



5.3.2.7 Climate Change

Climate change involves a long-term shift in global weather patterns, especially increases in temperature and storm activity. Though climate change is a global problem, its impacts will be local. For the CCSF Planning Area, potential climate change impacts include hotter weather, flooding from intensive rains, sea level rise, reduced snow pack, increase in disease vectors, rapid price increases, power outages, and shortages in food and other resources. This section profiles temperature increases, precipitation shifts, and sea level rise due to climate change.

Temperature Rise

Nature

Based on statistics gathered by the National Weather Service, extreme heat events were the number one cause of weather-related fatalities in the United States in 2012. Because of CCSF's temperate climate, most people do not view the city as an area of concern for extreme heat events. However, climate change models project a gradual warming during this century, with heat waves increasing in frequency and severity. San Francisco is particularly vulnerable because of our lack of physiologic and technologic adaptations. Indeed, San Francisco housing stock typically lacks central air conditioning due to its age and to the cooler climate. Studies by the California Department of Public Health in 2008 indicate that in past heat events affecting the state, the highest risk of heat-related illness occurred in cooler regions in coastal counties, not in the Central Valley where the highest actual temperatures were experienced. In addition, heat events can create intensive demands on the electric transmission system, leading to power outages and their accompanying impacts on people. For additional discussion of extreme heat as a hazard, see Section 5.3.2.3, above.

History

Climate change is a gradual process that has been occurring for the last several decades. Since 1920, average annual temperatures have been increasing across California and the San Francisco Bay Area. The July 2006 California heat wave, which was felt in San Francisco, was the largest heat wave on record since 1948. During the hottest day of that four-day event, San Francisco experienced temperatures over 100 degrees Fahrenheit. On that day, the daily emergency medical system call volume for San Francisco more than doubled due to heat-related health impacts throughout the city. In addition, since 2003, California has experienced electricity shortages resulting in 48 Flex Alerts and 25 transmission emergencies, typically during heat events, as air conditioning loads climb in the afternoon and remain high until late at night.

Location

An extreme heat event will affect the entire city. However, the San Francisco Department of Public Health (DPH) recently completed an extensive study to identify local neighborhoods and



population groups at greatest risk for heat waves and poor air quality in San Francisco. The study accounted for up to 20 different social, geographic, and environmental variables. Though the different index-creation techniques generated somewhat different patterns of vulnerability, a few neighborhoods were identified as highly vulnerable by all methods. These neighborhoods include Chinatown, Downtown Civic Center, Bayview, and Mission. For the San Francisco Heat Vulnerability Index Map showing areas of vulnerability to heat, see Figure C-** (Appendix C, Figures).

Extent and Probability of Future Events

California's climate is expected to become considerably warmer during this century. How much warmer, and how extensively the local climate will change as a result, are still to be determined. Much depends on the rate at which fossil fuels continue to be burned. The San Francisco Department of the Environment (DOE) has convened a climate adaptation working group, AdaptSF, which is tasked with making some of these determinations using available climate models. In addition, there is modeling suggesting that the Bay Area is expected to experience an increase in the severity and frequency of ozone episodes. These studies also suggest that for the Bay Area, the sensitivity of ozone to increases in temperature is relatively large compared to other regions, suggesting the Bay Area may be particularly sensitive to climate change.

The 2012 California Adaptation Planning Guide, prepared by the California Governor's Office of Emergency Services (Cal OES) and the California Natural Resources Agency, lays out the following temperature change projections for the Bay Area Region for the next 100 years to 2100, using the more aggressive or high carbon emission scenario:

- January: 4°F to 5°F increase in average temperatures.
- July: 5°F to 6°F increase in average temperatures.

The various warming models make the following additional projections for the Bay Area during the course of this century:

- After 2050, the rate of warming will become considerably greater.
- There will be greater warming in summer months than in winter months.
- Summer heat waves will become more common and more intense.
- Increased warming will have widespread effects on ecosystem health, agricultural production, water use and availability, and energy demand.

Precipitation Changes

Nature

In addition to changes in temperature, both California and the San Francisco Bay Area will continue to see a shift in precipitation patterns, though studies remain uncertain about the



extent of precipitation change. We have already seen a shift toward more extreme weather events globally, indicating that more floods and droughts may result throughout California. Such a precipitation shift will have an impact on agricultural production and on the state's food chain. Without adequate preparation, more intense and frequent rainstorms in San Francisco will severely stress the city's sewage system.

Increased warming has also resulted in a decrease in the overall volume of the snowpack in the Sierra Nevada Mountain range. As temperatures continue to rise, and as mountain areas receive more rain instead of snow, the snowpack will be further threatened. A reduction to the ensuing spring snowpack runoff will have direct implications for San Francisco's freshwater supply, as reduced runoff increases the risk of summer water shortages throughout the region. Moreover, reduced runoff from the Sierra Nevada Mountains into San Francisco Bay will affect the salinity of the bay, which threatens local ecosystems and infrastructure, as well as the livelihoods that depend on them. A wetter, warmer climate will also lead to an increase in vectors, insects or other organisms that spread disease, which in turn adds to the demand on the public health system.

History

Historically, precipitation patterns in the Bay Area Region are characterized by considerable variability between years and decades. According to the Western Regional Climate Center, San Francisco ranges from very wet winters that exceed its 100-year average of 21.14 inches of rain per year, to dry winters with nearly half the average annual rainfall. Though, historically, San Francisco has not experienced major flooding from winter storms, the El Nino winter storms of 1997-1998 and 2003-2004 did create isolated flooding events, resulting in displaced San Francisco residents.

The driest year of the last 100 reported years was 1924, when the state average rainfall was only 10.50 inches. The region with the most stations reporting the driest year in 1924 was the San Francisco Bay Region. The second driest year was 1977, when the average rainfall was 11.57 inches. California has experienced a series of multi-year droughts of large scale. Of note was the 1976-1977 drought, when statewide snowpack runoff hit an all-time low; 47 of the state's 58 counties declared local drought-related emergencies at that time. The 1987-1992 drought was notable for its six-year duration; 23 counties declared local drought emergencies during that period. For further discussion of drought as a hazard, see Section 5.3.2.1, above.

Location

Warming temperatures and reduced snow pack will affect water supplies for San Francisco and for the state. The Hetch Hetchy Regional Water System, which is owned and operated by San Francisco, provides water to 2.4 million people in CCSF and in the greater Bay Area. Eighty-five percent of the water comes from Sierra Nevada snowmelt stored in the Hetch Hetchy reservoir



situated on the Tuolumne River in Yosemite National Park. Hetch Hetchy water travels 160 miles from Yosemite to the San Francisco Bay Area.

Given more severe winter storms, certain areas of San Francisco are more prone to flooding due to topography and the network of San Francisco's combined sewer system. These areas are found on the east side of the City at locations that were historic drainage basins, particularly Mission Creek and Islais Creek. Significant subsidence is also occurring in the South of Market area that will contribute to local flooding. For maps showing areas within CCSF that are prone to stormwater ponding generally, see Figure C-12 (Appendix C, Figures). For further discussion of flooding as a hazard, see Section 5.3.2.2, above.

Extent and Probability of Future Events

The 2012 California Adaptation Planning Guide projects a moderate decline in annual rainfall, of one to three inches by 2050, and four to five inches by 2090, throughout the Bay Area Region, using the more aggressive or high carbon emission scenario. However, great caution is attached to this projection, as precipitation rates vary widely in the region. Nevertheless, the future would appear to be drier compared to historical annual precipitation averages. The decline in annual precipitation indicates that the greatest reduction in precipitation occurs in March and April, while the core winter months are relatively unchanged.

As mentioned earlier, if heat-trapping emissions continue unabated, the Sierra Nevada Mountain Region will see more precipitation fall as rain instead of snow, while the snow that does fall will melt earlier, significantly reducing the spring snowpack. By the end of the century, if temperatures rise to the medium warming range and precipitation decreases, late spring mountain stream flow could decline by up to 30 percent. Decreasing snowmelt and spring stream flows, coupled with increasing demand for water resulting from a growing population and from a hotter climate, could lead to increasing water shortages. California's water resources are already overstretched by the demands of a growing economy and population. Agricultural areas would be hard hit, with California farmers losing as much as 25 percent of the water supply they need.

Sea Level Rise

Nature

Surrounded on three sides by water, San Francisco is particularly vulnerable to rising sea levels. Sea level rise has been a constant for the past century, but as global temperatures increase, the rate of sea level rise will increase accordingly. Using conservative modeling with emission scenarios that are actually less than current emission rates, the California Climate Change Center estimated in 2009 that the number of San Franciscans at risk to a 100-year flood will increase from 190 to 3,800 individuals, given a 1.4 meter (4.5 feet) rise in sea level by 2100. Rising sea levels also present hazards to major CCSF infrastructure, including San Francisco International Airport (SFO); Highway 101, one of four major freeways into the city; the Port of



San Francisco and Fisherman's Wharf; the city's central recycling center at Pier 96; and the Financial District. For additional discussion of flooding as a hazard, see Section 5.3.2.2.

History

Present estimates by the California Climate Change Center assume that sea-level rise along the California coast, particularly at the mouth of San Francisco Bay, will be the same as global estimates. Over the past several decades of tide gage observations, sea level measured along the California coast from San Francisco southward to La Jolla has risen at a rate of about eight inches per century, which is consistent with global average rates.

Location

Sea level rise will affect all coastal areas of CCSF, including Ocean Beach, the Marina, the Embarcadero, and the entire bayside edge, as well as parts of Treasure Island. Flooding from sea level rise will likely damage buildings and roads in these areas. In addition, salt water intrusion will likely cause damage to underground infrastructure, such as pipes and foundations. Coastal flooding also presents a risk to major transportation infrastructure in the region, especially to the Port of San Francisco and to SFO. Given the many scenarios that may affect sea level rise, the San Francisco Department of Environment is currently reviewing the many maps showing CCSF areas vulnerable to sea level rise in to determine which map is most appropriate for use in mapping the City's vulnerability.

Extent and Probability of Future Events

As global temperatures continue to rise, sea levels will also continue to rise in response. Predictions of the rate of sea level rise vary, due primarily to uncertainty regarding the amount of meltwater from land-based ice in Greenland and Antarctica. In 2009, the California Climate Change Center predicted that by 2100, sea levels may rise up to 1.4 meters or 4.5 feet, posing a considerable threat to coastal and low-lying areas adjacent to San Francisco Bay. Under this scenario, the number of acres vulnerable to flooding is expected to increase 20 to 30 percent in most parts of the Bay Area, with some areas projected to experience increases of over 40 percent. The California Adaptation Planning Guide further estimates that coastal areas will experience an increase of approximately 15 percent in the acreage vulnerable to flooding. Increases of this magnitude would inundate coastal areas with salt water, accelerate coastal erosion, threaten inland water systems, and disrupt wetlands and natural habitats.