable energy, and improving air quality. SFO is also involved in Citywide efforts to plan for sea level rise and coastal flood inundation.
  flysfo.com

- **San Francisco Public Works** developed a Climate Action Plan to green the city's infrastructure by reducing energy use through energy efficient lighting and green building, promoting active transportation, conserving water, developing permeable pavement and green landscaping, developing sustainable building standards, and maintaining street trees.
  sfpublicworks.org

2.4

The Climate and Health Adaptation Framework

This Climate and Health Adaptation Framework marks an important shift in the Climate and Health Program's priorities from assessments to action. This framework is a compendium of the Program's work over the last several years and provides a menu of strategies and activities to improve public health through climate adaptation. As San Francisco's largest City department and a leader in public health, SFDPH will play a critical role in helping the City prepare for and adapt

to climate change to protect the health of at-risk populations in San Francisco, and serve as a model to other local health departments.

The Climate and Health Adaptation Framework is organized into three sections.

- The first section **reviews the Climate and Health Program's three vulnerability assessments** to summarize projected climate impacts, connect climate impacts to health outcomes, and recognize at-risk populations. These vulnerability assessments are *Understanding the Risk: An Assessment of San Francisco's Vulnerability to Extreme Heat Events* (2013*), San Francisco Climate and Health Profile* (2015), and *Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding and Extreme Storms* (2016).

- The second section identifies **climate risks and responses**. This section is organized by the climate risks established in the Obama Administration assessment. For each climate risk, we first examine the local baseline conditions of that risk. We then propose potential adaptations and interventions to either support existing City initiatives or develop new initiatives to prepare for the health impacts associated with each climate risks. Lastly, this section highlights climate risk health indicators to measure the severity of the health risks associated with climate change. These indicators come primarily from previous Climate and Health Program vulnerability assessments, but also from reports including *The Center for State and Territorial Epidemiologists' Environmental Health Indicators of Climate Change for the United States: Findings from the State Environmental Health Indicator Collaborative* (2009), and the Agency for Healthcare Research and Quality's Prevention Quality Indicators.

- The third section **examines SFDPH preparedness** and includes an analysis of a 2016 survey of SFDPH leadership perception of climate change and capacity to implement adaptations, an assessment of SFDPH's strategic planning documents to examine how they can best incorporate climate adaptation, and a spatial analysis of vulnerability of San Francisco's public health facilities.

Next Steps

The Climate and Health Program is currently drafting a Climate and Health Outreach Plan. The Climate and Health Outreach Plan will detail approaches and activities to work with City departments and San Francisco communities to select and refine adaptation strategies that meet programmatic goals, respond to the concerns of vulnerable communities, and coordinate with existing City initiatives. After the roll out of the outreach plan, the Climate and Health Program will develop a five year strategy to outline activities to implement this Plan, including monitoring and evaluation of adaptations to reduce the negative health impacts of climate change. The Climate and Health Program hopes a mix of community engagement and work by City staff will provide a proactive flexible approach to prepare the Department and the City for the health impacts of climate change. The Climate and Health Program's goal is to engage in open and ongoing dialogue with the diverse members of the community as well as a wide variety of public and private sector stakeholders. This input will help provide and maintain strategic direction, performance improvement systems and empower communities and ensure the program's goals reflect the residents being served.

3.

Review of Vulnerability Assessments

3.1

Climate Impacts Summary

Dependence on fossil fuels has increased the concentration of carbon dioxide and other greenhouse gases in the atmosphere, causing global temperatures to rise and weather to become more varied and extreme. Global climate change has local impacts. For San Francisco, these impacts include higher temperatures and more extreme heat days, sea level rise and more extreme storms, severe droughts, and poorer air quality. Technical information on climate projection sources and methodology can be found in the technical addendum on page 44.

Climate scientists project **higher temperatures, more extreme-heat days,** and **longer heat waves**. San Francisco is a temperate city with housing and infrastructure built for a cool coastal climate. Average yearly temperatures are expected to increase between 3.3°F and 5.5°F by 2100, while annual extreme heat days are expected to increase from about five currently, to 15-40 by 2050, and up to 90 by 2100. An extreme heat day is any day when the maximum temperature reaches the 98th percentile of all temperatures for that particular region. In San Francisco, an extreme heat day is any day that surpasses 85°F. Extreme heat events are the number one cause of weather-related deaths. Heat waves are three sequential extreme heat days and are also expected to increase.

San Francisco is surrounded by water on three sides, the Pacific Ocean to the west and the San Francisco Bay to the North and East, and is vulnerable to flooding, often called flood inundation. San Francisco is vulnerable to both coastal flood inundation and precipitation-related flood inundation. **Coastal flood inundation** occurs along the shoreline by the combined impact of **sea level rise** and **extreme storms**. As the atmosphere warms, both the melting of the polar ice caps and the thermal expansion of the oceans will cause sea levels to rise. Although water levels in the San Francisco Bay and along the Pacific shoreline rose around eight inches over the past century, the rate of increase is expected to accelerate.

Because greenhouse gas emissions could either increase or decrease over the next decades, sea level rise projections include both *most likely* and *upper range* projections. Most likely projections assume current greenhouse gas emissions and ice melt patterns accelerate at a constant rate. Upper range projections assume increased acceleration of greenhouse gas emissions and ice melt. The Climate and Health Program will use upper range projections to coordinate with existing Citywide planning efforts (Table 1).

Additionally, climate models predict coastal storms to become more frequent and extreme. These extreme storms are associated with high storm surge and heavy precipitation. In San Francisco, a 100-year extreme high tide roughly equates

42 inches of coastal flood inundation on top of the regular tidal water levels. The combined impact of sea level rise and storm surge may increase flooding, storm damage, pollution and pose threats to coastal infrastructure, such as roads, bridges, piers, and waterfront property.

Table 1

Climate Change Flood Projections

	Sea Level Rise Projections		Sea Level Rise + Storm Surge	
Year	**Most Likely**	**Upper Range**	**Most Likely**	**Upper Range**
2050	11 inches	24 inches	53 inches	66 inches
2100	36 inches	66 inches	78 inches	108 inches

Precipitation-related flood inundation is flooding in the City's interior caused primarily by heavy rainfall and disruptions to the stormwater/wastewater transit network. San Francisco precipitation levels have historically fluctuated between wet and dry extremes. Climate change will amplify this trend. California currently receives 35 – 45 percent of its annual precipitation from discrete extreme storm events. By the end of the century, these storms are expected to provide nearly 50 percent of California's precipitation. As the amount of rain that falls during a single extreme storm event increases, the City's stormwater management network may be overwhelmed, resulting in flooding along San Francisco's underground creeks, natural drainage basins, and areas where stormwater management capacity is exceeded.

In dry years, when coastal high-pressure systems do not dissipate during winter months, California could be subject to frequent and severe **droughts** like the 2011 -2015 drought that reduced state reservoirs to less than 30 percent of capacity.

Climate change is anticipated to have varied and complex effects on global and regional atmospheric patterns, which affect local **air quality**. Ground-level ozone levels will be influenced by climate change. Although San Francisco is on the lower end of the pollution spectrum compared to other urban areas, the City should expect a small increase in ozone levels as a direct result of climate factors and the City may experience short-term spikes in ozone levels. The effects of climate change on particulate matter (PM2.5) are less certain than they are with ozone, mainly because PM levels are strongly affected by local weather conditions. However, atmospheric stagnation, the absence of wind and vertical mixing, is correlated with increased PM levels, and is predicted to increase as a result of climate change. In addition, less rainy seasons that contribute to drought conditions have already negatively impacted Bay Area air quality. Longer fire seasons and more intense fires will mean higher levels of ozone and PM throughout much of California, including San Francisco and the Bay Area. The entire West coast can also expect to continue to receive a significant amount of ozone and PM2.5 pollution from Asia transported through the atmosphere. One study found as much as 29% of lead particulate registered in Bay Area air monitors comes from China and is likely accompanied by other forms of particulate.

3.2

Health Impacts Summary

The pathways that lead to human health impacts are both direct and indirect.

- **Direct** effects are health impacts resulting directly from the hazard event. These impacts include heat stroke from extreme heat, lacerations and non-fatal injuries from extreme storms, or respiratory illness from poor air quality.

- **Indirect** effects are downstream health impacts that include food insecurity caused by poor agricultural output in a particularly low precipitation year, health effects associated with income loss and job insecurity due to flood inundation, and increased rates of anxiety and depression as a result of isolation during extreme heat events.

Direct impacts of extreme heat includes increases in heat-related illnesses such as **heat-stroke**, **dehydration,** and heat-related mortality such as **heart disease**. High temperatures can also exacerbate the impact of pre-existing conditions such as **diabetes** and **renal disease**. Higher temperatures and stagnant air also worsen San Francisco's air quality and lead to higher rates of **respiratory illness**, **asthma**, and **allergies**. Indirect impacts of extreme heat include exacerbating **behavioral health** problems. The increase in heat-related hospitalizations and emergency room visits will strain the City's health care infrastructure and affect care for all San Franciscans. Heavy air conditioning usage can tax the City's electrical grid and threaten power outages, and increase energy costs for San Franciscans.

Health impacts from cold snaps include **hypothermia**, increased **mucus secretion and cough**, **shortness of breath**, and increased risk for **influenza** and other diseases. Homeless and housing insecure San Franciscans experience elevated risk. Cold snaps also indirectly impact San Francisco's indoor and outdoor air quality, which aggravates pre-existing respiratory conditions such as **asthma** and **bronchitis**.

Direct impacts of sea level rise and extreme storms include an increase in **fatal and nonfatal injuries** and **waterborne disease**. Standing water or failure of the sewage, wastewater, or drinking-water infrastructure may cause waterborne illnesses, such as bacteria, viruses, and parasites to flourish. Flooding may also cause the release of household toxic materials into the soil if they are being stored in areas such as garages and basement. Household dampness caused by both coastal and precipitation-related flood inundation can increase mold growth and lead to increased rates of **respiratory illness, asthma,** and **allergies**. Flood inundation can also indirectly impact public health. Flood inundation can affect the transportation network, which impedes access to home, work, medical care, pharmacies, and other facilities and contributes to automobile, bicycle, and pedestrian collisions. Extreme storms can cause power outages which impact those dependent on elevators or electronic medical devices. A prolonged power outage can increase exposure to **foodborne illness** through failures in refrigeration. Indirect effects of sea level rise and extreme storms also include individual and municipal economic losses and housing shortages due to dislocation, reduced supply, and unaffordability. **Income loss** exacerbates behavioral health stressors, food insecurity, and social isolation.

Higher concentrations of ground-level ozone will increase rates of asthma attacks, shortness of breath, coughing, chest-tightness, irritated mucus membranes, pulmonary inflammation, and respiratory illnesses and diseases. PM2.5 concentration can exacerbate **asthma, bronchitis**, and acute and chronic **respiratory disease**. These ailments will especially affect children because their lungs are still developing, and because their faster breathing rates increase their exposure to pollutants. In adults, worsened air quality from ground-level ozone or other pollutants could increase rates of chronic lung disease such as emphysema and premature death.

Pooled water from flood inundation can provide habitat for disease vectors while increases in temperature may accelerate the spread of **rodent and vector-borne disease,** such as West Nile and other mosquito-borne viruses and asthma and respiratory illness.

Drought strains the state's water supply, disrupts California's agricultural output, contributes to wildfires that worsen air quality, and could result in an increase in the price of produce, causing **income loss** and **food insecurity**. Less rain could allow respiratory irritants (e.g. particulate matter) to stay in the air longer. Drought conditions and high temperatures could also expand the blooming season for ragweed and other allergens, increasing resident exposure to respiratory irritants that cause **allergies**, **asthma**, and **respiratory illness**.

Extreme weather events, such as heat waves, storms, and droughts, may decrease San Franciscan's access to healthy food. **Food insecurity** is linked to cognitive developmental deficits, behavioral and psychological dysfunction, and increased frequency of headaches, stomachaches, colds, ear infections, and other illnesses in children and increased risk of chronic disease and mental health problems in adults.

All climate hazard events have impacts on **mental health**. These events can have the immediate effect of establishing or exacerbating anxiety reactions such as post-traumatic stress disorder and long-term effects of establishing or exacerbating instances of depression or other anxiety disorders. Mental health effects of climate hazard events are not limited to the disaster itself. Social isolation caused by displacement, limited mobility, and loss of people or property can lead to depression, distress, or generalized anxiety.

3.3

Vulnerable Populations Summary

Although climate change and climate change-related health outcomes will impact all San Franciscans, not all San Franciscans will suffer these impacts evenly. The degree to which a person is sensitive to climate exposures depends largely on established social, political, environmental, or economic inequalities. This is referred to as the **climate gap**. Factors that can affect the impact of climate change and climate change-related health outcomes include **socioeconomics and demographics** such as age, race, and income, **environmental factors** such as tree cover and air pollution, **exposure to hazards** such as flood inundation, storm surge, air pollution, and extreme heat risk, **infrastructure factors** such as housing quality, overcrowding, and air conditioning, access to neighborhood goods and services, transportation access and mobility, and **pre-existing health conditions**.

These connections will be explored further in section 4.1.1.

4.

Climate Risks and Responses

This section is organized by climate risk. Climate risks include both climate change impacts and health outcomes. Climate risks were chosen to correspond to the risks identified in the Obama Administration's 2016 report, *The Impacts of Climate Change on Human Health: A Scientific Assessment.*

Climate Risks

a. Climate change will have the largest health impact on **vulnerable populations.**

b. **Extreme heat** can be expected to cause an increase in the number of premature deaths.

c. **Extreme storms**, **sea level rise**, and **flood inundation** will have cascading direct and indirect impacts on public health, housing, and city services.

d. **Air pollution** will likely increase, worsening allergy and respiratory conditions.

e. Higher temperatures, sea level rise, extreme storms and flooding increase the risks of **waterborne illnesses.**

f. Climate change, including rising temperatures and changes in weather extremes, is expected to increase the **exposure of food to certain pathogens and toxins.**

g. Warmer winter and spring temperatures are projected to lead to changes in vectors and **vector-borne disease.**

h. Rising temperatures, extreme heat events, and changing precipitation patterns are projected to exacerbate **drought** conditions in California.

i Assigned to each climate risk are: **Baseline Conditions, Strategies for Consideration:** Themes across Literature Review, Best Practices and Interviews, **and Climate Risk Health Indicators.**

Baseline conditions summarize the current impact of the climate risk on San Francisco. Baseline information is primarily derived from the Climate and Health Program's vulnerability assessments. Additional sources are identified by climate risk in the Citations Addendum on page 44.

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews are interventions and adaptations that were selected after a systematic review of national and international best practices, academic research, and interviews with departmental stakeholders. This framework adopts a holistic definition of interventions and adaptations which reflects public health's role in addressing climate change. From a health perspective, an intervention is an outward-facing, discrete action that aims to interrupt the exposure-health outcome pathway. An adaptation is an action that enhances the health department's ability to address the health impacts of climate change. These activities include engagement and outreach, facilitation and interdepartmental collaboration, deployment of data tools and innovative technologies, curriculum development and training, and planning and program development. Interventions and adaptations included under "Strategies for Consideration" does not necessarily signify that strategies are not already in progress, but may just highlight an opportunity for a health lens and additional collaboration.

We developed a screening matrix tool to systematically prioritize adaptations and interventions that aligned with the Climate and Health Program objectives. The screening matrix prioritized activities based on anticipated localized climate change impacts, consequent health impacts and subsequent vulnerable populations, empirical evidence of interventions and the effectiveness and feasibility of implementation in San Francisco. More information about the development of the screening matrix tool and detailed information about the interventions and adaptation screened can be found online at *http://bit.ly/2l1xRL9.*

In order to develop an evaluative framework for each intervention, we have also identified **climate risk health indicators** that measure health impacts and community resiliency associated with climate change-related hazard events.

4.1

Climate change will have the largest health impact on vulnerable populations.

The **climate gap** articulates that the severity of climate-related health outcomes are stratified. The degree of health impact depends on socioeconomic and demographic factors, environmental factors, hazard exposure, infrastructure factors and pre-existing health conditions. This section will examine what this means for San Francisco.

4.1.1

Baseline Conditions in San Francisco

San Francisco is a wealthy city, yet this wealth is not evenly distributed and many San Franciscans are economically threatened by low wages and a high cost of living. San Francisco has the highest level of income inequality in California. While household income for white families is over $100,000, household income for Black/African American families is $30,000 a year. Income is associated with many adverse health outcomes.

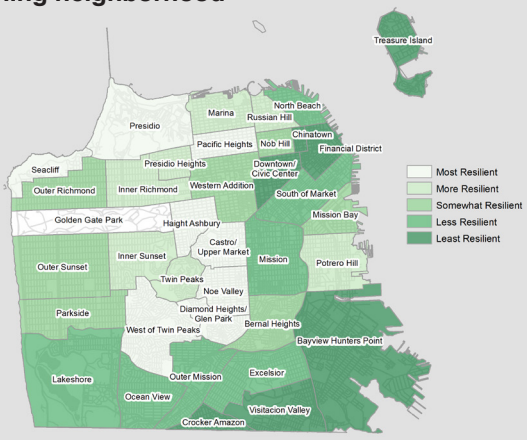
Many San Franciscans do not have secure, affordable, and quality housing. There are over 7,500 homeless people in San Francisco. This population is extremely vulnerable to the health impacts associated with extreme weather events. As rental prices have increased by 22 percent between 2000 and 2012, evictions have also increased. Neighborhood turnover affects social cohesion, which is closely associated with community resiliency. Housing instability is associated with stress, which can lead to other negative health outcomes.

San Francisco has an aging population. Elderly populations are at an increased risk for many health outcomes associated with extreme weather events, including cardiovascular illness and respiratory disease. The proportion of adults 65 and over in San Francisco is projected to increase from 13.7 percent in 2010 to nearly 20 percent in 2030.

Because these socioeconomic and demographic factors, infrastructure and housing quality factors, environmental factors, and pre-existing health factors can change the impact of climate change, the SFDPH established the Community Resiliency Indicator System (Figure 1). The Community Resiliency Indicator System measures climate change vulnerability and resiliency among San Francisco neighborhoods to identify vulnerable neighborhoods to collectively plan climate interventions that will increase the City's adaptive capacity.

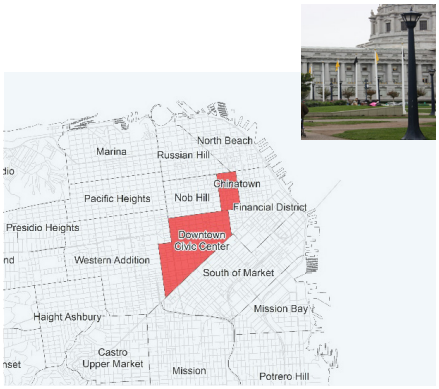
Figure 1

San Francisco community resiliency, by 2012 planning neighborhood



More information on the methodology used to develop the community resiliency indicators can be found in the Technical Addendum on page 44.

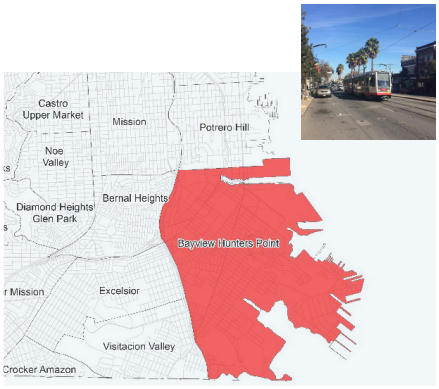
Analysis of the community resiliency indicators identifies **Bayview/Hunter's Point, Chinatown, Downtown/Civic Center, the Financial District, Mission Bay, SOMA, and Visitation Valley** as most vulnerable. This next section highlights three of the aforementioned neighborhoods which have been the most impacted. Information for all San Francisco neighborhoods can be found at *www.sfclimatehealth.org.*



Neighborhood Highlight:

Downtown/Civic Center and Chinatown

The high density downtown neighborhoods of **Downtown/Civic Center** and **Chinatown** are among San Francisco's most vulnerable to the health impacts of extreme heat. These neighborhoods have high concentrations of impervious surfaces that absorb heat, low percentage of tree coverage that provide shade, and heavy traffic volume that both generate heat and worsen air quality. These two neighborhoods are also home to some of the most vulnerable populations in the city. They have the highest percentage of low-income families and disproportionately large concentrations of elderly residents, non-English speakers, and residents with physical disabilities. The Tenderloin neighborhood, part of Downtown/Civic Center, is home to much of San Francisco's homeless population. Chinatown and Downtown/Civic Center are the two neighborhoods with the highest concentrations of housing code violations, which is an indicator of poor housing quality.



Neighborhood Highlight:

Bayview/ Hunters Point

The **Bayview/Hunters Point** neighborhood is especially vulnerable to hazard events. Located along the City's southeastern shoreline, much of the neighborhood sits adjacent to the Bay on flood plains and is vulnerable to flood inundation caused by sea level rise, storm surge, and precipitation. The neighborhood has a lower employment rate than any other neighborhood in San Francisco and a higher concentration of low-income families than any neighborhood besides Chinatown and Downtown/Civic Center.

Unlike Chinatown and Downtown, Bayview/Hunters Point has fewer public transit options and fewer healthy food options. Low voter turnout and a high crime rate in the Bayview/Hunters Point demonstrate a necessity to increase social cohesion to enhance community resilience.

Neighborhood Highlight:

South of Market (SOMA) and Mission Bay

SOMA and Mission Bay are neighborhoods in the midst of transition. Historically industrial, these neighborhoods have recently been the site of high density residential developments, high-rise office buildings, and corporate and university campuses. While the City is actively preparing for this rapid rate of growth, these changes will create new challenges in everything from the delivery of healthcare to the transportation network. These neighborhoods have significant risk of exposure to extreme weather events. They sit along the City's eastern shoreline above underground creeks and are vulnerable to flood inundation in extreme storms. These neighborhoods are also vulnerable to extreme heat. SOMA has among the City's highest percentage of impervious surface and lowest percentage of tree cover. Crisscrossed by freeways and heavy-traffic arterials, these neighborhoods are in air pollution exposure zones. SOMA is also home to a large concentration of the San Francisco's homeless population, low-income residents, and residents with a physical disability.

4.1.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews:

Climate Risk 1: Climate change will have the largest health impact on vulnerable populations.

Interventions & Adaptations

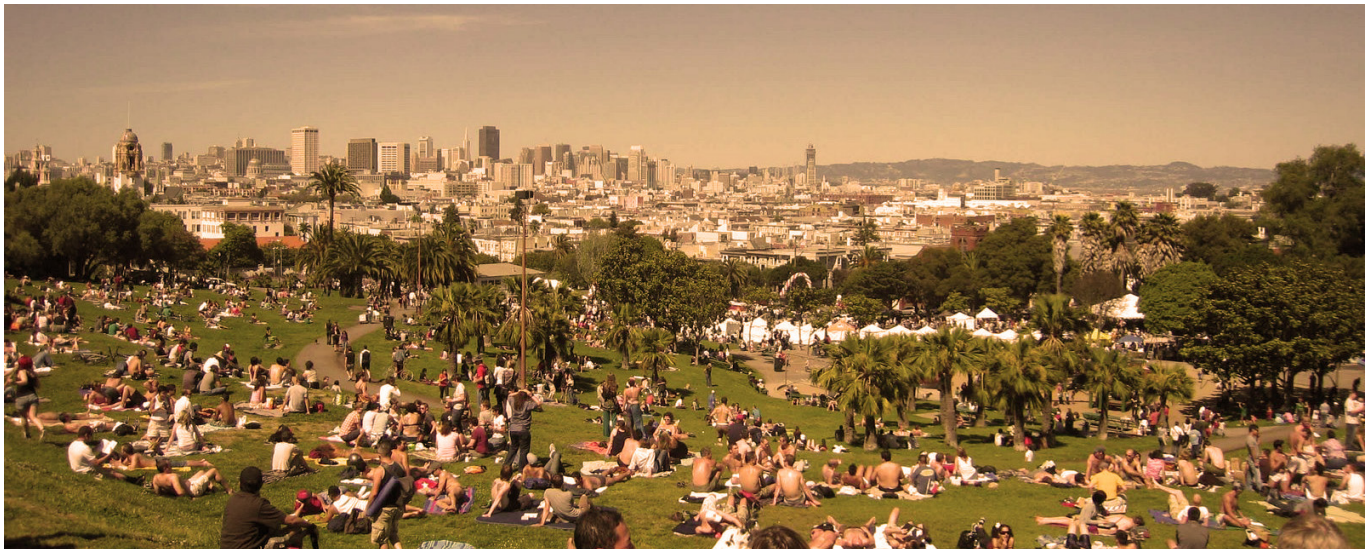
1.A	Work with the healthcare sector to conduct an analysis of the current use and possible expansion of e-health distance-spanning technology (telemedicine/virtual visits) to improve access for residents during extreme storms and heat events.
1.B	Work with City departments to conduct a gap analysis on community-based organizations contacted post-disaster to ensure that all vulnerable populations can access post-disaster outreach and communications.
1.C	Ensure behavioral health is integrated into pre-disaster planning for response and recovery.
1.D	Consider development and implementation of psychological first aid training for disaster service workers within SFDPH and support the evaluation of that training.
1.E	Develop a curriculum for healthcare service providers about climate change health impacts, at-risk individuals and populations, how to proactively discuss risks with patients, and what resources are available for further information or support.
1.F	Develop a strategy to engage vulnerable populations and the organizations and networks that support them, about health outcomes associated with climate hazard events and how best to design solutions to mitigate, prepare, respond, and recover from them.
1.G	Compile all climate health-related engagement materials under one webpage and integrate it into the Department of Public Health website.
1.H	Assist interdepartmental efforts to map vulnerable communities, and service areas for San Francisco's community based organizations.
1.I	Support the development of a comprehensive interdepartmental webpage that consolidates available city, state, and federal resources to help City departments, community-based organizations, and resident's access funding opportunities.
1.J	Develop and formalize climate data maintenance plan that establishes standards for the organization and upkeep of climate and health data to ensure data can be continuously used to advocate for resources and evaluate the effectiveness of adaptations and interventions.
1.K	Investigate opportunities to measure Citywide social cohesion.
1.L	Create trainings to assist individuals and families to create household emergency response plans to prepare for climate change-related hazard events.

4.1.3

Climate Risk Health Indicators

The following indicator is from the San Francisco Community Resiliency Indicator System and tracks the vulnerability factors that modify the health effects of climate change and measure the success of adaptation and response strategies. This indicator can be summarized by neighborhood, census tract, or census block group depending on the scope of the intervention.

- Community Resiliency Score (composition of all Community Resiliency Indicators from the San Francisco Community Resiliency Indicator System).



4.2

Extreme heat can be expected to cause an increase in the number of premature deaths.

Heat-related illnesses are a broad range of diseases from mild heat stress to the most severe, life threatening—heat stroke. Extreme heat events increase all-cause mortality and mortality related to heat, respiratory, cardiovascular, cerebrovascular, and nervous system causes, resulting in a significant public health burden. This sections summarizes how extreme heat impacts San Francisco.

4.2.1

Baseline Conditions in San Francisco

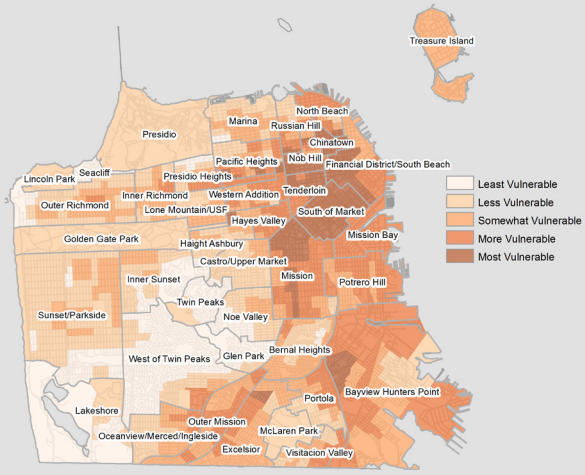
It typically takes human biology two weeks to adapt to temperature extremes. San Francisco does not regularly experience extreme heat events or extreme heat waves, so San Franciscans have a more difficult time thermo-regulating. As a result, San Franciscans are at higher risk for largely preventable heat-related illnesses. An analysis of the 2006 California heat wave found significant increases in a wide range of morbidities statewide, with the highest rates of emergency room visits for heat-related illness in cooler climates, including San Francisco.

Downtown neighborhoods are most impacted by the urban heat effect. The **urban heat effect** refers to the warming effect that urban development has on surface temperatures in urban environments. Impervious surfaces such as asphalt and concrete that absorb heat, large buildings that block wind, and windows that reflect sunlight increase surface temperatures. The urban heat effect results in more intense heat for neighborhoods with more impervious surfaces and fewer trees and vegetation to provide shade and absorb the heat, such as the SOMA and Mission neighborhoods.

While everyone is vulnerable to heat-related illness, certain populations are more at risk, including the elderly, low-income, and those with chronic mental disorders and pre-existing medical conditions. In addition, environmental exposure factors affect vulnerability to extreme heat. These environmental factors include temperature, air quality, tree density, and proximity to parks/green space. Housing can

Figure 2

San Francisco vulnerability to the health impacts of extreme heat, by 2000 census block



also modify the relationship between temperature and heat-related illnesses. Because San Francisco is a temperate city, local housing and infrastructure were built for a cool coastal climate. Many of San Francisco's old residential buildings do not have air conditioning or have poor ventilation.

In 2012, to assist in the development and evaluation of programs and policies to better prepare for, respond to, and recover from heat-related hazard events the SFDPH developed a Heat Vulnerability Index (Figure 2 on previous page) to identify the community determinants of extreme heat vulnerability and the most vulnerable neighborhoods. Factors found to modify the relationship between heat and illness were identified from the literature and data were collected for 21 variables for the City's 574 Census block groups. After taking into account correlation among variables, the analyses showed the major contributors to citywide and neighborhood relative heat vulnerability include socioeconomic vulnerability, social isolation, air quality, urban density, no vegetation, and a higher elderly population. For more information on the Heat Vulnerability Index, the full report can be found online at *http://bit.ly/2md7lHr*

The neighborhoods identified as highly vulnerable to the health effects of extreme heat include Chinatown, SOMA, Tenderloin, Mission, and Bayview/Hunters Point. In addition to identifying the locations of residents who exhibit relative heat vulnerability, the index identified the major drivers of vulnerability. For the City as a whole, socioeconomic vulnerability accounted for the most variability of all the variables; suggesting socioeconomic factors have the greatest effect on an individual's ability to deal with extreme heat events. Factors such as ethnicity, linguistic isolation, and low education also contribute significantly to relative heat vulnerability.

4.2.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews:

Climate Risk 2: Extreme heat can be expected to cause an increase in the number of premature deaths.

Interventions and Adaptations

2.A	Continue to work with City departments, community-based organizations, and academic researchers to investigate new opportunities to support the development of greenspace and tree canopy in areas identified as urban heat islands.
2.B	Work with San Francisco health clinics to identify, evaluate, and augment Continuity of Operations Plans (COPs) to prepare for extreme weather events.
2.C	Work with SFDPH's Public Health Emergency Preparedness and Response and other City departments to investigate opportunities to identify and establish memorandums of understanding (MOU's) with cooling centers that can be dispensed throughout the City to make air conditioned places publicly available for those who do not have access to air conditioning.
2.D	Work with the healthcare sector to improve diagnosis and reporting protocols around heat-related illnesses and deaths.
2.E	Investigate opportunities to work with City departments to promote the home insulation assistance program or cooling assistance programs.
2.F	Investigate opportunities to expand the reach of weather-related warnings and alerts to vulnerable populations.
2.G	Work with City partners to investigate opportunities to develop pilot projects to install cool pavement and cool roofs on City-owned property in locations with populations vulnerable to extreme heat.
2.H	Investigate opportunities to work with City partners to develop thermal comfort recommendations for facilities serving vulnerable populations.

4.2.3

Climate Risk Health Indicators

The following indicators are recommended to track the health effects of extreme heat due to climate change and to measure the success of adaptation and response strategies.

- Rate of heat-related deaths, hospitalizations, and emergency room visits during summer months
- Injuries and deaths due to extreme weather events
- Number of hospital discharges in San Francisco attributed to dehydration related illnesses
- Age-adjusted rate of hospitalizations due to asthma (pediatric and adult)
- Mortality related to heat

4.3

Extreme storms, sea level rise, and flood inundation will have cascading direct and indirect impacts on public health, housing, and city services

Extreme storms, sea level rise, and flood inundation are associated with many direct health outcomes including respiratory illnesses, waterborne illnesses, and physical injuries. However, extreme storms may have a greater impact indirectly with power outages, and disruptions to water, transportation, and communications systems that are essential to maintaining access to health care and emergency response services safeguarding human health.

4.3.1

Baseline Conditions in San Francisco

San Francisco is surrounded by coastline on three sides. Coastline infrastructure is in close proximity to major residential, business, tourism, financial areas and warehouse, industrial, sports, educational, and medical facilities. Much of the land that now comprises San Francisco's Bay waterfront is landfill – dredged mud and sand from the bottom of the Bay. Neighborhoods built on landfill are at increased risk for flood inundation during extreme storms because of their low elevation and location in natural drainage basins. San Francisco's natural streams and creeks were covered by development. During heavy precipitation events, stormwater runoff pools along these natural drainage channels and threatens adjacent roads, homes, and businesses.

Housing quality can affect exposure to the health effects of flooding. For example, leaky roofs and windows or poor plumbing may expose residents to dampness and molds that aggravate respiratory conditions. San Francisco's homeless population is particularly vulnerable to the health impacts of flood inundation and extreme storms which include waterborne disease, respiratory illnesses and stress and anxiety.

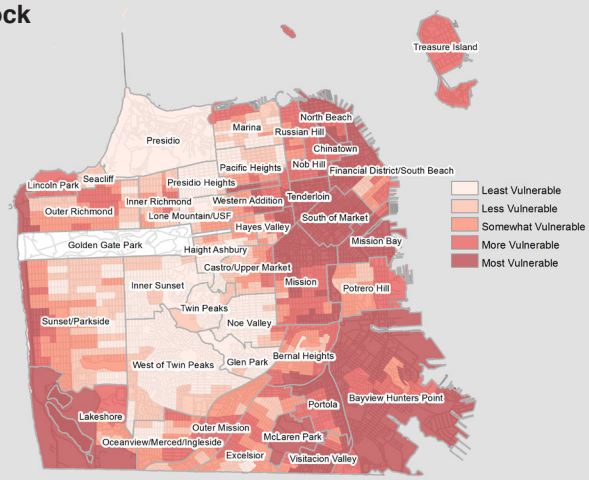
The stormwater and wastewater transport and management system, the power and electrical system, the transportation network, housing, and future development in flood plains will be affected by flooding and extreme storms. San Francisco is one of the few West Coast cities with a combined stormwater-wastewater sewer system. During the heaviest rainfall, when storage and treatment facilities are at capacity, stormwater and wastewater are discharged into the San Francisco Bay after removal of solid waste, grit, and trash.

Power outages associated with extreme storms negatively impact a broad range of health, household, and economic needs. The transportation network and paratransit network connects residents and visitors to homes, schools, jobs, businesses, municipal services, and health care and emergency response services. Any disruption to the transportation system will have cascading, and even life threatening, impacts on people's ability to access these necessary destinations and services. City agencies are currently engaged in various adaptive initiatives to protect against flood inundation and its indirect impacts.

In 2015, the SFDPH conducted an assessment of San Francisco's vulnerability to the health effects of flooding and extreme storms. The assessment aimed to identify the locations of communities vulnerable to flood inundation and

Figure 3

San Francisco vulnerability to the health impacts of flooding and extreme storms, by 2010 census block



extreme storms to assist in the development and evaluation of programs and policies to better prepare for, respond to, and recover from the health effects of the events.

The analysis examined indicators of social and demographic, exposure, health, and housing vulnerability. Data were collected for census block groups, standardized to z-scores, adjusted for highly correlated components, summed to create a Flood Health Vulnerability Index (Figure 3) and mapped for the City. The analysis identified the areas where people are most likely to suffer harm and are less able to respond to the stressors associated with extreme storms and flood inundation. Especially vulnerable neighborhoods include **Bayview/Hunter's Point, Mission Bay, SOMA, Downtown/ Civic Center (Tenderloin), Chinatown,** and **North Beach**. For more information on the Flood Health Vulnerability Index, the full report can be found online at *http://bit.ly/20Y8u9a*

4.3.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews:

Climate Risk 3: Extreme storms, sea level rise, and flood inundation will have cascading direct and indirect impacts on public health, housing, and city services.

Interventions & Adaptations

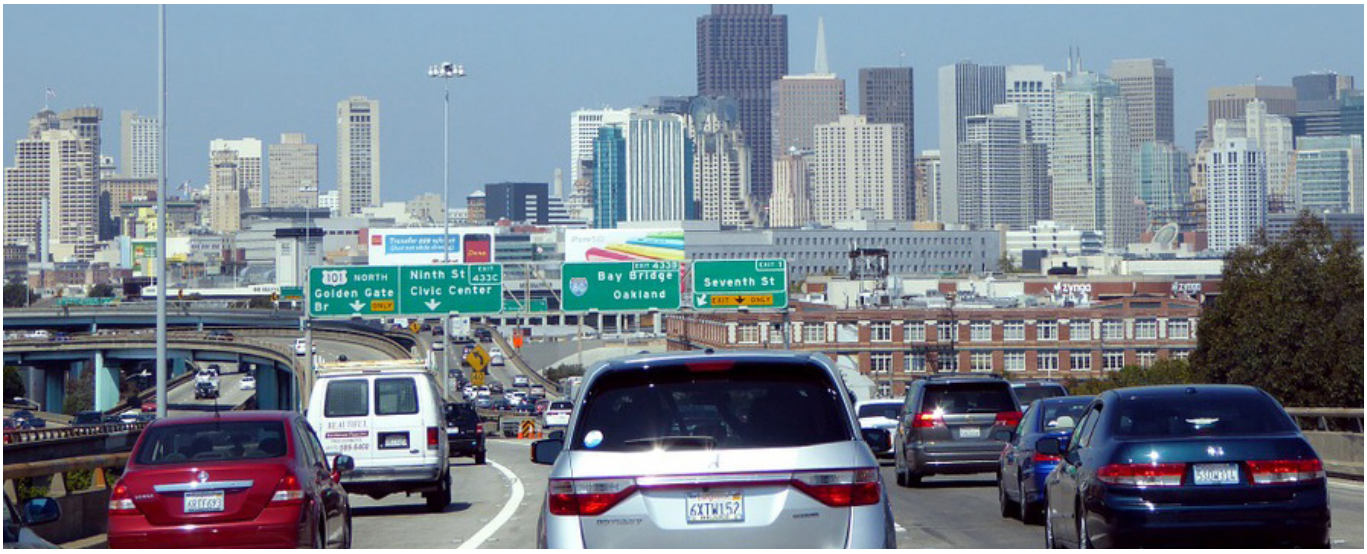
3.A	Research and update the power outage annex of the SFDPH emergency operations plan (EOP) with special consideration to vulnerable populations.
3.B	Foster cross-disciplinary partnerships between the San Francisco Department of Public Health and other City agencies to support ongoing efforts to promote climate mitigation and adaptation in the health care sector.
3.C	Evaluate use and effectiveness of public information services during and after extreme weather events.
3.D	Develop engagement resources on how to properly address in-home dampness and water intrusion, explain tenant and landlord responsibilities, and how to select a professional contractor.
3.E	Work with City departments to use community resiliency indicators to prioritize Citywide climate adaptation or climate mitigation improvements to areas with vulnerable communities.
3.F	Support Citywide vulnerability and risk assessment work to ensure focus on human health and equity.

4.3.3

Climate Risk Health Indicators

The following indicators are recommended to track the health effects of extreme storms, sea level rise, and flood inundation and to measure the success of adaptation and response strategies.

- Injuries and deaths due to extreme weather events
- Rate of hospitalizations due to asthma (pediatric and adult)
- Rate of hospitalizations due to diabetes (pediatric and adult)
- Rate of hospitalizations due to schizophrenia and other psychotic disorders
- Waterborne illnesses (Section 3.5.3)
- Foodborne illnesses (Section 3.6.3)
- Vector-borne disease from mosquitoes or rodents (Section 3.7.3)



4.4

Air pollution will likely increase, worsening allergy and respiratory conditions.

As temperatures increase, the warm, dry, and stagnant air will accelerate the creation of ground level ozone and other fine particulates. Similarly, in seasons where California's high-pressure system does not dissipate, a prolonged inversion layer could trap particulates in the atmosphere. This section identifies how air quality impacts health in San Francisco.

4.4.1

Baseline Conditions in San Francisco

Air quality in California is regulated based on Environmental Protection Agency (EPA) National Ambient Air Quality Standards (NAAQS) for a number of pollutants including ozone and PM2.5. For the past 40 years, San Francisco has consistently fallen well below national and state, average and maximum ozone and PM2.5 levels (Figure 4).

Using data from the Bay Area Air Quality Management District (BAAQMD), the SFDPH modeled total PM2.5 concentration from all sources in the city. The neighborhoods with the worst air quality are either along heavily-trafficked transit corridors or adjacent to industrial activity. These communities include **SOMA**, **Financial District**, **Tenderloin**, **Bayview/Hunter's Point**, and the **Outer Mission**.

San Francisco Health Code Article 38 (Figure 5) sets ventilation requirements for new residential construction in areas with poor air quality as defined in the Air Pollution Exposure Zone Map, which was developed in 2014 by BAAQMD, the

Figure 4

San Francisco concentration of particulate matter (PM2.5)

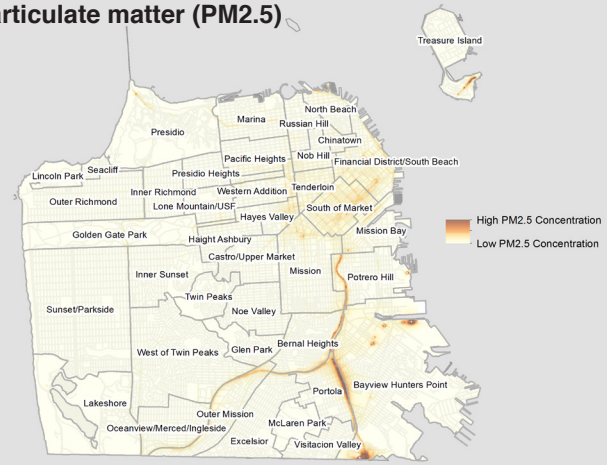
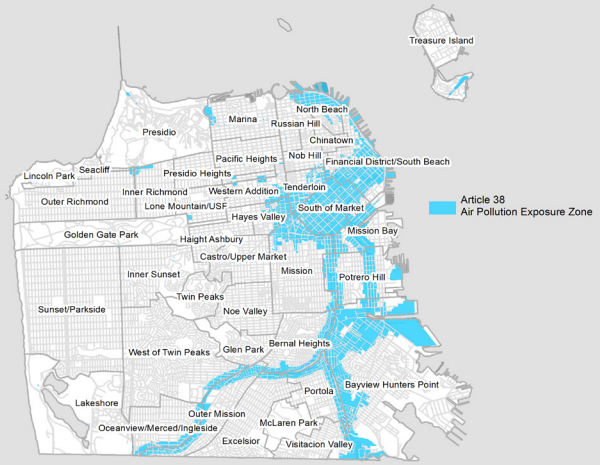


Figure 5

San Francisco Article 38 exposure zone



San Francisco Planning Department, and the SFDPH. The Air Pollution Exposure Zone identifies sites that either had a cancer risk of greater than 100 per one million exposed or PM2.5 concentrations greater than 10μg/m^3. The pollution model used to develop the map identified freeways, roadways, permitted stationary pollution sources, buses, ports, and other transportation networks.

Air pollution-related health impacts in San Francisco are largely influenced by proximity to high-traffic corridors and industrial areas, where people of color and low-income residents are disproportionately located. In addition, the largest increases in ozone levels from climate change will occur in areas where ozone is already high. Communities that are currently most exposed will suffer the worst of the changes. Groups that are less physically capable of dealing with the health impacts, like children and older adults, as well as those who have little protection from outdoor air, like the homeless, are more vulnerable to changes in air quality. The urban heat island effect also influences air pollution and means that those living in dense urban centers are going to be further hit with air quality challenges. Despite relatively smaller average increases in ozone and PM levels, the impact will not be evenly distributed and can have significant effects on vulnerable populations.

The areas with the highest rate of preventable hospitalizations related to air quality (chronic obstructive pulmonary disease and asthma), indicating heightened vulnerability to poor air quality include **Bayview/Hunter's Point, Chinatown, Western Addition and SOMA**.

4.4.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews:

Climate Risk 4: Air pollution will likely increase, worsening allergy and respiratory conditions.

Interventions & Adaptations

4.A	Monitor hospitalizations, emergency room visits, 911 calls, and meteorological data to recognize when the number of asthma symptoms or diagnoses is higher than normal in order for the health department to design preventative interventions.
4.B	Investigate the use of deploying sensor technologies and digital tools on climate change and environmental quality to address health disparities and empower citizens/communities to understand climate change.
4.C	Work with air quality programs to develop internal City capacity to measure pollen concentration.
4.D	Work with City departments to develop a program to minimize pollen allergies through non-allergen planning and designing of urban greenspaces.
4.E	Examine opportunities to work with the healthcare sector and existing air quality programs to develop communication and engagement materials for asthmatic patients and patients with severe allergies and/or respiratory illnesses.
4.F	Work with the healthcare sector to assess how climate data can be better integrated into patient care.
4.G	Assess opportunities to utilize autonomous vehicles to support vulnerable populations.
4.H	Investigate opportunities to support, expand, and improve use of home air filtration systems in air pollution exposure zones with a specific focus on sensitive receivers.

4.4.3

Climate Risk Health Indicators

- Rate of hospitalizations due to asthma (pediatric and adult)
- Rate of hospitalizations due to chronic obstructive pulmonary disease

4.5

Higher temperatures, sea level rise, extreme storms, and flooding increase the risks of waterborne illnesses.

Waterborne illnesses are caused by contact with water contaminated by disease-causing microbes or pathogens. Contact with contaminated water can occur by either ingesting contaminated drinking water or by touching, swimming, or wading in contaminated recreational water or flood waters. As extreme storms become more frequent and more severe, heavy precipitation events may cause municipal storm drains to overflow or residential stormwater management systems to malfunction. Contact with stormwater or wastewater has been associated with increased rates of gastrointestinal illness.

4.5.1

Baseline Conditions in San Francisco

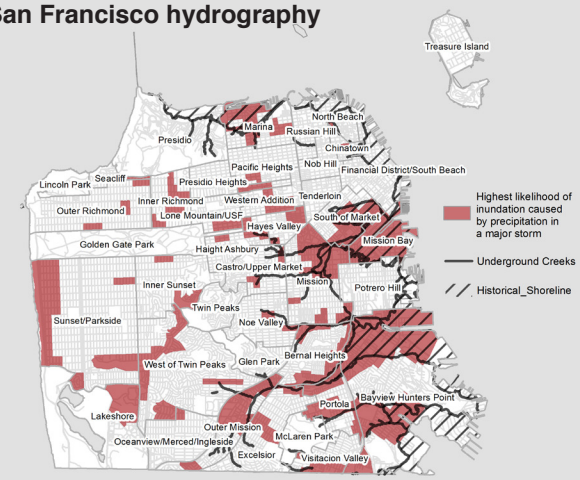
The most common pathway that connects climate change-related environmental impacts to waterborne illness is through direct contact with contaminated floodwaters. In San Francisco, those floodwaters are most likely to be sewer or storm drain overflows. During the ten rainiest days between 2009 and 2014, the San Francisco 311 service received over 1400 sewer-related complaints. These complaints were clustered around San Francisco's underground creeks. The San Francisco Public Utilities Commission (SFPUC) confirmed the connection between storm drain and sewer overflows and underground creeks in their risk projections for precipitation-related flooding (Figure 6).

Populations that are particularly vulnerable to illnesses associated with contact of contaminated water include children, elderly residents, populations with pre-existing health conditions, populations in high-risk sewer overflow zones, and those without adequate housing or in homes with poor plumbing. Heavy rainfall during December of 2014 may have contributed to a spike in Shigella cases among San Francisco's homeless population.

Warmer water temperatures and lower river flows have expanded the geographic range of harmful cyanobacterial algae blooms. Cyanobacteria are associated with many health outcomes including rashes, diarrhea, and flu-like symptoms. Although San Francisco's beaches have historically been free of bacteria, lakes throughout California have been closed due to these algae blooms and health impacts may affect San Franciscans who recreate in these waters. The SFPUC

Figure 6

Precipitation-related flood inundation and San Francisco hydrography



monitors San Francisco beach water quality for total coliform, Escherlichia coli and enterococcus.

San Francisco enjoys a high quality drinking water system. San Francisco receives its water from the Sierra Nevada's Tuolumne River watershed. The water is routinely tested for contaminants as it is transported to San Francisco and then treated. The SFPUC is planning to augment Hetch Hetchy water with groundwater pumped from the North Westside Groundwater Basin in San Francisco. This water will be treated by blending it with Hetch Hetchy water.

Although Cryptosporidiosis is associated with heavy precipitation events, SFDPH is already engaged in Cryptosporidium surveillance. Other waterborne bacteria that may be impacted by climate change include salmonella, shigella, and giardia.

4.5.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews:

Climate Risk 5: Higher temperatures, sea level rise, extreme storms, and flooding increase the risk of waterborne illnesses.

Interventions and Adaptations

5.A	Organize and facilitate workgroup to align wastewater management regulations and processes among City Departments.
5.B	Engage with regional planning efforts to ensure safe and reliable drinking water during hazard events.

4.5.3

Climate Risk Health Indicators

- Rate of hospitalizations for cryptosporidiosis, shigellosis, and giardiasis
- Rate of hospitalizations for diarrheal and gastrointestinal illness and gastrointestinal conditions following extreme storm events

4.6

Climate change, including rising temperatures and changes in weather extremes, is expected to increase the exposure of food to certain pathogens and toxins.

Foodborne disease and illnesses refer to bacteria, viruses, and parasites spread through the food we eat. Climate change is expected to affect ambient air and water temperatures, precipitation levels, and the frequency of extreme weather events, all of which are key factors in the introduction of pathogens into the food chain, food contamination, and foodborne disease.

4.6.1

Baseline Conditions in San Francisco

There are a number of ways in which changes in climate are expected to increase the risk of foodborne illness. In San Francisco, there were an estimated 54 foodborne gastrointestinal illness related outbreaks between 2006 and 2014. In 2014, 2.95 per 100,000 people over the age of five were hospitalized due to foodborne illness and 10.6 per 100,000 people over the age of five visited the emergency room due to foodborne disease.

Higher ambient temperatures can increase the number of pathogens already present on produce, meats, and seafood. For example, salmonella on raw chicken doubles in number approximately every hour at 70°F, every 30 minutes at 80°F, and every 22 minutes at 90°F. Diarrheal illness has been associated with power outages. Syndromic surveillance after a 2003 New York City power outage revealed an increase in foodborne illness. Researchers hypothesized that consumption of spoiled food was a likely rationale for the increase.

Rising ocean temperatures can lead to an increase in the frequency of naturally occurring pathogens such as *Vibrio parahaemolyticus,* which causes illness linked to shellfish consumption. Likewise, increased temperatures combined with decreased salinity from greater rainfall, could result in increases of *Vibrio vulnificus*, which is also linked to illness from shellfish consumption. Increases in sea surface temperature are also expected to expand the endemic range of ciguatoxin producing algae, which contaminates fish with toxins and can lead to ciguatera fish poisoning when consumed. The 2015-16 Dungeness crab season was delayed 5-months in California by California Department of Fish and Wildlife because crabs were found to have toxic *Domoic Acid*, which can cause serious health effects including death. This neurotoxin is spread by algal blooms, which are correlated with increases in water temperatures. Water temperatures are expected to rise with climate change. Warmer water increases fish and mammal metabolic rates, accelerating the uptake of contaminants like methylmercury. Once introduced into the food chain, these contaminants can cause serious health effects.

4.6.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews:

Climate Risk 6: Climate change, including rising temperatures and changes in weather extremes, is expected to increase the exposure of food to certain pathogens and toxins.

Interventions & Adaptations

6.A	Develop food safety emergency plan to formalize protocols to prepare for and respond to climate-related hazard events, including formalizing communication and reporting protocols.
6.B	Develop resources for SFDPH staff and food establishments that communicate the impacts of climate change on foodborne illness, and best practices to mitigate that impact.

4.6.3

Climate Risk Health Indicators

- Foodborne gastrointestinal illness outbreaks
- Rate of hospitalizations for diarrheal and gastrointestinal illness and gastrointestinal conditions following extreme storm events
- Rate of ER visits and hospitalizations for foodborne illnesses

4.7

Warmer winter and spring temperatures are projected to lead to changes in vectors and vector-borne disease.

Vector-borne and zoonotic illnesses are diseases transmitted through animal vectors, including mosquitos, ticks, fleas, and host populations like rats and mice. Climate patterns may increase the risk of exposure to vector-borne and zoonotic illnesses by increasing host populations and pathogen reproduction rates. The following summarizes how vector-borne disease impacts public health in San Francisco, and identifies how climate change could modify that impact.

4.7.1

Baseline Conditions in San Francisco

It is difficult to predict how changes in temperatures, precipitation, and extreme storms will impact host populations because other factors unrelated to climate change, such as infrastructure, global travel, and the effectiveness of vector control programs, can also affect host populations. Temperature and precipitation changes can accelerate the spread of rodent and vector-borne diseases. We have divided this section by disease vector.

Mosquitos. Although mosquito-carried diseases such as West Nile Virus have historically impacted San Francisco less than other Bay Area counties with greater concentrations of open space, changes in precipitation, especially towards wet and dry extremes, as is predicted with climate change, will impact both the growth and dispersal of mosquito populations. Changes in precipitation patterns, especially those that create more pooled stormwater, will increase mosquito breeding habitats. As mosquito populations increase, rates of West Nile virus and other mosquito-borne illnesses will also increase. Birds are the main host for West Nile Virus and temperature and precipitation may influence their migration patterns.

Native to Africa, the Aedes aegypti mosquito has expanded into the Southern United States and was recently discovered for the first time in the San Francisco Bay Area. This expansion is caused by several factors including temperature and global travel patterns. Some research indicates Aedes aegypti can expand into areas with drought-conditions by breeding in stored water and unmaintained swimming pools. Researchers predict an increase in temperature will allow the mosquito to live in environments where cool winter temperatures currently limit their spread. The Aedes aegypti mosquito is a vector for such diseases as Chikaungungya, Zika, and Dengue Fever.

Rodents. Particularly rainy seasons after dry seasons have been linked to increases in host populations such as rats and mice. The most common rats and mice in San Francisco are Norway rats, Roof rats, and House mice. The largest health impact associated with these species is allergies and asthma, but House mice can also spread Lympocytic Chorio-menigitis and bites may lead to bacterial infections. Hantavirus, associated primarily with Deer mice native to California but not San Francisco, increases as rodent populations increase. Many hantavirus outbreaks in the United States follow particularly rainy seasons. Hantavirus can cause hemorrhagic fever with renal control syndrome and hantavirus cardiopulmonary syndrome.

Ticks. Lyme disease is the most common vector-borne disease in the United States. The primary vector for Lyme disease, the Ixodes scapularis tick, is concentrated in the Eastern half of the United States. Ninety five percent of United States cases of Lyme disease occur in just 14 states, concentrated primarily in the mid-Atlantic seaboard and Upper Midwest. Lyme can also be spread by nymphal Ixodes pacificus, which lives along the West Coast including the San Francisco Bay Area. The populations of these tick nymphs tend to grow during particularly wet or hot seasons.

Other. Some research suggests that as food and water scarcity caused by drought conditions worsens, host populations will increasingly move towards urban centers. This will increase exposure to animals such as bats and skunks that carry rabies and coyotes and other animals that may be hosts to fleas, ticks, and other vectors.

4.7.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews:

Climate Risk 7: Warmer winter and spring temperatures are projected to lead to changes in vectors and vector-borne disease.

Interventions & Adaptations

7.A	Support efforts to create a collaborative interagency vector control workgroup to coordinate activities by providing data about the link between climate change and public health.
7.B	Support SFDPH's Vector Control Program engagement efforts by developing and compiling outreach and education materials.
7.C	Consider enhancing technical support to SFDPH's Vector Control Program through sensor technology, mapping and data analysis to assist surveillance efforts.
7.D	Support Vector Control Program to formalize emergency vector surveillance training curriculum for DPH staff in case of breakout, and add training curriculum to a vector control emergency response plan.

4.7.3

Climate Risk Health Indicators

- Cases of Lyme Disease
- Cases of West Nile Virus and other mosquito-borne diseases
- Positive test results in City sentinels and reservoirs

4.8

Rising temperatures, extreme heat events, and changing precipitation patterns are projected to exacerbate drought conditions in California.

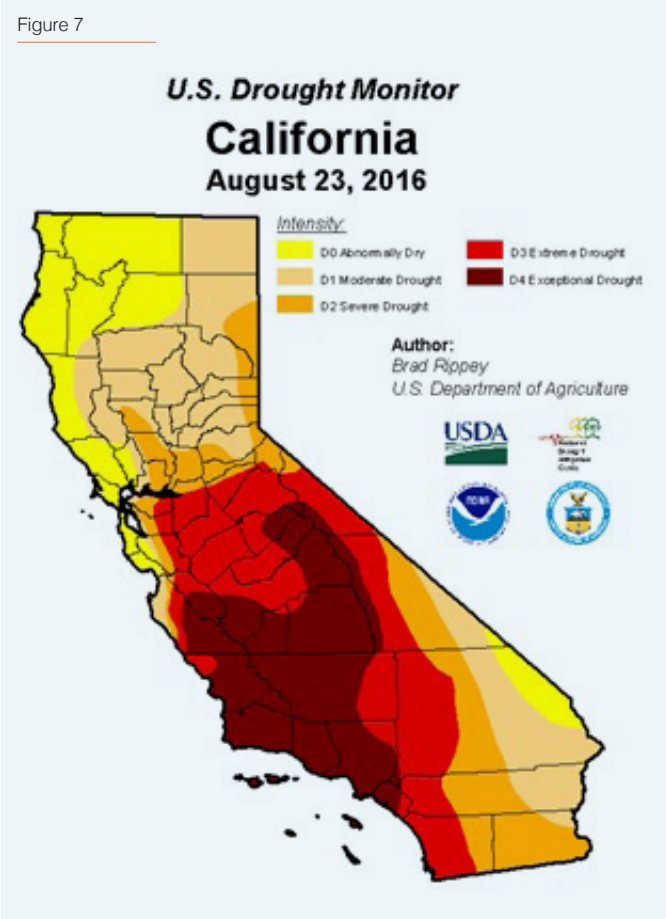
Because precipitation levels in California are prone to fluctuation, the state is vulnerable to long droughts which impact agricultural output, pollens, and air quality. This section examines how droughts impact public health in San Francisco.

4.8.1

Baseline Conditions in San Francisco

Since 2011, California has experienced the state's driest periods since they began keeping precipitation records in 1895 (Figure 7). In 2015, snowpack in the Sierra Nevada Mountains was at 5 percent of normal, jumping back to 87 percent of normal after an El Niño-fueled the 2015-2016 rainy season. Although the 2016-2017 rainy season effectively ended drought conditions in Northern California, the cumulative impact of the 2011-2016 drought exacerbated the impact of 2016-2017's extreme storms as rain and wind dislodged drought-damaged trees and hillsides.

Figure 7



Years of drought conditions impact surface water flows and cause reservoirs to drop significantly below historical averages. The drought severely impacted California's economy in 2015. An estimated $500 million was lost in hydropower production and an estimated $2.7 billion was lost due to the fallowing of cropland. San Francisco receives most of its water from the Hetch Hetchy reservoir near Yosemite. In 2014, the SFPUC approved an 8-9 percent increase in water and wastewater services, raising rates an estimated $7-$10 more per month for the average household. The state also took steps to combat drought affects by instituting mandatory water conservation measures. These measures include regulations on watering public street medians and outdoor

irrigation.

The 2011-2016 drought has significantly impacted the health of Sierra Nevada forests, killing an estimated 66 million trees. The combined effects of the drought, higher temperatures, historic forest management practices that prematurely extinguish small fires that clear underbrush and decay, human development that encroaches into wildland, and invasive species have all conspired to make wildfires greater in both frequency and intensity. The most direct impact of wildfires on San Francisco is the health impacts associated with smoke that may drift into San Francisco. Wildfire smoke is particularly harmful to human health. The gases and particulate matter that constitute wildfire smoke can cause respiratory ailments and can exacerbate pre-existing health conditions by triggering asthma attacks or worsening chronic heart and lung diseases. Wildfire smoke can also cause allergic reactions and irritate the eyes, nose, and throat. Young children and elderly are particularly vulnerable to the health impacts associated with poor air quality and there is correlation between wildfire smoke inhalation during pregnancy and low birthweight.

While the probability of a wildfire in San Francisco is relatively low, Marin, Solano, Napa, and San Mateo counties all have increased vulnerability to wildfires. A wildfire in an adjacent county would impact San Francisco. The 2016 Soberanes Fire burned more than 100 square miles in Garrapata State Park and Big Sur south of Monterey. The smoke from this fire impacted air quality across California. In the Bay Area, smoke from the Soberanes fire prompted the BAAQMD to request Bay Area residents to carpool and stay indoors.

Wildfires statewide also indirectly impact San Francisco. The 2013 Rim Fire burned about 400 square miles in the Stanislaus National Forest, adjacent to the Hetch Hetchy watershed. The fire burned through power lines and destroyed power infrastructure, causing $36.3 million worth of damage. To maintain service, San Francisco was forced to purchase power through alternative sources while the infrastructure was repaired.

4.8.2

Strategies for Consideration: Themes across Literature Review, Best Practices and Interviews

Climate Risk 8: Rising temperatures, extreme heat events, and changing precipitation patterns are projected to exacerbate drought conditions in California.

Interventions & Adaptations

8.A	Conduct a public health drought vulnerability assessment.
8.B	Work with City departments to support water and power financial assistance programs by either expanding program reach, providing data analysis or support, or connecting vulnerable populations to the program.
8.C	Work with City departments to develop in-building leak audit program for low-income homes.

4.8.3

Climate Risk Health Indicators

- Rate of hospitalizations due to asthma (pediatric and adult) during documented wildfires

5.

Assessment of Public Health Department Climate Preparedness

Since 2010, SFDPH's Climate and Health Program has worked to address the public health consequences of climate change-related hazard events. This Climate and Health Adaptation Framework represents the program's strategic transition from assessing climate health outcomes to designing and implementing adaptations and interventions. While section four of the Climate and Health Adaptation Framework is outwards-facing and proposes adaptations and interventions to address citywide climate change-related health impacts, this section will look inwards and assess the degree to which SFDPH is prepared for these impacts and how the department can best support future climate preparedness activities.

As climate change emerges as one of the greatest public health threats of the 21st century, local public health departments must develop an organizational culture, strategic framework, and physical spaces that best support departmental initiatives to prepare for and respond to the health impacts of climate change-related hazards.

This section includes:

- The analysis of **Are We Ready? Preparing for the Health Impacts of Climate Change**. This 2016 survey asked SFDPH management how they expect climate change to impact both the City of San Francisco and their specific programs, whether climate change and climate change-related health outcomes are considered as they develop and oversee SFDPH programs, and what resources and tools may be necessary to support future climate adaptation activities.

- **An assessment of SFDPH's strategic planning documents**. This sections examines how and where SFDPH's strategic departmental objectives and structural planning documents currently align with the objectives of the Climate and Health Program, and identifies opportunities for these documents to better support climate preparedness.

- A **vulnerability assessment of San Francisco's public health facilities** that uses spatial analysis and Climate and Health Program vulnerability assessments to identify facilities that are located in neighborhoods projected to experience a greater climate change-related health burden.

5.1

Are We Ready? Preparing for the Health Impacts of Climate Change, Survey Results, and Key Themes

Introduction and Objectives

As the SFDPH Climate and Health Program begins planning new adaptations and interventions to protect the public against the health risks of climate hazard events, the program must simultaneously build capacity within the Department to better prepare for and recover from these impacts. To ensure the program's future activities directly aligned with the needs of the Department, a short survey was conducted in summer 2016 of SFDPH's branch, division, program, and service leadership. The survey aimed to assess climate change vulnerability, identify current programs that either directly or indirectly address climate change, and understand how future programs can best be implemented.

This survey analysis report is structured to correspond with survey objectives. The objectives of the 'Are We Ready? Preparing for the Health Impacts of Climate Change' survey were to better understand:

1. SFDPH Leadership's **current perception** of climate change environmental impacts and health outcomes in relation to San Francisco, SFDPH programs and activities, and the populations served by these programs and activities.

2. **Current SFDPH activities** that either incorporate climate adaptation or produce climate health co-benefits.

3. The **capacity of SFDPH** programs to develop or incorporate new interventions to assess and address the health impacts of climate change.

Survey results will help the Climate and Health Program bet-

ter design tools to facilitate the inclusion of climate change preparedness into existing SFDPH programs and activities, and leverage the Department's resources to design new climate health interventions.

Survey Design and Methodology

The SFDPH is divided into two divisions, the Population Health Division and the San Francisco Health Network. The Climate and Health Program surveyed these divisions separately. The Population Health Division survey was administered to Population Health Division leadership in April 2016. The survey was sent to 63 individuals and had a response rate of 59 percent (N = 37). The Health Network survey was administered in July 2016. The survey was sent to 74 individuals and had a response rate of 45 percent (N = 33).

The survey structure was based on the best practices identified through a literature review of climate change surveys targeting public health professionals and organizations. The review identified 11 relevant scholarly articles after searching through climate change surveys of public health professionals in the PubMed database. Many questions asked SFDPH leadership to evaluate the risk of climate change-related environmental impacts or health outcomes to the programs they manage, services they administer, or the populations who use those services. These designations will be referred to as 'programs/populations' for the remainder of the report.

A full list of survey questions and results for Population Health Division and Health Network surveys can be found online at *http://bit.ly/2kQsuMM*.

Survey Key Results

We have synthesized survey results into three themes that correspond to the three survey objectives. The first theme examines how survey responses may reflect SFDPH Leadership's **current perception** of climate change environmental impacts and health outcomes in relation to San Francisco, SFDPH programs and activities, and the populations served by these programs and activities. The second theme focuses on survey questions that examine **current SFDPH activities** that either incorporate climate adaptation or produce climate health co-benefits. The final theme examines how respondents evaluated the **capacity of SFDPH** programs to develop or incorporate new interventions to assess and address the health impacts of climate change.

Key Theme 1: Current Perception of Climate Change Impacts

We surveyed SFDPH leadership and asked them whether they have already seen evidence of climate change impacts to either the City of San Francisco or their programs/populations. We were interested in: 1) how SFDPH leadership perceives the temporality of climate change impacts and;

Figure 8

Health Network Question 8: Have you already seen evidence of climate change impacts on the City of San Francisco, or the services or programs you manage?

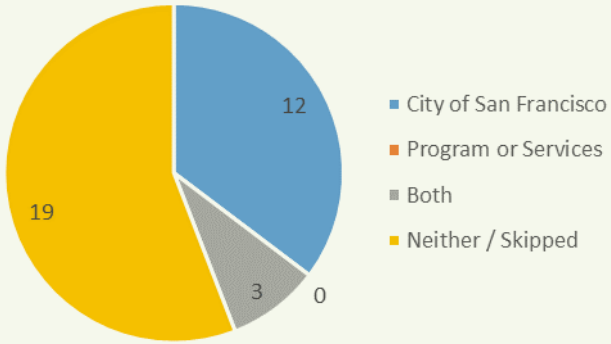
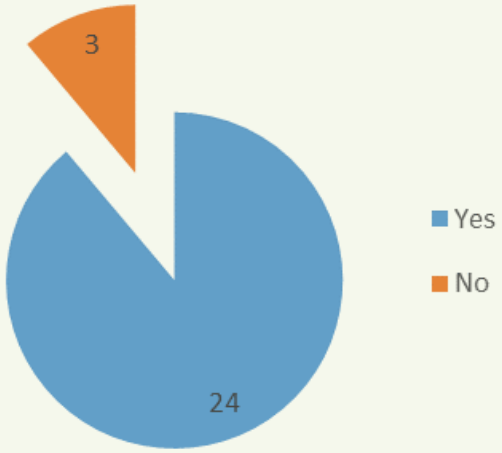


Figure 9

Health Network Question 11: Do you believe climate change will impact your branch or program or the populations you serve?



2) how SFDPH leadership perceives risk of climate change impacts to the City of San Francisco versus how SFDPH leadership perceives risk of climate change impacts to SFDPH programs/populations.

How SFDPH Leadership Perceives Temporality of Climate Change Risk

We asked SFDPH leadership whether they have already seen evidence of climate change impacts and whether they expect to see evidence of climate change impacts in the future. Figures 8 and 9 from the SFHN survey represent this theme. These figures demonstrate that although leadership perceived climate change as likely to impact both the City of San Francisco and their programs/populations, they were more likely to anticipate climate change's future impacts than to recognize current impacts.

Figure 8 shows that although 44 percent (N = 34) respondents reported they have seen evidence of climate change impacts to the City, only three have also seen that same evidence reflected in Health Network programs/populations. Alternatively, Figure 9 asks whether Health Network leadership expect climate change will impact their program in the future. While only three respondents have seen evidence of climate change impacting their programs thus far, 24 believe that climate change will impact their programs eventually.

How SFDPH Leadership Perceives Impacts to the City versus Impacts to Programs/ Populations

In Figure 10, Population Health Division leadership was asked to assign risk of likely environmental impacts to either or both of the City of San Francisco and their specific programs/populations. Respondents perceived greater risk to the City of San Francisco than to their programs or populations served by those programs. The greatest difference in perceived risk to the City of San Francisco versus programs/ populations is for the environmental impact 'drought', where 69 percent (N = 36) respondents identified drought as a 'very likely' significant impact for San Francisco while only 39 percent (N =34) respondents assessed the same risk for their program or those served by that program.

Key Theme 1 Discussion

Survey results indicate that the current perception of climate change among SFDPH leadership tends to assign risk to future impacts over current impacts, and impacts to the City rather than specific impacts to SFDPH programs or the populations served by those programs.

This may indicate that although climate change is broadly considered a threat, the actual impacts of that threat are not as widely known. This trend is particularly compelling for the climate impact 'drought'. Media attention of California's 2011 - 2016 drought may have contributed to a high perception of risk, but because less attention was paid to the health impacts of drought on urban environments, SFDPH leadership did not assign similar risk to their specific programs or the populations they served. These results indicate that there may be an opportunity for the Climate and Health Program to target outreach and engagement to SFDPH leadership that emphasizes how climate change has and will specifically impact SFDPH programs and San Francisco's vulnerable populations.

Figure 10

Population Health Division: Comparison of the perceived likelihood of climate impact on San Francisco versus likelihood of climate impact on SFDPH programs/populations.

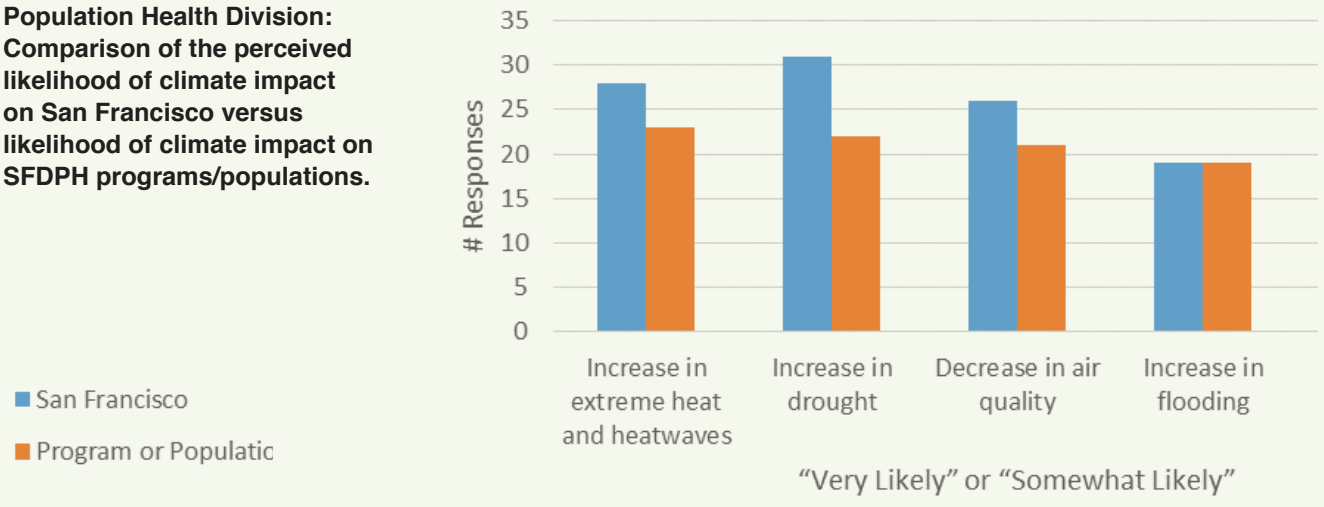


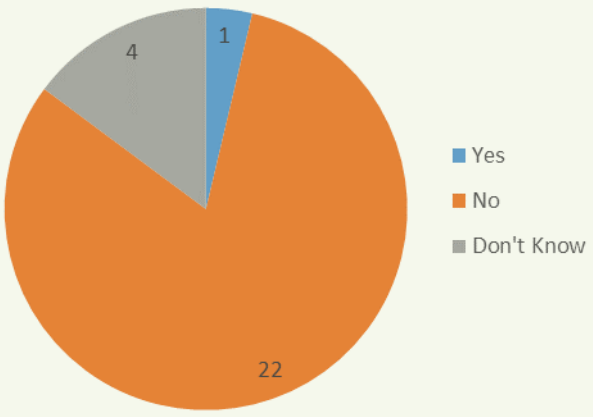
Table 2

Health Network Question 9: Below is a list of conditions and health issues that may be impacted by climate change. For each of the health issues, please answer 'yes' if it is currently an area of programmatic activity for your specific program. (Please answer 'No' if your specific program does not perform this activity).

Conditions and Issues	Yes	No
Heat waves and heat-related illnesses	10	22
Extreme storms and floods	5	26
Droughts	3	27
Vector-borne disease	17	15
Water- and food-borne disease	14	18
Anxiety, depression, or other mental health conditions	23	8
Quality or quantity of fresh water available to your jurisdiction	7	25
Quality of the air and air pollution in your jurisdiction	9	23
Unsafe or ineffective sewage and septic system operation	9	23
Food safety or security	14	18
Housing for residents displaced by extreme weather events	6	25
Need for healthcare services for people with chronic conditions during service disruption	19	11

Figure 11

Health Network Question 15: Does your office or program use long-range weather or climate information in planning or implementing and programmatic actvities



Key Theme 2: Current SFDPH Climate Change-related Activities

Many SFDPH programs focus on activities that either have climate health co-benefits or will be particularly impacted by climate change environmental impacts. These activities include programs to provide services after emergency events and programs to prevent and to treat climate-related health outcomes including health-related illness and asthma. We were interested in assessing the degree to which SFDPH is engaged in these activities, whether SFDPH leadership perceives these programs as climate change-related, and whether these programs utilize climate tools to plan their activities.

Alignment of SFDPH Activities and Climate Health Co-Benefits

Surveys asked SFDPH leadership whether their programmatic activities relate to climate change mitigation or adaptation and whether they incorporate long-range weather or climate information into program-planning processes. In the Health Network Survey, many respondents indicated that their programmatic activity included climate-related issues such as 'Heat Waves and Heat Related Illness', 'Anxiety, Depression, or Other Mental Health Conditions', and 'Food Safety and Security'. Eight-three percent of respondents (N=32) are engaged in at least one programmatic activity that will be impacted by climate change and climate change-related health outcomes. However 81 percent of respondents (N=27) reported that they **did not** use long-range weather projections when planning programmatic activities (Figure 11).

Key Theme 2 Discussion

Many of the SFDPH programs that are either likely to be impacted by climate change or focus on activities intersecting with climate-related issues do not incorporate climate adaptation, including using long-range climate and weather projections, when planning programmatic activities.

While a majority of SFDPH programs will be impacted by climate change and climate change-related health outcomes, there are relatively few programs actively preparing for this impact. In the San Francisco Health Network survey, many healthcare facilities may already know the health impact of extreme heat and experience increase demand during extreme heat events, but have not developed adaptations to systematically prepare for increased demand in the future. The programs that are both projected to be impacted by climate change and without the capacity to research and

implement interventions may be receptive to Climate and Health outreach and engagement. Programs with climate health co-benefits can actively acknowledge climate health co-benefits within their program objectives and outreach materials.

Key Theme 3: Capacity to Develop Adaptations and Interventions

In order to develop sophisticated climate health interventions that protect the public from the health outcomes associated with climate hazard events, the Climate and Health Program was interested in assessing which obstacles have prevented or are currently preventing the incorporation of climate adaptation into Population Health Division programmatic activities.

Survey results indicated that a majority of SFDPH's leadership believed that climate change would impact both the City and programs/populations, but did not incorporate climate change adaptation into program planning activities. Population Health Division leadership who responded that they believe climate change will impact their programs were asked to identify which 'barriers' have prevented them from incorporating climate change into their planning processes. Figure 12 shows 'Lack of resources (funding or staff)' as the barrier that the most respondents believed either 'A Great Deal' or 'Somewhat' prevented the incorporation of climate change adaptation into planning processes instead of 'Not At All' or 'Does Not Apply' (N = 36). 'Lack of information about best practices to adapt my program to climate change impacts', 'Lack of information about how San Francisco weather will change' and 'Lack of information about how climate change will impact public health' all were identified as greater barriers than 'Not a priority for my program' (Figure 12).

Population Health Division leadership was then asked to identify which possible interventions would be most useful to reduce public health impacts of climate change (N = 36). Of the interventions listed, 'Information on how climate change may impact my program and program-specific climate adaptation best practices' and 'Information on the San Francisco populations most likely to be affected by the health impacts of climate change' were identified as the most useful.

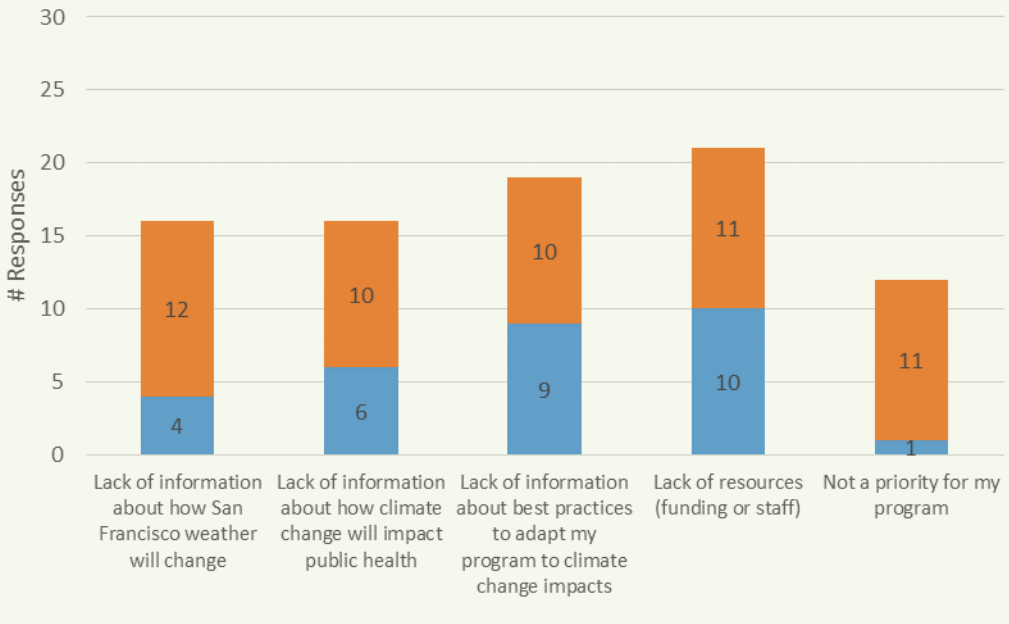
Key Theme 3 Discussion

The survey results indicate that there is an opportunity to more acutely explain how climate change and climate change-related health outcomes will impact specific SFDPH programs, which populations are most vulnerable to those impacts, and to identify interventions to protect those populations. Specifically, the Climate and Health Program can develop educational and outreach tools to communicate climate and health impacts, and based on the response to those tools, develop interventions that prepare SFDPH services for climate change-related stressors.

While much of this work is already being done by the Climate and Health Program, survey results indicate there is opportunity to establish new internal partnerships to expose

Figure 12

Population Health Division Questions 10 & 16: Of respondents who believe that climate change impact their programs, which barriers have prevented them from incorporating climate change into their planning processes?



more SFDPH programs to specific climate risk and climate adaptation information. Because 'Lack of Resources (funding or staff)' was identified as a barrier, the Climate and Health Program could work to connect particularly impacted programs to external funding opportunities.

Conclusion

As the Climate and Health Program begins to develop adaptations and interventions that respond to the health consequences of climate change, it is important to understand how SFDPH leadership is currently engaged with these issues. The 'Are We Ready? Preparing for the Health Impacts of Climate Change' surveys assessed the degree to which SFDPH leadership identifies climate change as a significant health threat, the status of climate adaptation within SFDPH programs, and the capacity of SFDPH to prepare for climate change in the future.

The results of the surveys indicate that there is an opportunity to connect SFDPH leadership's knowledge of climate change impacts to San Francisco to specific impacts to their programs and the vulnerable populations served by those programs. Internal SFDPH education and outreach can help increase the Department's capacity to understand the causal pathways that connect climate change to health outcomes to vulnerable populations. The survey also identified opportunities for the Climate and Health Program to develop tools and resources to assist leadership in preparing for the impact of climate change. Specifically, SFDPH leadership identified knowledge of program-specific adaptations and interventions and resources (funding or staff) as necessary first steps towards increasing the Department's climate resilience.

This survey will help the Climate and Health Program better understand and respond to the composition of SFDPH's engagement with climate change and will inform the development of adaptations and interventions. A follow-up survey could help the Climate and Health Program evaluate the impacts of interventions and adaptations designed to respond to gaps identified in this survey.

Limitations

There are opportunities for further research into local health department leadership preparedness for climate change and climate change-related health impacts. These opportunities include surveys with larger sample sizes and higher response rates. Further research may benefit from examining whether there is any difference in the perception of climate risk and responses between local health department leadership and the staff they supervise.

5.2

An Assessment of San Francisco Department of Public Health's Guiding Documents

This assessment is intended to summarize SFDPH's guiding documents for the purpose of identifying opportunities to more formally integrate climate preparedness and community resiliency into the Department's strategic planning. The documents included in this assessment are:

- The San Francisco Community Health Assessment (2016)
- The San Francisco Strategic Plan for Population Health (2015)
- The San Francisco Health Network Strategic Plan Update (2016)
- The San Francisco Indicator Project (2015)
- The San Francisco Health Care Services Master Plan (2013)

5.2.1

San Francisco Community Health Assessment (CHA)—2016

Document Summary

The San Francisco Community Health Assessment (CHA) uses qualitative and quantitative resources to assess health in San Francisco, designate priority issues, and act as the foundation for Department-wide planning processes. The CHA is broken into four steps: 1) Community Health Status Assessment; 2) Assessment of Prior Assessments; 3) Community Engagement and; 4) Health Need Identification. The foundational issues identified in the CHA include; 1) Economic Barriers to Health and; 2) Racial Health Inequities. The main health needs include; 1) Psychosocial Health; 2) Healthy Eating; 3) Safety and Violence Prevention; 4) Access to coordinated, culturally and linguistically appropriate services across the continuum; 5) Housing Stability/Homelessness; 6) Substance Abuse and; 7) Physical Activity.

Some Key Points that address vulnerable populations, climate change, or extreme weather events:

- The CHA uses census data to provide a snapshot of San Francisco's demographic trends. San Francisco's elderly population is projected to increase. Elderly residents are vulnerable to many of the health impacts of climate change and climate change-related hazard events.

- Many of the vulnerable populations whose health was identified as either a 'foundational issue' or a 'health need' are the same populations most vulnerable to the health impacts of climate change and climate hazard events. These populations include non-white populations, populations with pre-existing behavioral health conditions, homeless populations, and populations who may be linguistically isolated.

- The health need 'Physical Activity' has climate health co-benefits. Walking and bicycling can both increase individual health and reduce the greenhouse gas emissions that contribute to climate change.

What implications does this report have on preparedness efforts for climate-related events in San Francisco?

The CHA informs many of SFDPH's strategic planning documents by summarizing demographics and identifying health needs and foundational issues. The health needs and foundational issues become focus areas for the Community Health Improvement Plan (CHIP) and San Francisco Department of Public Health's Population Health Division's Strategic Plan. The CHIP is the citywide plan to protect and improve health for all San Franciscans, and is administered by the San Francisco Health Improvement Partnership (SFHIP), a collaboration between SFDPH, San Francisco's non-profit hospitals, and UCSF.

The CHA successfully identifies San Francisco's current health needs and foundational issues and the document may also be an opportunity to assess San Francisco's emerging health trends. This analysis can help the City proactively anticipate how demographic, economic, climate, or technological trends may impact health and plan for associated risks. An 'emerging trends' analysis could either frame climate change as a standalone issue or as a risk that will modify the health burden of established health needs and foundational issues.

5.2.2

San Francisco Department of Public Health's Strategic Plan for Population Health—December 2015

Document Summary

SFDPH's Strategic Plan for the Population Health Division builds upon the Community Health Assessment (CHA) and the Community Health Improvement Plan (CHIP) to identify the Population Health Division's six focus areas: 1) Ensure Safe and Healthy Living Environment; 2) Healthy Eating and Physical Activity; 3) Access to Quality Care and Services; 4) Black/African American Health; 5) Mother, Child, and Adolescent Health; and 6) Health for People at Risk or Living With HIV. The strategic plan attaches Division objectives, identifies stakeholders, recommends programmatic and policy strategies, and proposes evaluative indicators for each focus area.

Some Key Points that address vulnerable populations, climate change, or extreme weather events:

- A headline indicator for the focus area 'Ensure Safe and Healthy Living Environment' is 'Number of days in San Francisco with good air quality'. Citywide air quality is identified as a headline indicator because it is associated with adverse health outcomes including aggravated asthma, chronic bronchitis, and can be a contributing factor to ischemic heart disease, cancers, and lower respiratory infections. Climate Change increases the frequency and severity of extreme heat events and these heat events exacerbate the creation of ground-level ozone and impact air quality. Extreme heat may also modify the growing season for allergen-producing plants and increase the severity of allergies in San Francisco. Programmatic and policy strategies to impact this headline indicator are many of the interventions proposed in this San Francisco Climate and Health Adaptation Framework, including using Climate and Health environmental assessments and weather alerts in programmatic activities.

- A headline indicator for the focus area 'Healthy Eating and Physical Activity' is 'Percent of residents who have food security (resource, access, and consumption)'. As climate change increases year-to-year, fluctuation of precipitation levels and a lengthy drought may impact the cost of produce and modify the food security of San Franciscans.

What implications does this report have on preparedness efforts for climate-related events in San Francisco?

The San Francisco Strategic Plan for Population Health identifies headline indicators for each of the six focus areas identified in the CHA and the CHIP. These indicators act as the base unit of the strategic plan and are attached to a background narrative, best practices, stakeholders and partners, and San Francisco-specific strategies. While the Strategic Plan for Population Health acts as a comprehensive forward-facing planning document, each headline indicator could be enhanced by an 'emerging trends' section that anticipates

how contextual factors (i.e. housing, climate change, demographics, technology) may modify the indicator in the future.

While 'Number of days in San Francisco with good air quality' is included as a headline indicator, additional analysis could be included on how air quality will be impacted by climate change-related events. Climate change should be included in the narrative attached to this priority area, climate adaptation should be identified as a best practice, and interventions identified in this Climate and Health Adaptation Plan should be included in strategies to meet indicator objectives.

5.2.3

San Francisco Health Network Strategic Plan—August 2016

Document Summary

This update to the San Francisco Health Network (SFHN) Strategic Plan reviews SFHN priorities and provides updates on both the development of the Strategic Plan, associated strategic initiatives, and the True North Metrics used to evaluate SFHN processes. The Strategic Plan is divided into four sections; SFHN Priorities, Strategic Plans, A3Ts and True North Metrics. A3Ts and True North Metrics are both concepts from the concept in the *Lean* improvement process. An A3T is a strategy implementation tool to build alignment among organizational functions and strategic functions. True North Metrics are a compass proving a guide to take an organization from the current condition to where they want to be.

SFHN Priorities

- Stabilize SFHN Leadership
- Operationalize ZSFG hospital opening
- Develop marketing/branding strategy and roadmap
- Collaborate on DPH enterprise space planning
- Participate in DPH workforce development trainings
- Expand payer base using Oliver Wyman payer strategy roadmap
- Integrate and standardize operational processes across SFHN
- Implement CMS 1115 Medicaid waiver programs
- Plan for the DPH enterprise EMR

True North Targets

- Safety
- Quality
- Care Experience
- Workforce
- Financial Stewardship
- Equity

Strategic Plans and A3Ts

- Right information, anytime, everywhere
- Align care, finances, & clinical operations for accountable care using the statewide waivers
- Right care, right place, right time
- Stabilize finances
- Optimize external communication & outreach
- Create timely, actionable, & relevant data to support continuous improvement
- Operational integration
- Implement the master facility plan

Some Key Points that address vulnerable populations, climate change, or extreme weather events:

- The SFHN Strategic Plan's strategic initiatives to improve medical service will also protect vulnerable populations against the health impacts associated with climate-related extreme weather events. Some of the most pertinent initiatives include:
  - The SFHN Strategic Plan prioritizes safety and quality of service to reduce hospital readmissions and decrease client re-hospitalizations. This would be accomplished through improved discharge follow-up and improved emergency department follow-up.
  - To ensure that SFHN staff is best able to solve problems and respond to system needs and emphasizes workforce development.
  - The Plan articulates that SFHN can improve equity and eliminate health disparities. These initiatives would focus on the vulnerable populations most likely to be impacted by climate change.
  - The Strategic Plan emphasizes implementation of the master facility plan to increase care experience and operational integration.

What implications does this report have on preparedness efforts for climate-related events in San Francisco?

Many initiatives proposed by the SFHN Strategic Plan have implications on climate change-related preparedness efforts.

As part of the initiative to increase safety and the quality of care, facilities must ensure they are resilient to power outages, flood events, and other extreme weather events and they are prepared for increased service demand during and after such events. Example resilience activities include, receiving notifications of weather warnings, alerts, and advisories for hazard conditions, working with facility managers to review utility and infrastructure vulnerability, and develop adaptations such as Solar+Storage to ensure continuity of service during extreme weather events.

In addition to preparing for climate change impacts, health facilities can play a lead role in mitigating greenhouse gas emissions. A climate resilient health care facility recognizes and commits to sustainable practices that benefit the hospital and broader community. The health care sector can also offer education and advocacy around climate change policy. Health care professionals, especially doctors and nurses, are known to be positive messengers for health in society. As we start to understand the enormous health care and social costs of climate change, health care professionals are in a prime position to educate their patients about the public health impacts of climate change and help prepare them for these impacts.

5.2.4

San Francisco Indicator Project

Document Summary

Developed in 2015 and managed by the SFDPH's Population Health Division's Environmental Health Branch, the San Francisco Indicator Project is a neighborhood-level data system that measures San Francisco's performance as a healthy, equitable community. The project collects data from many domains including the environment, transportation, community, public realm, education, housing, economy, and health. The data is used to support City planning and decision making and community advocacy.

Some Key Points that address vulnerable populations, climate change, or extreme weather events:

- Environmental indicators include: Natural Areas, Contaminated Sites, Air Quality, Impervious Ground Surfaces, Tree Canopy, and Sewer Overflows. These indicators all either measure or modify the impact of climate change-related hazard events.
- Transportation indicators that measure the safety, availability, or use of non-motorized transportation have climate health co-benefits from reducing automotive greenhouse gas emissions and increasing resiliency.
- Community indicators such as block parties, voting rates, and likelihood of leaving San Francisco can be associated with social cohesion. Social cohesion is a predictor of resiliency during emergencies.
- Housing health and safety violations can be used to approximate the quality of housing. Housing quality can modify exposure to heat, mold, or the health impacts of power outages.

What implications does this report have on preparedness efforts for climate-related events in San Francisco?

- The Climate and Health Program has developed the *Extreme Heat Vulnerability Index* (2012), *Community Resiliency Indicator System* (2015), and the *Flood Health Vulnerability Index* (2016) to identify communities particularly vulnerable to the health impacts of climate change-related hazard events. These indices could be integrated into the San Francisco Indicator Project as a method to formalize community resiliency as a core objective of the public health department.

- As the Climate and Health Program develops adaptive interventions, evaluative indicators could be integrated into the San Francisco Indicator Project, either as part of a new domain or within the existing framework.

5.2.5

San Francisco Health Care Services Master Plan—October, 2013

Document Summary

The Health Care Services Master Plan was developed by the San Francisco Department of Public Health and the San Francisco Planning Department to provide the Health Commission, the Planning Commission, The Mayor's Office and the Board of Supervisors information on "the current and projected need for, and locations of, health care services in San Francisco" and recommendations and guidelines "how to achieve and maintain appropriate distribution, and access to, such services". This document aligns with the priorities of the CHIP, and the key findings are divided into four distinct sections:

- **Community Health Status Assessment** that uses data indicators to identify current health status and socioeconomic and demographic trends.

- **Health System Trends Assessment** that assesses how government policy, technology, funding, and organizational structure may impact the quality and breadth of health service.

- A **Capacity + Gap Assessment** that quantifies the current and future capacity of City medical services and identifies service gaps and underserved communities.

- A **Land Use Assessment** that inventories the supply, need, and demand for medical uses in San Francisco neighborhoods and identifies the land use burdens that these uses may have on other neighborhood services.

Some Key Points that address vulnerable populations, climate change, or extreme weather events:

- One of the Health Care Services Master Plan's key findings from the Capacity + Gap Assessment section is the connection between vulnerable populations (age, immigration status, language, income, pre-existing health conditions, access to transportation) and the ability to access health services. The document indicates that reaching populations with low health literacy may be a gap in SFHN service. Climate change-related health impacts are closely associated with health literacy; the ability for residents to both prepare for hazard events and access services during and after those events and can significantly improve resiliency.

- Guidelines 3.3.1 – 3.3.3 are policy recommendations for developing capacity to care for San Francisco's growing senior population. This population is particularly vulnerable to climate change-related hazard events, including extreme heat and power outages.

- The Capacity + Gap Assessment identifies that San Francisco's behavioral health services system is likely to be strained under Health Reform. These behavioral health conditions are likely to be modified by climate change-related stressors.

What implications does this report have on preparedness efforts for climate-related events in San Francisco?

- The Health Care Services Master Plan uses quantitative and qualitative resources to assess the capacity and scope of current health services, identify gaps in health services, and anticipates future system trends. This document may be an opportunity to integrate climate and health principles into SFDPH planning infrastructure.

    - The Healthcare Services Master Plan uses data to forecast health needs. This section could incorporate climate projections (i.e. temperature, air quality, sea level rise, precipitation) or climate health indices (i.e. Community Resiliency Index, extreme heat index, flood health index) to anticipate future Citywide and neighborhood demand for health services.

- Many of the key findings, recommendations, and guidelines have climate health co-benefits. These co-benefits (i.e. mass transportation and greenhouse gas reduction, green space and stormwater management) could be more explicitly referenced.

- The Health Care Services Master Plan directs the planning and development of new medical and health services infrastructure. This plan could identify and formalize recommendations for new and existing health facilities to pursue adaptive improvements including expanding solar capacity, enhancing stormwater management improving heating and cooling systems, and installing blue or green roofs.

5.3

San Francisco Department of Public Health Facility Survey: Vulnerability Assessment

As climate change increases the frequency and severity of extreme weather events and modifies their associated health outcomes, it is important to assess the resiliency of San Francisco's health infrastructure. The San Francisco Department of Public Health owns and operates hospitals, health clinics, and administrative offices throughout the City of San Francisco. To ensure that these services maintain operations in extreme weather events, the Climate and Health Program has started to inventory adaptive improvements in SFDPH-owned buildings. The objectives of this inventory are to:

- Assess the vulnerability of SFDPH-owned infrastructure to climate health stressors.
- Identify possible upgrades to SFDPH infrastructure to protect against climate hazard events.
- Develop a dialogue with SFDPH facilities staff to foster a culture of climate preparedness.
- Identify opportunities to align SFDPH facilities with City and national climate mitigation best practices.

This document represents the first step of the Public Health Facility Survey and acts as a vulnerability assessment of climate health stressors on SFDPH-owned administrative buildings, health clinics, and other SFDPH-owned property. This assessment demonstrates that many SFDPH-owned properties are in neighborhoods projected to be affected by the health impacts of extreme heat, flooding, and air pollutants. We expect this assessment to advance the Public Health Facility Survey by allowing staff to identify necessary upgrades to SFDPH infrastructure and align those adaptive improvements with projected vulnerabilities.

The San Francisco Department of Public Health Facility Survey examines the vulnerability of **SFDPH-owned clinics and administrative offices**. The clinics and administrative buildings in this vulnerability assessment do not represent an exhaustive list of SFDPH operations, but rather the infrastructure owned by SFDPH. SFDPH also operates health clinics and mental health facilities in leased buildings. Other facilities not included in this assessment include:

- Privately-operated hospitals and health clinics
- SFDPH services that operate out of facilities leased to SFDPH.
- Zuckerberg San Francisco General Hospital
- Laguna Honda Hospital
- SFDPH leased or contracted services

Vulnerability Assessment

More detailed information about the data used in the vulnerability assessment can be found in the Technical Addendum on page 44.

Sea level rise and temporary storm surge (Figure 13) will exacerbate instances of flood inundation along San Francisco's shoreline. Facilities located in areas vulnerable to flood inundation must prepare by developing adaptive infrastructure to ensure continuity of service. We assessed the impact of 108 inches of coastal flood inundation of SFDPH clinics and administrative offices.

Figure 13

SFDPH-owned facilities and coastal flood inundation (storm surge and sea level rise)

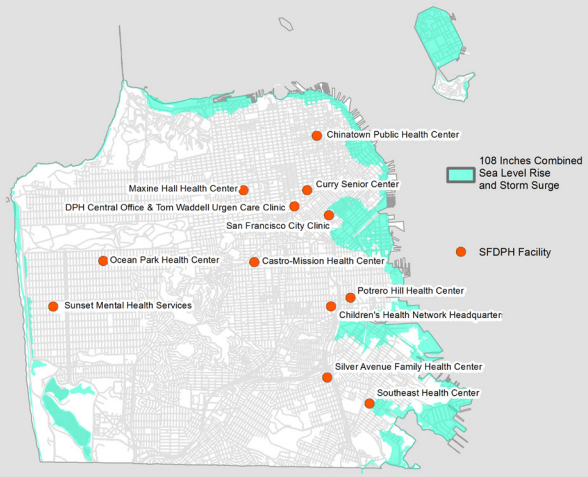


Figure 14

SFDPH-owned facilities and precipitation-related flood inundation during extreme storms

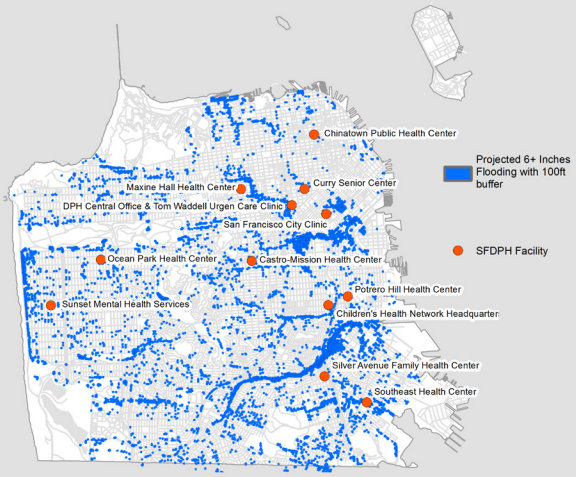
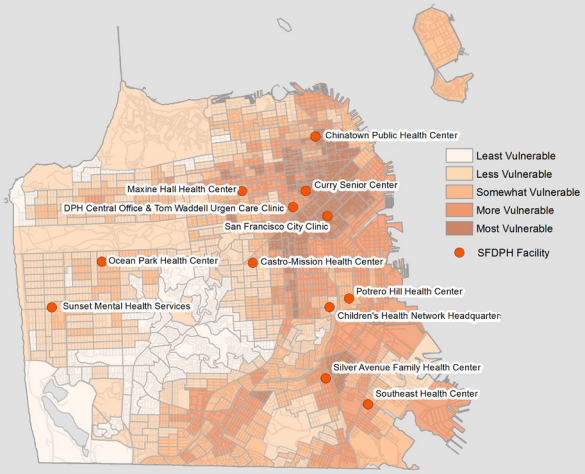


Figure 16

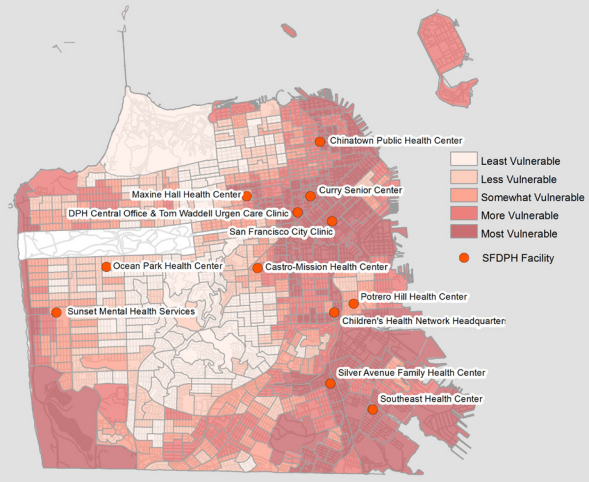
SFDPH-owned facilities and the health impacts of extreme heat, by 2000 census blocks



Climate change is expected to increase the frequency and intensity of extreme storms and will exacerbate instances of **precipitation-related flood inundation** (Figure 14) in the City's interior. Facilities located adjacent to precipitation-related flooding must ensure adaptive infrastructure is sufficient to protect against stormwater overflow. We identified facilities located within 100 feet of locations projected to experience more than 6 inches of precipitation-related flood inundation in a 100-year storm. Any flooding below 6 inches is likely to be immediately captured by existing storm drains. The purpose of the 100-foot buffer is to account for uncertainty in the exact locations of flood inundation, and to acknowledge inundation's impact on adjacent infrastructure.

Figure 15

SFDPH-owned facilities and the health impacts of flooding and extreme storms, by 2010 census block



The health impacts of climate change-related flood inundation and extreme storms will have robust and cascading impacts on public health. SFDPH facilities located in census block groups vulnerable to the **health impacts of flood inundation and extreme storms** (Figure 15) will be expected to serve the increased demand of the adjacent communities.

By 2100, climate change is projected to increase San Francisco's average yearly temperatures between 4.1°F and 6.2°F and increase the number of extreme heat days by nearly 90 per year. Extreme heat is associated with many health outcomes including heat-related illness, respiratory illness, diabetes, and cardiovascular illness. Facilities located in census block groups vulnerable to **the health impacts of extreme heat** (Figure 16) will be expected to meet the increased demand of the adjacent communities.

Figure 17

SFDPH-owned facilities and the community resiliency indicator system, by 2012 planning neighborhoods

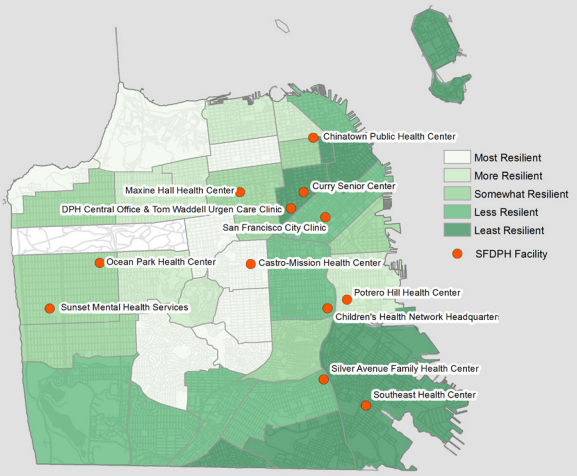
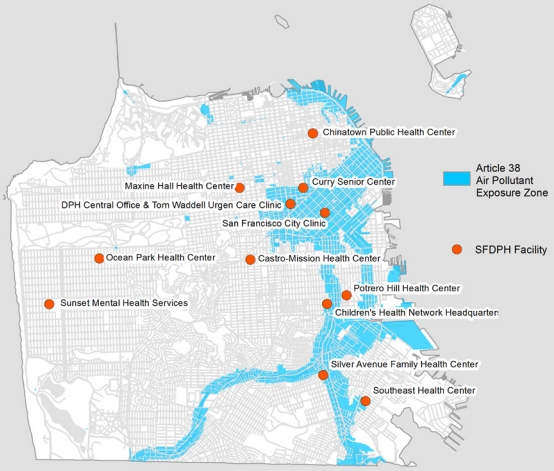


Figure 18

SFDPH-owned facilities and the Article 38 air pollution exposure zone



Resiliency or vulnerability can be modified by socioeconomic and demographic factors such as age, race, and income, environmental factors such as air quality, extreme heat, and impervious surface, infrastructure factors such as transit access and housing quality, pre-existing health conditions, and proximity to neighborhood goods and services. Facilities located in neighborhoods vulnerable to the **health impacts of climate change-related extreme weather events** (Figure 17) will be expected to meet the increased demand of the adjacent communities.

Climate change will modify air quality as extreme heat accelerates the creation of ground level ozone and other fine particulates. The **Air Pollution Exposure** (Figure 18) map identifies air pollution exposure zones based on cancer risk, PM2.5 concentration, and proximity to freeways. Facilities located in air pollution exposure zones must ensure adaptive infrastructure to protect against the health impacts of air pollution and establish capacity to serve adjacent vulnerable communities.

Table 3

Facility Climate Risk Inventory

Clinic Name	Address	Sea Level Rise	Precipitation	Flood Health Index	Extreme Heat Vulnerability	Community Resiliency Index	Air Pollution Exposure
Department of Public Health Central Offices	101 Grove St	No	No	Very High Vulnerability	High Vulnerability	Very High Vulnerability	Yes
Castro-Mission Health Center	3850 17th Street	No	No	Low Vulnerability	Medium Vulnerability	Very Low Vulnerability	No
Chinatown Public Health Center	1490 Mason Street	No	No	Very High Vulnerability	High Vulnerability	Low Vulnerability	No
Community Health Network Headquarters	2789 25th St	No	No	Very High Vulnerability	Very Low Vulnerability	High Vulnerability	No
Curry Senior Center	333 Turk St	No	No	Very High Vulnerability	Very High Vulnerability	Medium Vulnerability	Yes
Maxine Hall Health Center	1301 Pierce Street	No	No	Very High Vulnerability	Very High Vulnerability	Very High Vulnerability	No
Ocean Park Health Center	1351 24th Avenue	No	No	Very High Vulnerability	Very High Vulnerability	High Vulnerability	No
Potrero Hill Health Center	1050 Wisconsin Street	No	No	Medium Vulnerability	Low Vulnerability	High Vulnerability	No
San Francisco City Clinic	356 07th St	No	Yes	Very Low Vulnerability	High Vulnerability	Medium Vulnerability	Yes
Silver Avenue Family Health Center	1525 Silver Avenue	No	No	High Vulnerability	Very High Vulnerability	High Vulnerability	Yes
Southeast Health Center	2401 Keith Street	No	Yes	High Vulnerability	Very High Vulnerability	High Vulnerability	Yes
Sunset Mental Health Services	1990 41st Ave	No	No	High Vulnerability	Medium Vulnerability	Very Low Vulnerability	No
Tom Waddell Health Center	50 Lech Walesa	No	No	Very High Vulnerability	High Vulnerability	Very High Vulnerability	Yes

6.

Addendums

6.1

Technical Addendum: Projection Methodology

Projection	Description	Source
Temperature	Average yearly temperature, in degrees Fahrenheit	Scripts Institute of Oceanography, Cal-Adapt and California Nevada Applications Program. Temperature: Extreme Heat Tool, http://cal-adapt.org/temperature/heat/. Accessed October, 2016.
Extreme Heat Days	Annual extreme heat days. An extreme heat day is a day that maximum temperature reaches the 98th percentile of all temperatures for that particular region. In San Francisco an extreme heat day is any day over 85 degrees Fahrenheit.	California Climate Action Team, Preparing California for Extreme Heat: Guidance and recommendations, October 2013. http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf
Sea Level Rise and Storm Surge	Sea level rise and storm surge projections are relative to year 2000 and represent the most likely (mid-range) estimates and upper range estimates. These projections assume no major adaptive infrastructure developments. The most likely projection is 77 inches of flood inundation and the upper range projection is 108 inches of flood inundation. The technical memorandum indicates that projections use Dynamic Water Level (tide + storm surge + setup) instead of Total Water Level (dynamic water level + run-up).	Committee on Sea Level Rise in California, Oregon and Washington, "Sea-Level Rise for the Coasts of California, Oregon and Washington: Past Present and Future" National Research Council, http://ssi.ucsd. edu/scc/images/NRC%20SL%20rise%20W%20coast%20USA%2012.pdf San Francisco Sea Level Rise Committee for the San Francisco Capital Planning Committee (2015) "Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability Risk to Support Adaptation".
Extreme Storms	Extreme storms are defined in this document as atmospheric river events. Atmosphere river events are where intense winds transport bands of water vapor 2000km from Hawaii, across the Pacific Ocean, and to the Western United States.	Dettinger, Michael et. al. "Storms, floods, and atmospheric rivers-- Putting the extreme into Calfornia extremes" USGS, Scripps Institute of Oceanography, 2012. http://www.scwa.ca.gov/files/docs/outreach/calendar/extreme-events/Atmosperic%20Rivers%20Dettinger%20EE%203-14-12.pdf Dettinger, Michael, 2011. Climate Change, Atmospheric Rivers, and Floods in California – A Multimodel Analysis of Storm Frequency and Magnitude Changes. Journal of the American Water Resources Association (JAWRA) 47(3):514-523. DOI: 10.1111/j.1752-1688.2011.00546.x
Precipitation-related flood inundation	We defined precipitation-related flood inundation includes anywhere projected to receive more than 6 inches of precipitation-related inundation during 100-year storm events. This measurement aligns with the depth of the City storm drains and assumes all inundation under 6 inches should be captured by existing stormwater infrastructure.	San Francisco precipitation-related inundation projected during extreme storm events, San Francisco Public Utilities Commission. Developed by AECOM. 2015.
Flood health index	The Flood Health Index uses socioeconomic and demographic indicators, exposure, pre-existing health conditions, and housing quality to identify communities most vulnerable to the health impacts of flood inundation and extreme storms. The Flood Health Index was developed by the San Francisco Department of Public Health's Climate and Health Program in 2016. A detailed description of Flood Health Index methodology can be found in the 2016 report, "Climate and Health Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding and Extreme Storms".	San Francisco Department of Public Health. Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding and Extreme Storms (2016). Retrieved from: https://extxfer.sfdph.org/gis/ClimateHealth/Vunerability%20Assessments/FloodVulnerabilityReport_v5.pdf
Extreme heat index	The indicators used to develop the Extreme Heat Vulnerability Index include socioeconomic and demographic factors, environmental exposure factors, and infrastructure conditions. The Extreme Heat Vulnerability Index was developed by the San Francisco Department of Public Health's Climate and Health Program in 2012. A detailed description of Extreme Heat Vulnerability Index can be found in the 2012 report, "Understanding the Risk: An Assessment of San Francisco's Vulnerability to Extreme Heat Events".	San Francisco Department of Public Health. Understanding the Risk: An Assessment of San Francisco's Vulnerability to Extreme Heat Events, (2012). Retrieved from: http://www.sfhealthequity.org/ component/jdownloads/finish/42/269
Community resiliency indicator system	The Community Resiliency Indicator System uses 38 indicators to approximate vulnerability and resiliency in San Francisco. These indicators fall into the following domains: Hazard Indicators, Environmental Indicators, Transportation Indicators, Community Indicators, Public Realm Indicators, Housing Indicators, Economy Indicators, Health Indicators, and Demographic Indicators. More information on the Community Resiliency Indicator System methodology can be found in the San Francisco Climate and Health Profile (2014) or on the website www.sfclimatehealth.org.	San Francisco Department of Public Health. San Francisco Climate and Health Profile (2014). Retrieved from: http://www.sfclimatehealth.org/wp-content/uploads/2015/01/SFDPH_ClimateHealthProfile_FinalDraft.pdf
Article 38 air pollution zone exposure	The Air Pollution Exposure Zone identifies sites that either had a cancer risk of greater than 100 per one million exposed or PM2.5 concentrations greater than 10μg/m^3. The pollution model used to develop the map identified freeways, roadways, permitted stationary pollution sources, and bus, port and other transportation networks.	Planning, DPH "Memorandum Re: 2014 Air Pollutant Exposure Zone Map" (2014) Message To File doi: https://sfgov.legistar.com/View.ashx?M=F&ID=3451071&GUID=F9D277DE-D3C3-413E-870B-6067814C1A7A

6.2

Citations

The San Francisco Climate and Health Adaptation Framework builds upon earlier work of the San Francisco Department of Public Health's Climate and Health Program. The Climate and Health Program reports and assessments used to develop this Climate and Health Adaptation Framework include:

- *Analysis of Extreme Heat Events and Illness in San Francisco, CA* (2013)
- *Environmental Health Indicators of Climate Change* (2013)
- *Understanding the Risk: An Assessment of San Francisco's Vulnerability to Extreme Heat Events* (2013)
- *San Francisco Climate and Health Profile* (2015)
- *Understanding the Risk: An Assessment of San Francisco's Vulnerability to Flooding and Extreme Storms* (2016)

Other data sources have been identified below by Climate and Health Adaptation Framework section.

2.1 Climate Impacts Summary

Camalier, L., Cox, W., & Dolwick, P. (2007). The effects of meteorology on ozone in urban areas and their use in assessing ozone trends. Atmospheric Environment, 41(33), 7127-7137. doi:http://dx.doi.org.ezproxy.stanford.edu/10.1016/j.atmosenv.2007.04.061

Dawson, J. P., Adams, P. J., & Pandis, S. N. (2007). Sensitivity of PM2.5 to climate in the

eastern US: A modeling case study. Atmos.Chem.Phys., 7(16), 4295-4309. doi:10.5194/acp-7-4295-2007

Dettinger, Michael. (2011) Climate Change, Atmospheric Rivers, and Floods in California – A Multimodel Analysis of Storm Frequency and Magnitude Changes. Journal of the American Water Resources Association (JAWRA) 47(3):514-523. DOI: 10.1111/j.1752-1688.2011.00546.x

Ewing, S. A., Christensen, J. N., Brown, S. T., Vancuren, R. A., Cliff, S. S., & Depaolo, D. J. (2010). Pb isotopes as an indicator of the Asian contribution to particulate air pollution in urban California. Environmental Science & Technology, 44(23), 8911-8916. doi:10.1021/es101450t

Holloway, T., Spak, S. N., Barker, D., Bretl, M., Moberg, C., Hayhoe, K., . . . Wuebbles, D. (2008). Change in ozone air pollution over Chicago associated with global climate change. Journal of Geophysical Research: Atmospheres (1984-2012), 113 doi:10.1029/2007JD009775

Jacob, D. J., & Winner, D. A. (2009). Effect of climate change on air quality. Atmospheric Environment, 43(1), 51-63. doi:http://dx.doi.org/10.1016/j.atmosenv.2008.09.051

San Francisco Planning Department (2016) Sea Level Rise Adaptation Plan

doi: http://default.sfplanning.org/plans-and-programs/planning-for-the-city/sea-level-rise/160309_SLRAP_Final_ED.pdf

3. Climate Risks and Interventions

English P.B., Sinclair A.H., Ross Z., Anderson H., Boothe V., Davis C., Ebi K., Kagey B., Malecki K., Shultz R., et al. Environmental health indicators of climate change for the United States: Findings from the State Environmental Health Indicator Collaborative. Environ. Health Perspect. 2009;117:1673–1681. doi: 10.1289/ehp.0900708

Agency for Healthcare Research and Quality. Quality Indicator User Guide: Prevention Quality Indicators (PQI) Composite Measures, Version 4.3 (2011). Downloaded from: http://www.qualityindicators.ahrq.gov/Downloads/Modules/PQI/V43/Composite_User_Technical_Specification_PQI_4.3.pdf

3.1 Climate change will have the largest health impact on vulnerable populations

San Francisco Department of Public Health (2016) Community Health Assessment

doi: https://www.sfdph.org/dph/files/hc/HCAgen/HCAgen2016/April%205/CHAshort.pdf

3.4 Air Pollution will likely increase, worsening allergy, and respiratory conditions

Bay Area Air Quality Management District. (2015). Air quality summary reports. Retrieved from http://www.baaqmd.gov/about-air-quality/air-quality-summaries

Planning, DPH "Memorandum Re: 2014 Air Pollutant Exposure Zone Map" (2014) Message To File

doi: https://sfgov.legistar.com/View.ashx?M=F&ID=3451071&GUID=F9D277DE-D3C3-413E-870B-6067814C1A7A

3.5 Higher temperatures, sea level rise, extreme storms, and flooding increase the risks of water-related illness

Cunningham, Jay et. al. Driving Water Safety in San Francisco: A Reservoir of Good Practice (2016). City and County of San Francisco Civil Grand Jury. Downloaded from: http://civilgrandjury.sfgov.org/2015_2016/2015-16_CGJ_Final_Report_Drinking_Water_Safety_7_19_16.pdf

SFPUC, North Westside Basin Groundwater Sustainability Plan (2016)

Trtanj, J., L. Jantarasami, J. Brunkard, T. Collier, J. Jacobs, E. Lipp, S. McLellan, S. Moore, H. Paerl, J. Ravenscroft, M. Sengco, and J. Thurston, 2016: Ch. 6: Climate Impacts on Water-Related Illness. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. U.S. Global Change Research Program, Washington, DC, 157–188. http://dx.doi.org/10.7930/J03F4MH

Wade, TJ., S. Sandhu, D. Levy, S. Lee, M. LeChevallier, L. Katz, and J, Colford, Jr.

Did a Severe Flood in the Midwest Cause an Increase in the Incidence of Gastrointestinal Symptoms?Am. J. Epidemiol. (2004) 159 (4): 398-405 doi:10.1093/aje/kwh050

3.6 Climate change, including rising temperatures and changes in weather extremes, is expected to increase the exposure of food to certain pathogens and toxins

2005-2010- *State of California, Department of Finance, Race/Ethnic Population with Age and Sex Detail, 2000–2010. Sacramento, California, September 2012;* 2011-2015- Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the United States, States, and Counties: April 1, 2010 to July 1, 2014. June 2015. U.S. Census Bureau, Population Division

Asimov, Nanette and Paolo Lucchesi "Don't eat Dungeness crab, California health department warns" San Francisco Chronicle: November 7, 2015. doi: http://www.sfgate.com/news/article/Don-t-eat-Dungeness-crab-California-health-6608939.php

Mead, P. S., L. Slutsker, V. Dietz, L. F. McCaig, J. S. Bresee, C. Shapiro, P. M. Griffin, and R. V. Tauxe. "Food-Related Illness and Death in the United States." *Emerging Infectious Diseases* 5, no. 5 (1999): 607–25.

Melissa A. Marx, Carla V. Rodriguez, Jane Greenko, Debjani Das, Richard Heffernan, Adam M. Karpati, Farzad Mostashari, Sharon Balter, Marcelle Layton, and Don Weiss. Diarrheal Illness Detected Through Syndromic Surveillance After a Massive Power Outage: New York City, August 2003. American Journal of Public Health: March 2006, Vol. 96, No. 3, pp. 547-553.

doi: 10.2105/AJPH.2004.061358

Simon, Paul A., Phillip Leslie, Grace Run, Ginger Zhe Jin, Roshan Reporter, Arturo Aguirre, and Jonathan E. Fielding. "Impact of Restaurant Hygiene Grade Cards on Foodborne-Disease Hospitalizations in Los Angeles County." *Journal of Environmental Health* 67, no. 7 (March 2005): 32–36, 56-60.

Ziska, L., A. Crimmins, A. Auclair, S. DeGrasse, J.F. Garofalo, A.S. Khan, I. Loladze, A.A. Pérez de León, A. Showler, J. Thurston, and I. Walls. "Ch. 7: Food Safety, Nutrition, and Distribution." The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Washington, DC: U.S. Global Change Research Program, 2016. http://dx.doi.org/10.7930/J0ZP4417

3.7 Warmer winter and spring temperatures are projected to lead to changes in vectors and vector-borne disease

Beard, C.B., R.J. Eisen, C.M. Barker, J.F. Garofalo, M. Hahn, M. Hayden, A.J. Monaghan, N.H. Ogden, and P.J. Schramm, 2016: Ch. 5: Vectorborne Diseases. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. U.S. Global Change Research Program, Washington, DC, 129–156. http://dx.doi.org/10.7930/J0765C7V

Dooley, Diana S. and Karen L. Smith *Yearly summaries of selected general communicable diseases in California, 2011-2014'* Surveillance and Statistics Section, Infectious Diseases Branch, Division of Communicable Disease Control, Center for Infectious Diseases, California Department of Public Health. 2015. https://www.cdph.ca.gov/data/statistics/Documents/YearlySummaryReportsofSelectedGeneralCommDiseasesinCA2011-2014.pdf

Intergovernmental Panel on Climate Change. Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of the Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge (UK): Cambridge University Press; 2014.

3.8 Rising temperatures, extreme heat events, and changing precipitation patterns are projected to exacerbate drought conditions in California, which impact related health risks for San Franciscans

Ekstrom, Julia A. 2012. Climate Change Impacts, Vulnerabilities, and Adaptation in the San Francisco Bay Area: A Synthesis of PIER Program Reports and Other Relevant Research. California Energy Commission. Publication number: CEC-500-2012-071.

Hanak, Ellen, Jeffrey Mount, and Caitrin Chappelle. "California's Latest Drought." *Public Policy Institute of California*. N.p., July 2016. Web.

Keller, Chris, and Aaron Mendelson. "San Francisco Public Utilities Commission July Water Use." *KPCC*. Southern California Public Radio, 7 Sept. 2016. Web.

Krawchuk, M., and M. Moritz. 2012. Fire and Climate Change in California: Changes in the Distribution and Frequency of Fire in Climates of the Future and Recent Past (1911– 2099). California Energy Commission. Publication number: CEC-500-2012-026.

Krishnakumar, Priya, Armand Emamdjomeh, and Matt Stevens. "One Year after California's Worst Snowpack Ever, Levels Are Back to 87% of Normal." *Los Angeles Times*. Los Angeles Times, 30 Mar. 2016. Web.

National Resources Defense Council (2013) "Where There's Fire, There's Smoke: Wildfire Smoke Affects Communities Distant from Deadly Flames" Issue Brief. Retrieved from https://www.nrdc.org/sites/default/files/wildfire-smoke-IB.pdf

NBC Bay Area Staff. Soberanes Fire Smoke, High Temperatures Impacting Bay Area Air Quality. NBC Bay Area 7/26/2016. Retrieved from: http://www.nbcbayarea.com/news/local/Soberanes-Fire-Impacts-Air-Quality-388256732.html

Roberts, Chris. Rim Fire damage costs San Francisco $36.3 Million. San Francisco Examiner 11/13/2013. Retrieved from: http://archives.sfexaminer.com/sanfrancisco/rim-fire-damage-costs-san-francisco-363-million/Content?oid=2625731

U.S. Drought Monitor. National Drought Mitigation Center (NDMC), the U.S. Department of Agriculture (USDA), the National Oceanic and Atmospheric Administration (NOAA), 23 Aug. 2016. Web.

Report can be found online at www.sfclimatehealth.org

City and County of San Francisco
San Francisco Department of Public Health
Office of Policy and Planning
Climate and Health Program