City of Rancho Palos Verdes Vulnerability Assessment

South Bay Cities Council of Governments

September 10, 2019

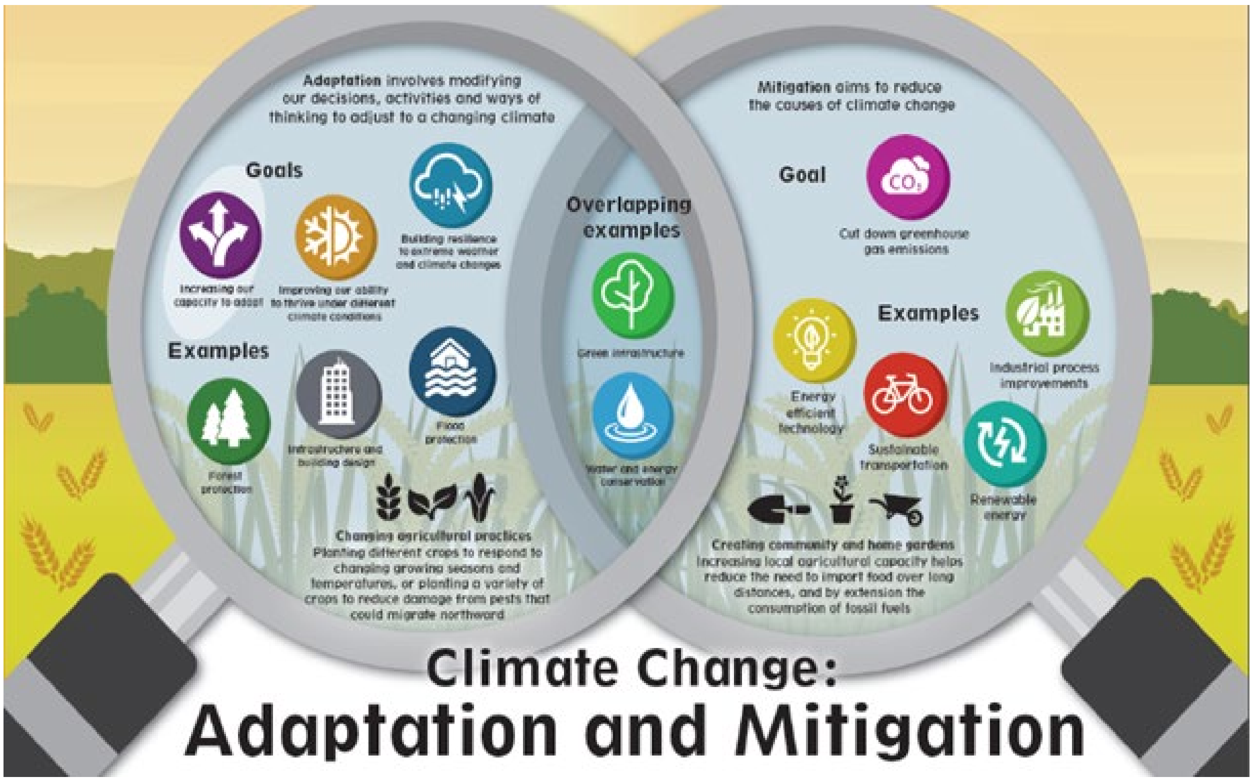


Table of Contents

Introduction

The Vulnerability Assessment was developed by the South Bay Cities Council of Governments (SBCCOG) on behalf of the City of Rancho Palos Verdes (RPV) to educate city staff and the general public on the potential impacts of climate change on of critical facilities and residents' well-being. Additionally, this document will help the City comply with California Senate Bill 379, which requires all cities to address climate adaptation and resiliency strategies in their general plan upon the next revision of their local hazard mitigation plan. Specifically, SB 379 requires local jurisdictions to conduct a vulnerability assessment that identifies areas at risk from climate change impacts. This vulnerability assessment, in accordance with the Office of Planning and Research's guidelines, adheres to the framework provided by the California Adaptation Planning Guide, and provides the City of RPV with:

1. Climate projections from the Cal-Adapt tool
2. Information on the types of structures and populations that will be exposed and/or sensitive to various climate hazards
3. Maps that identify geographic areas of highest risk

> CA Senate Bill 379…
>
> *California Senate Bill 379 (adopted 2015) requires all cities and counties to include climate adaptation and resiliency strategies in the safety elements of their general plans upon the next revision beginning January 2017.*
>
> *The bill requires the climate adaptation update to include a set of goals, policies, and objectives for their communities based on a vulnerability assessment, as well as implementation measures*.

Plan Alignment

Aligning goals and actions across local hazard mitigation plans (LHMP), adaptation plans, general plans, and other planning documents allows mitigation and adaptation efforts to be integrated into local jurisdictions' everyday planning. The City of RPV adopted their Emissions Reduction Action Plan (ERAP) in 2017 and updated their LHMP and General Plan in 2016 and 2018, respectively. This document is meant to build off and bolster the vulnerability assessment provided in the 2016 LHMP, with an emphasis on hazards that are exacerbated by climate change. This assessment, along with the LHMP, will provide a baseline for the City of RPV to plan, implement and track the progress of adaptation strategies complementary to those adopted in the City's ERAP.

Part 1: Climate Projections

As part of the technical work, the SBCCOG recorded future projections for temperature, precipitation, and wind from Cal-Adapt, an interactive, publicly accessible web-based application that provides easy-to-understand visualizations of locally relevant climate related risks. Scientific reports and planning guidance documents are also referenced to determine the extent of sea level rise and how climate-related hazards including floods, wildfire, and drought will change in frequency and severity by 2050 and 2100.

Representative Concentrated Pathway (RCP) is a greenhouse gas concentration trajectory or forecast.

Projections are based on the standardized climate change scenarios from the Intergovernmental Panel on Climate Change (IPCC) Representative Concentrated Pathways (RCP): 1) The "mitigating" scenario (RCP 4.5) and 2) the "business as usual" scenario (RCP 8.5). Guidance from the State Office of Planning and Research recommends local agencies and jurisdictions utilize the business as usual (RCP 8.5) for planning out to 2050 and utilize a risk management approach for the selection of emissions scenarios past 2069.

Temperature

Consistent with the results of the Los Angeles Regional 4th Climate Assessment, average temperatures for the City of RPV are expected to increase 3-4° F by the mid-century, and 4-7° F by the late century, depending on the emissions scenario (**Table 1**).

Table 1: Average Temperature Projections for the City of RPV

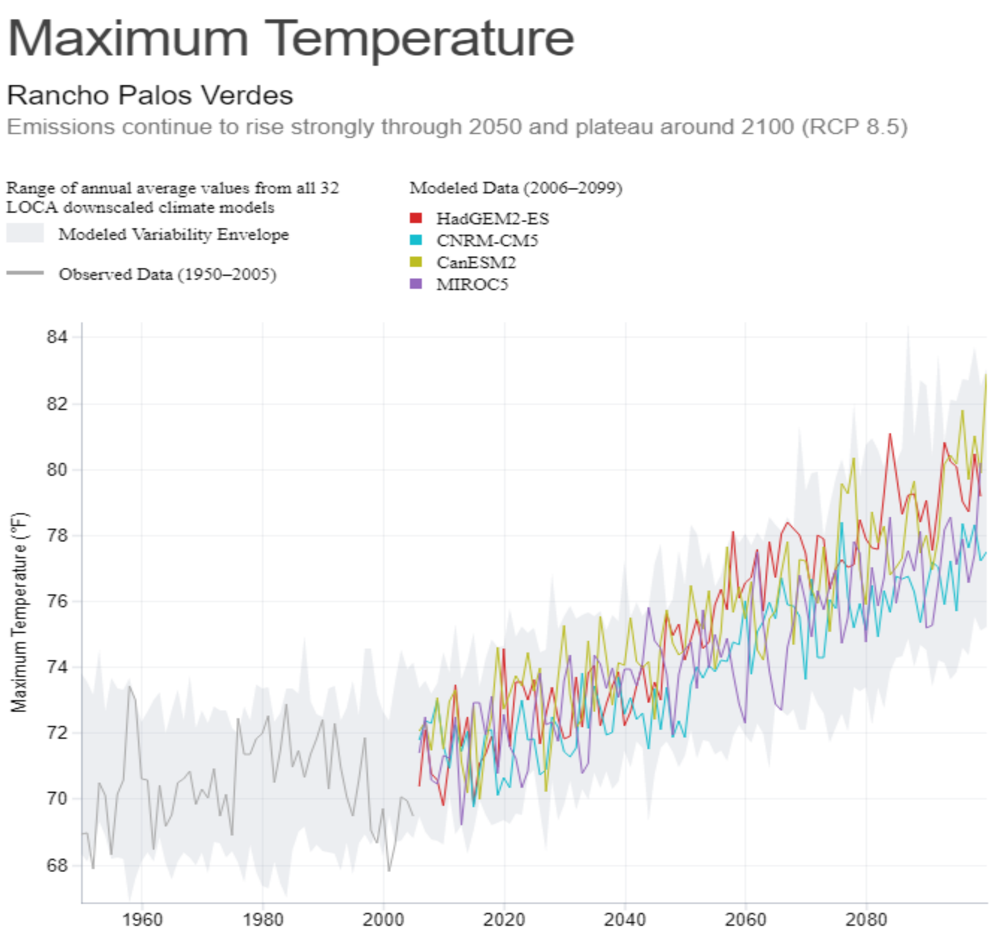
City of RPV	Historical Annual Mean (1960-1989)	Projected Annual Mean for 2020-2049 (RCP 8.5)	Projected Annual Mean for 2040-2069 (RCP8.5)	Projected Annual Mean for 2040-2069 (RCP4.5)	Projected Annual Mean for 2070-2099 (RCP8.5)	Projected Annual Mean for 2070-2099 (RCP4.5)
Degrees Fahrenheit (°F)	71.6	73.9	75.6	74.5	78.3	75.5

Figure 1 provides annual averages of observed and projected maximum temperature values for the City of RPV under the business as usual (RCP 8.5) scenario. The gray line (1950-2005) is

observed data. The colored lines (2006-2010) are projections from four downscaled climate models[1] – called Localized Constructed Analogs, or LOCA models. These models were selected by California's Climate Action Team Research Working Group as the most relevant for the State of California and used in the California's Fourth Climate Change Assessment. Projected future climate from these four models can be described as producing:

- A *warm/dry* simulation (HadGEM2-ES)
- A *cooler/wetter* simulation (CNRM-CM5)
- An *average* simulation (CanESM2)
- A model simulation that couples the atmosphere and ocean general circulation models together with the land and sea ice modules (MIROC5)

Figure 1: Average Temperature Projections for the City of RPV



[1] The newly developed LOCA downscaling method estimates finer-scale (6km) climate detail using systematic historical effects on topography on local weather patterns.

A prolonged period of abnormally hot weather is defined as a heat wave. Heat waves can have an impact on both the environment including habitat and public health. Research and studies have provided evidence that the second warm night - when the interior of households is expected to rise due to outdoor temperatures[1] - have an increased negative effect on morbidity and mortality. In addition, the impacts of heat waves are geographically variable in nature as local populations adapt to the prevailing climate via physiological, behavioral, cultural, and technological adaptations.[2] For this Vulnerability Assessment, an extreme heat day and warm night is defined as "when the maximum temperature exceeds the 98th historical percentile of maximum temperatures based on daily temperature maximum data between 1961 and 1990".[3]

A heat wave in September 2007 lasted only one week but resulted in 18 heat-related deaths.

The July 2018 heat wave caused major outages impacting roughly 35,000 LADWP customers. Southern California Edison reported 19,000 outages.

The City of RPV will experience an increase in average annual heat in a variety of ways, including increased number of extreme heat days and warmer summer evenings (**Table 2**). The number of extreme heat days is projected to rise through the year 2100, where the average year could include 15 extreme heat days under a "business as usual" emissions scenario.[4]

Table 2: Historic and Projected Average Number of Extreme Heat Days and Warm Nights

City of RPV	Threshold Temp (°F)	Observed (1960-1989)	Projected for 2020-2049 (RCP 8.5)	Projected for 2040-2069 (RCP8.5)	Projected for 2040-2069 (RCP4.5)	Projected for 2070-2099 (RCP8.5)	Projected for 2070-2099 (RCP4.5)
Extreme Heat Days	92.1	4	5	7	5	15	7
Warm Nights	66.8	4	15	30	17	68	25

Precipitation

Most climate scientists agree that precipitation in the Greater Los Angeles Area is highly variable from year to year. As a result, there is some ambiguity around what the effect climate change will have on precipitation levels throughout the South Bay. From years 1961-1990 the sub-region received an average of 12.9 inches of rainfall per year.[5] Projections indicate there will be only small changes in average precipitation (**Table 3**); however dry and wet extremes are both expected to increase in the future. These extremes will vary from one year to another with wetter winter conditions offset by the drier spring conditions. By the late-21st century, the wettest day of the year is expected to increase in the sub-region about 20%.

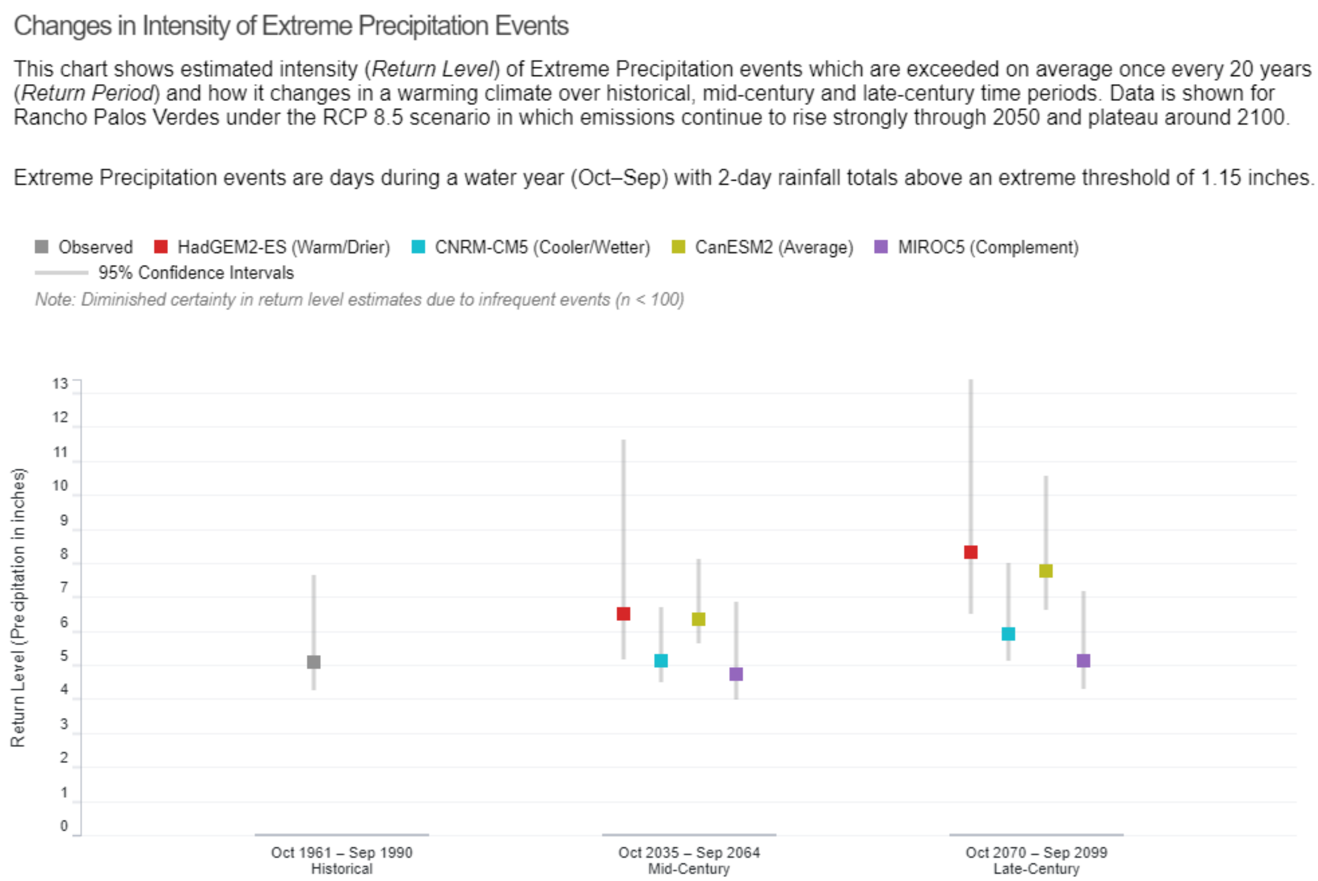
Table 3: Average Precipitation Projections for the City of RPV

City of RPV	Historical Annual Mean for 1961-1990 (Observed)	Projected for 2020-2049 (RCP 8.5)	Projected for 2040-2069 (RCP 8.5)	Projected for 2040-2069 (RCP 4.5)	Projected for 2070-2099 (RCP 8.5)	Projected for 2070-2099 (RCP 4.5)
Precipitation (inches)	12.5	13.4	12.9	12.8	14.9	12.9

Extreme precipitation events are days during a water year (Oct-Sep) with 2-day rainfall totals above an *extreme threshold* of 1.09 inches.[2] The South Bay is projected to experience approximately 2-3 more extreme precipitation events per year by end-of-century under a business as usual scenario (2070-2099, RCP 8.5). **Figure 2** shows estimated intensity ("Return Level") of extreme precipitation events-- which are exceeded on average once every 20 years-- and how it increases in a warming climate over historical, mid-century and late-century time periods. Data is shown for a 6x6 km grid cell for RPV under the business as usual scenario (RCP 8.5). The gray line (1950-2005) is observed data. The colored lines (2006-2010) are projections from the four downscaled climate models (LOCA):

[2] The extreme threshold sets the conditions for which a precipitation event is considered "extreme". The threshold is set to the lowest annual maximum precipitation accumulation in the historical record (1961-1990).

Figure 2: Projected Intensity of Precipitation Events in RPV



Wind

Globally, wind speeds have fallen by as much as 25% since the 1970s.[6] This phenomenon, termed 'stilling' is a consequence of rising global temperatures; air movements are powered by differences in temperature between two locations. The bigger the difference between warm and cold air, the stronger the wind. One effect of global warming is a smaller global temperature differential.

In October 2018, Santa Ana wind gusts reaching 75 mph knocked out power to more than 30,000 Southern California Edison and 500 Los Angeles Department of Water & Power customers.

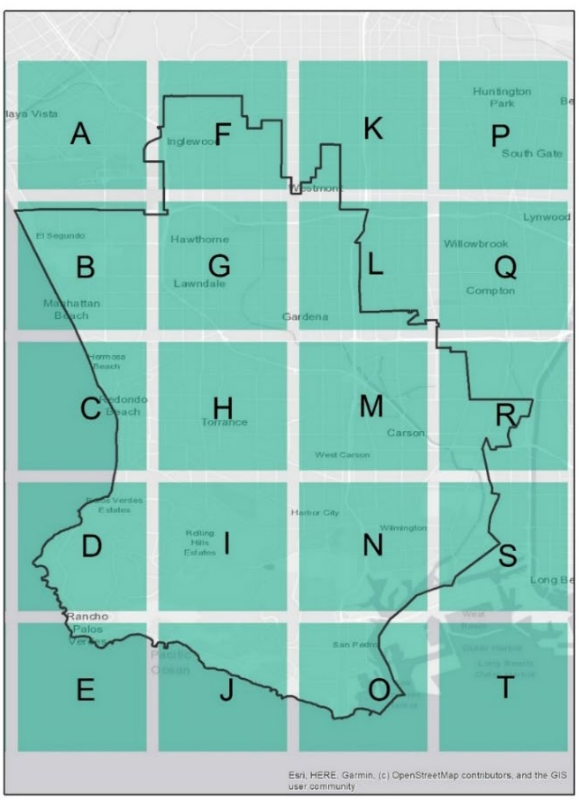
In the South Bay, Santa Ana winds carry high-density air from a higher elevation down under the force of gravity. The Santa Ana winds blow in an offshore direction steered by the topography of the coastal hills and valleys. These winds are an important feature of the region's weather variability, and their high speed and low relative humidity can drive destructive wildfires.

In urban areas like the South Bay, a reduction in wind could contribute to increased smog and compound heat-related impacts. On the other hand, over the next 20 years higher projected wind speeds suggest a potential risk of windstorms that can disrupt power distribution among other adverse impacts. **Table 4** highlights how daily average wind speeds are expected to change for the City based on 6x6 km grid-cell projections.

Table 4: Projected Daily Average Wind Speeds

Map ID (Figure 3)	South Bay City	Historical Average Daily Wind Speed (m/s) 1950-2005	Projected Wind Speed 2006-2039 (RCP 8.5)	Projected Wind Speed 2040-2069 (RCP 8.5)	Projected Wind Speed 2040-2069 (RCP 4.5)	Projected Wind Speed 2070-2099 (RCP 8.5)	Projected Wind Speed 2070-2099 (RCP 4.5)
E	West RPV	3.52	7.16	2.19	2.84	4.73	7.80
J	East RPV	3.27	5.10	1.52	2.54	3.19	5.82

Figure 3: Wind Projection Grid Cell IDs



Sea Level Rise

Sea levels are projected to continue to rise in the future, but to what extent varies largely on different emissions scenarios and uncertainty to the extent warming will have on climate systems. Authors of the 4th Climate Assessment suggest that sea levels could be as high as 2.87m (9.4 ft) by 2100.

The California Coastal Commission has released Guidance (2018) on how to assess and address sea-level rise risks in local communities. This guidance is consistent with previous direction from the Ocean Protection Council (2018) on sea-level rise scenarios to use in planning and development by coastal communities and state agencies.

Specifically, the Coastal Commission recommends “all communities evaluate the impacts from the medium-high risk aversion scenario.”

Local governments should also include the extreme risk aversion scenario (**Table 5**) to evaluate the vulnerability of planned or existing assets that have little to no adaptive capacity, would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety or environmental impacts should that level of sea level rise occur.

Table 5: Sea Level Rise Probabilistic Projections for City of Los Angeles

Projected Sea Level Rise (in feet): *Los Angeles*			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	Upper limit of "likely range" (~17% probability SLR exceeds…)	*1-in-200 chance (0.5% probability SLR exceeds…)*	*Single scenario (no associated probability)*
2030	0.5	0.7	1.0
2040	0.7	1.2	1.7
2050	1.0	1.8	2.6
2060	1.3	2.5	3.7
2070	1.7	3.3	5.0
2080	2.2	4.3	6.4
2090	2.7	5.3	8.0
2100	3.2	6.7	9.9
2110*	3.3	7.1	11.5
2120	3.8	8.3	13.8
2130	4.3	9.7	16.1
2140	4.9	11.1	18.7
2150	5.4	12.7	21.5

Source: Ocean Protection Council Sea Level Rise Guidance Document, 2018

While only advisory, if a community wants to construct in the coastal zone – whether a community has a Local Coastal Program (LCP) or if they are going directly to the Coastal Commission for a Coastal Development Permit – the City will need to get approval from the Coastal Commission, which will in turn expect the city to have considered medium-high-risk sea-level scenarios consistent with Commission guidance documents. Therefore, the SBCCOG assessed the potential impact of medium-high and extreme risk aversion scenarios for the City of RPV (see SLR risk assessment on p. 22).

Floods

Current modeling is limited in its ability to produce quantitative estimates of the effect of climate change on flood hazard risks; however, an understanding of the basic features of climate change allows for a qualitative assessment of impacts on flood-related hazards.

High frequency flood events (e.g. 10-year floods) will likely increase with a changing climate.[7] Along with reductions in the amount of the snowpack and accelerated snowmelt, scientists project greater storm intensity, resulting in more direct runoff and flooding.[8] With the added potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which will increase sediment loads and impact water quality.[9] As the flow of water and landscape changes, what is currently considered a 100-year flood may strike more often, leaving many communities already exposed to flood hazards at greater risk.[10]

El Nino

El Nino and La Nina are opposite phases of what is known as the El Nino-Southern Oscillation (ENSO) cycle. The ENSO cycle describes the fluctuations in wind patterns, sea-surface temperatures, and ocean atmosphere interactions across the Equatorial Pacific. El Nino events are characterized by higher than normal sea surface temperatures in the eastern and central tropical Pacific Ocean and can result in higher rainfall for the California coast.[11]

El Nino has a major impact on the weather and flooding conditions of the Pacific coast. During El Nino winters, storm tracks often dip further south than their normal track and directly impact Southern California with more frequent storms, increased chances of heavy rainfall and higher wave heights with accompanying floods, landslides, and coastal erosion.

A scientific paper published in Nature in 2014 used 20 climate models to assess changes in El Nino behavior assuming climate change over the next 100 years[12]. They found a consistent pattern across most models, doubling the frequency of intense El Nino events. The probability of a 1/20-year intense El Nino (such as those in 1982−83 and 1997−98) will increase roughly to 1/10 years. Although there remains much uncertainty over the effects of climate change on climate variability such as El Nino, the most damaging events in California will likely be driven by El Nino storms in combination with high tides.

Tropical Cyclones and Storms

There is a low frequency of tropical cyclones making landfall in Southern California due to low seawater temperatures and north-westward track.[13] Such cyclones usually require warm water

(>26.5°C; 80°F), but the coastal waters in California rarely rise above 24°Celsius (75°F). Another reason for the low probability of hurricanes in California is the general northwestward or westward direction of tropical cyclones, steering them away from land. Climate change may affect the frequency, intensity, and location of tropical cyclones. A study by Mendelsohn et al. (2012) used four different models to estimate tropical cyclone tracks in the current and future climate.[14] They observed increasing storm power in the northeast Pacific consistently over the four models, which may indicate increased future storm activity in Southern California; however, there are currently few studies that have investigated the effect of climate change on tropical cyclones and storms for this area.

Drought

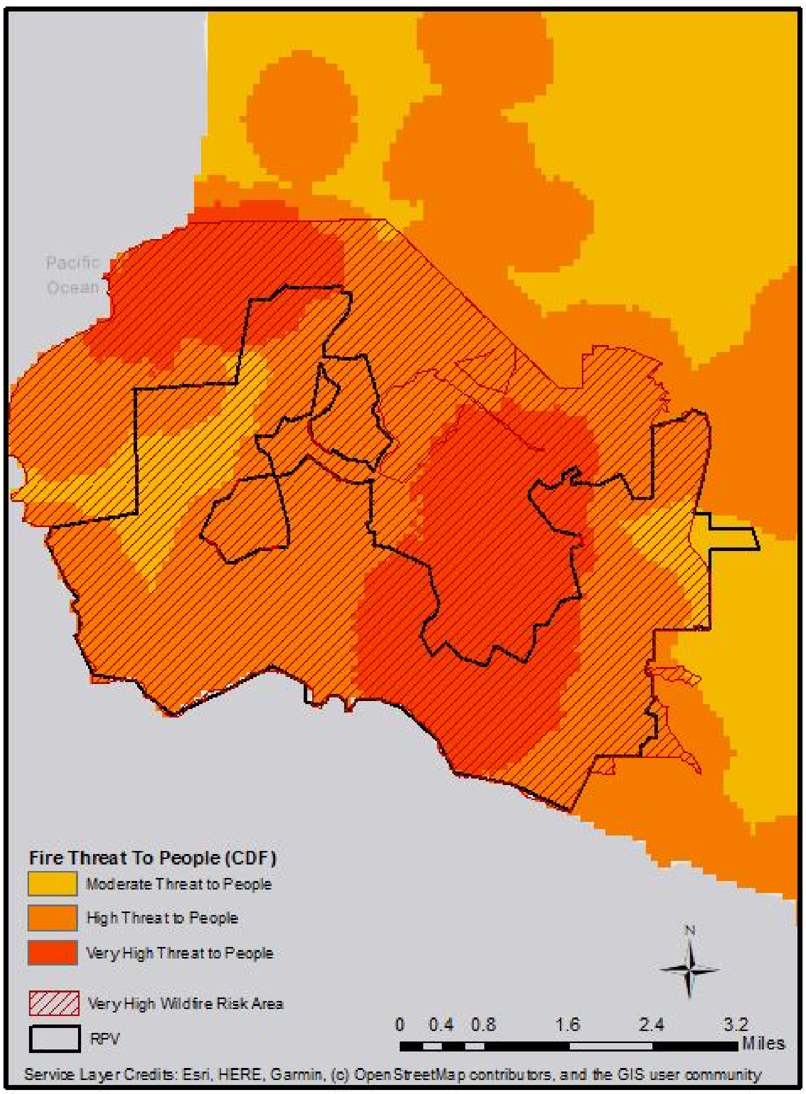
Most of the imported water used in the City of RPV ultimately comes from snowmelt originating in the Sierra Nevada range. Researchers at UCLA found that more precipitation will likely fall as rain rather than snow and accumulated snow will melt sooner than in modern history due to elevated temperatures.[15] As a result, runoff will occur earlier in the season and in greater volumes, making capture for use much more difficult in the future.[16] Reduced winter precipitation levels and warmer temperatures have greatly decreased the size of the Sierra Nevada snowpack (the volume of accumulated snow), which in turn makes less fresh water available for communities throughout California. By the end of this century, California's Sierra Nevada snowpack is projected to experience a 48-65% loss, corresponding to emissions scenarios RCP 4.5 and RCP 8.5, respectively, from the historical (1981-2000) April average.

Continued decline in the Sierra Nevada snowpack volume is expected, which may lead to lower volumes of available imported water. Adding to this situation, external factors such as increased demand on imported supplies outside of the Los Angeles region will likely amplify the problem and lessen the dependability of imported water sources to the region. The City of RPV via Cal Water Service Co. imports approximately 75% of its water supply, though the City has taken steps to decrease their reliance on imported water by investing more aggressively in local water sources including groundwater (19%) and recycled water (6%).[17]

Wildfire

A wildfire is an uncontrolled fire spreading through vegetative fuels and is one of the hazards in the subregion that poses a substantial risk to life and property. In addition to this direct threat, smoke released during an event can have a detrimental effect on air quality. As shown in Figure 4, most of the City of RPV is designated as a Very High Fire Severity Zone (Cal-Fire designation). **Figure 4** shows the California Department of Forestry and Fire Protection's (CDF) Fire Threat layer, which combines expected fire frequency and fire behavior with proximity to urban areas to create threat classes ranging from moderate to extreme.

Figure 4: Wildfire Threat, City of RPV



Wildfires may start for any number of reasons, including arson, human error, or lightning, irrespective of climate change. Throughout the western United States there is a strong relationship between drought conditions and fire activity.[18] However, in Southern California during the twentieth century, there was a surprisingly weak relation between drought and area burned,[19] but length of drought played a role in extending the fire season.[20] Since the temperature/humidity threshold required for a wildfire event is met every year in Southern California, global warming is less responsible for increased fire frequency compared to other considerations (such as population growth) in the South Bay.

One of the difficulties in sorting out the role of climate in driving fire is that fires started by humans play a major role in the bioregion and complicate the interpretation. For example, drought indices are closely correlated to the area burned during the twentieth century. Human population growth also parallels these changes in area burned, and increased fires started by humans are likely a major contributor to the late twentieth century increase in burning. It is estimated that humans account for over 98% of all wildfires in the lower foothills and coastal zone.[21] With increasing population growth, fire suppression efforts have worked hard to keep up with increasing numbers of fires; however, twentieth-century fires have been more abundant in Southern coastal California than historically was the case. [22]

Part 2: Risk Assessment

This preliminary vulnerability assessment defines and assesses risk as a function of a *hazard* occurrence, *exposure* of structures and people within a hazard zone, and *sensitivity* of a population to to climate impacts. The goal of the risk assessment is to identify areas where there is an intersection of a hazard-prone area (i.e. flood prone area, or hotspot) with potentially exposed facilities and sensitive populations.

Critical facilities are essential to the health and welfare of the whole population and are especially important following hazard events. The potential consequence of losing them are so great that they should be carefully inventoried. The **Structural Vulnerability** section of this risk assessment overlays critical facilities and buildings with hazard prone areas (from flooding and sea level rise) to assess potential risk to structures.

Sensitive populations are those that may be more vulnerable to the impacts of climate change than others, and have an increased likelihood of experiencing morbidity or mortality during a climate-hazard event. The **Social Vulnerability** section of this assessment overlays sensitive populations with hazard prone areas (hotspots and flood-prone areas) to assess potentital risk to people.

By overlaying hazard-prone areas with facilities, structures, and sensitive populations, the City of RPV is identifying priority areas for adaptation measures to be implemented. In doing so, the City of RPV is pursuing equitable adaptation planning, or the practice of prioritizing investment and action in the most vulnerable areas.

Structural Vulnerability

Critical facilities are community assets that ensure the safe and effective operation of basic governmental services. In some instances, critical facillities help to provide key services, such as public safety or utilities. Other critical facilities, such as administrative centers, are necessary to maintain government operations during a disaster and can help coordinate response and recovery activities.

The SBCCOG, with guidance from the City of RPV, identified critical facilities in **Figure 5, 6, and 7.**

Figure 5 includes the following categories of critical facilities:

- Government/Public Facilities including public schools, government offices including City Halls, police and fire departments
- Healthcare Facilities including hospitals, medical centers, emergency and disaster offices, red cross centers, and health clinics
- Hazardous Facilities including facilities that receive hazardous waste for treatment, storage or disposal, and Environmental Protection Agency designated Superfund Sites.

Figure 6 maps all energy facilities and supporting infrastructure including oil fields, electrical substations, power plants, natural gas stations and transmission circuits.

Figure 7 maps water facilities and supporting infrastructure including water lines (force mains and gravity mains), pump stations, MS4 outfalls and water treatment facilities.

Figure 5: Government, Healthcare and Hazardous Facilities

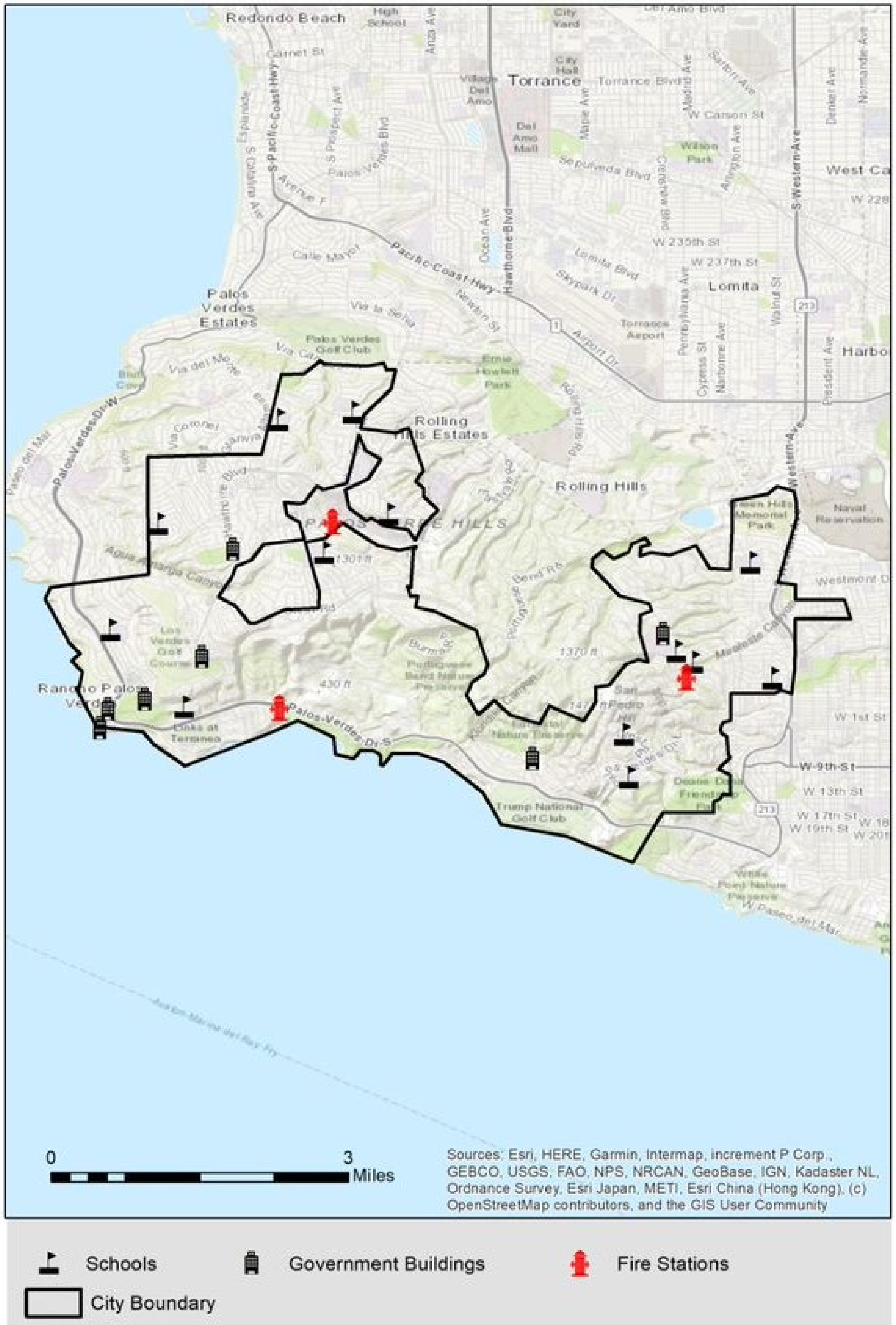


Figure 6: Energy Facilities and Supporting Infrastructure

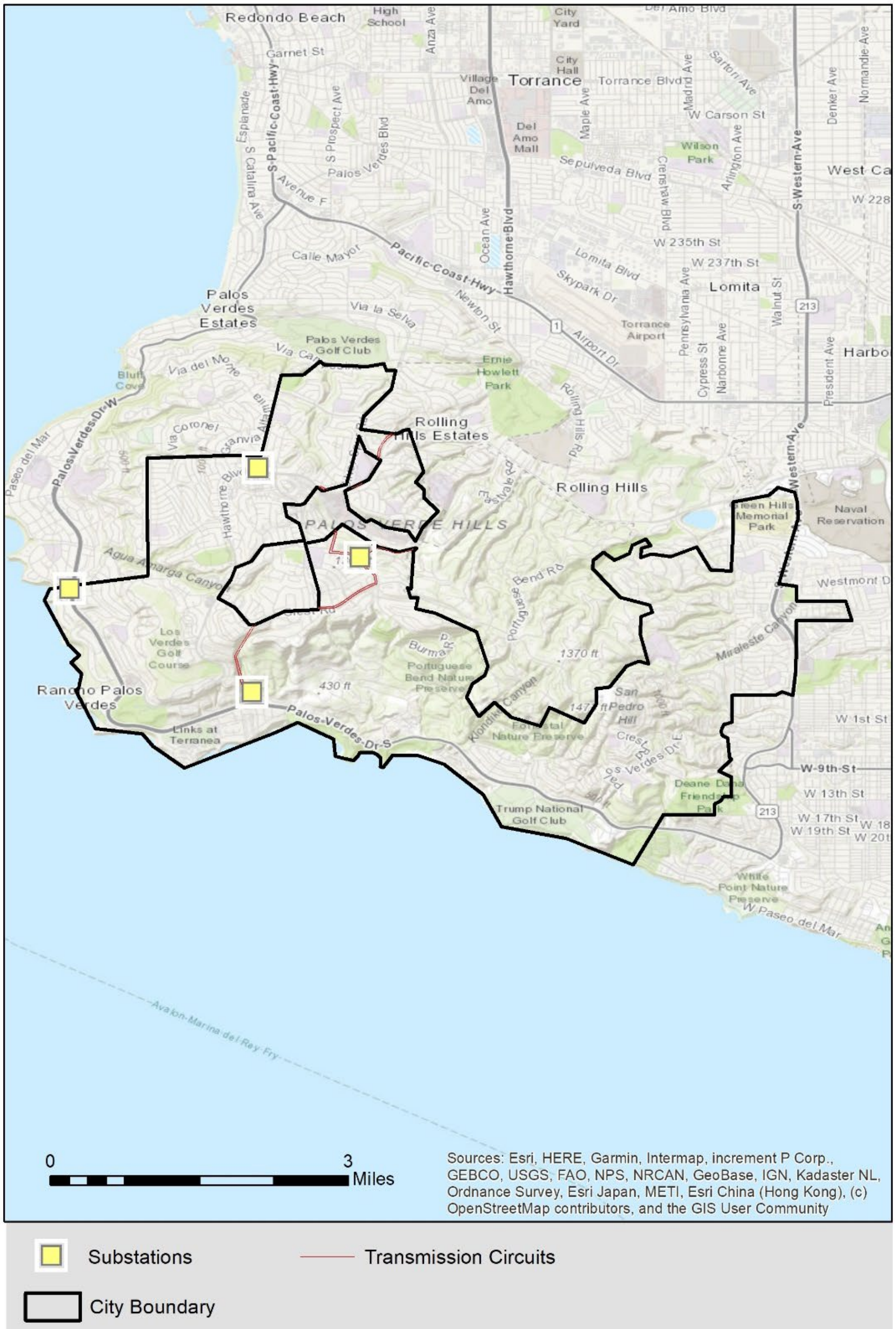
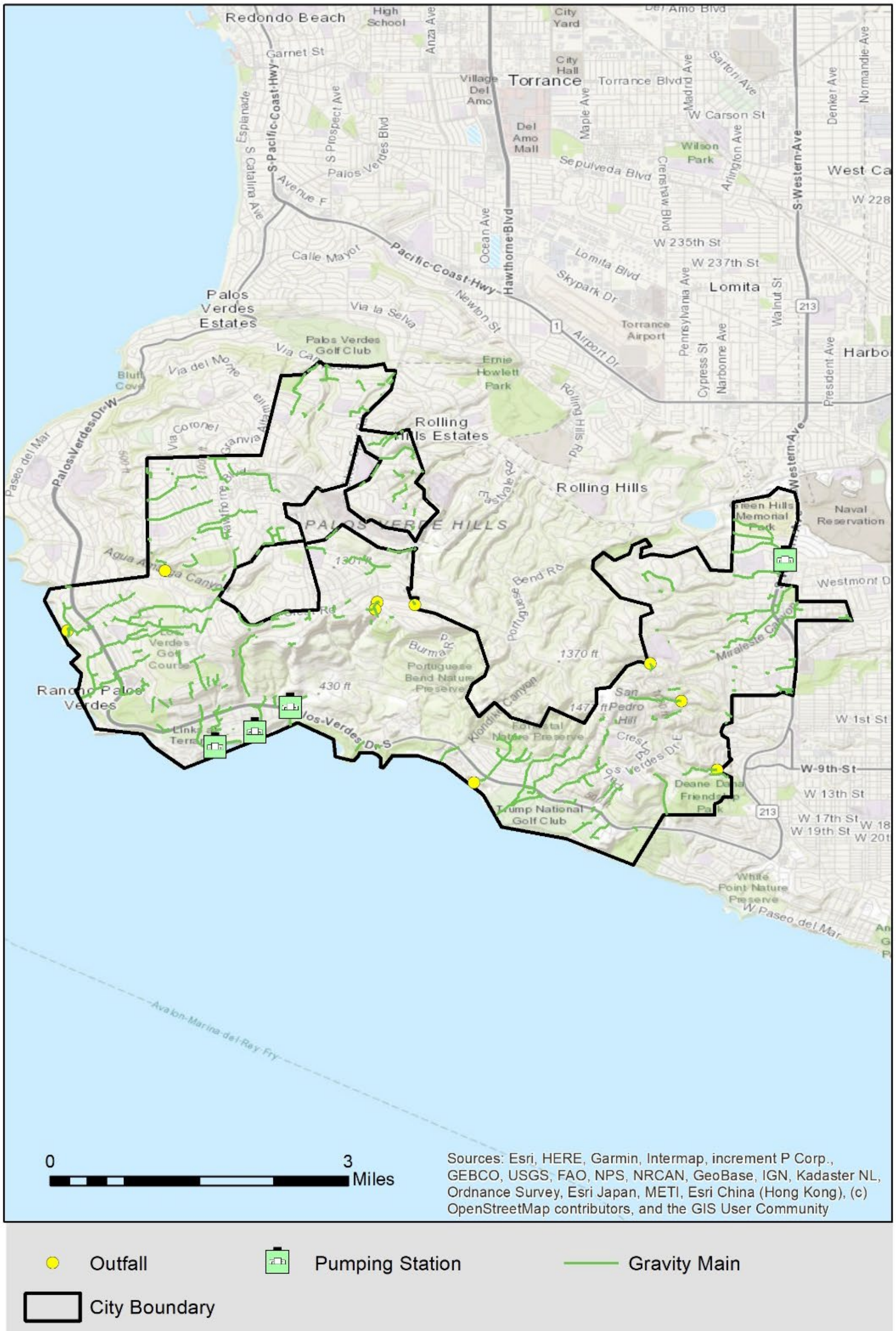


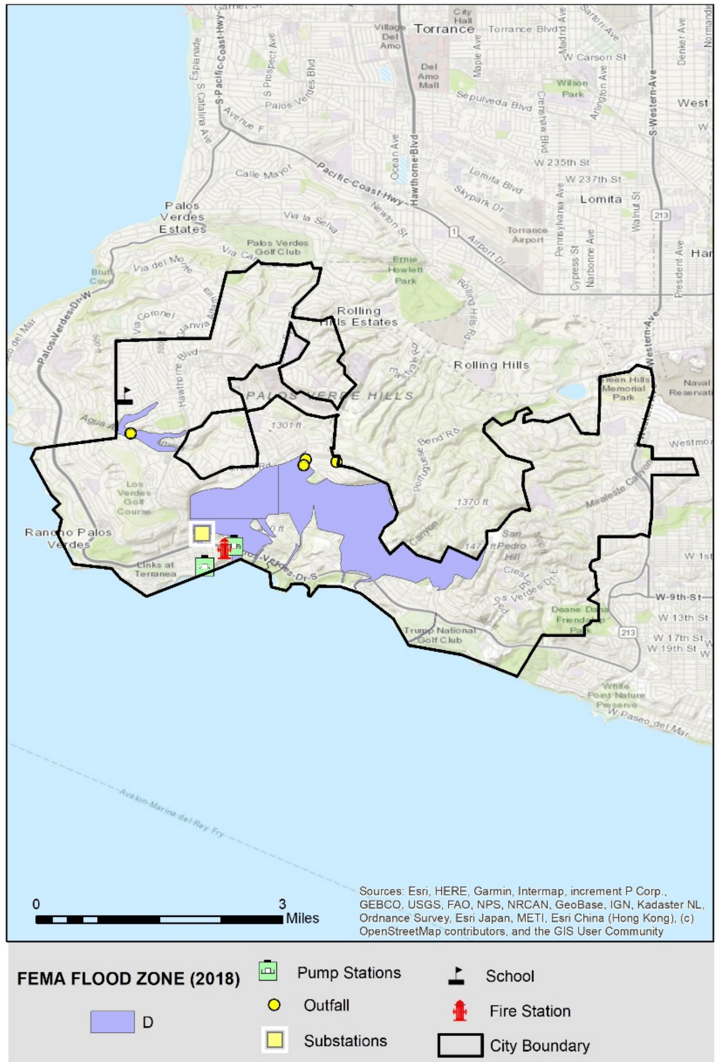
Figure 7: Water Facilities and Supporting Infrastructure



Flood Risk

The flood risk in the City of RPV is limited and largely undetermined. The City of RPV is not located near any major waterways of the Los Angeles Basin, and therefore has largely been free of significant flood events. While there are several critical facilities located within a FEMA designated (2018) flood zone, mapped in **Figure 8,** the Zone D designation represents areas for where there is possible but undetermined flood hazards. Further hydrological assessments should be conducted to better understand the risk of localized flooding in the case of extreme precipitation events.

Figure 8: Critical Facilities in or near Flood Zone



Urban Flooding- Cloudburst Events

Urban flooding is caused by extreme precipitation events, or *cloudbursts*, wherein rain falls on impervious surfaces and overwhelms local storm water drainage capacity. Urban flooding has little to do with bodies of water and occurs in places that are well outside of mapped floodplains. To help cities prepare for future cloudbursts, the SBCCOG developed "blue spot" (depression or sinks in the landscape) maps that show flood-

Impervious surfaces are land surfaces (pavement) that repel rainwater and do not permit it to infiltrate (soak into) the ground.

prone areas during sudden rainstorms and identify structures at risk by calculating how much rainfall is needed to make each bluespot fill up during a cloudburst. Buildings located in a bluespot that fill up quickly are at greater risk than buildings in a bluespot that fills up slowly.

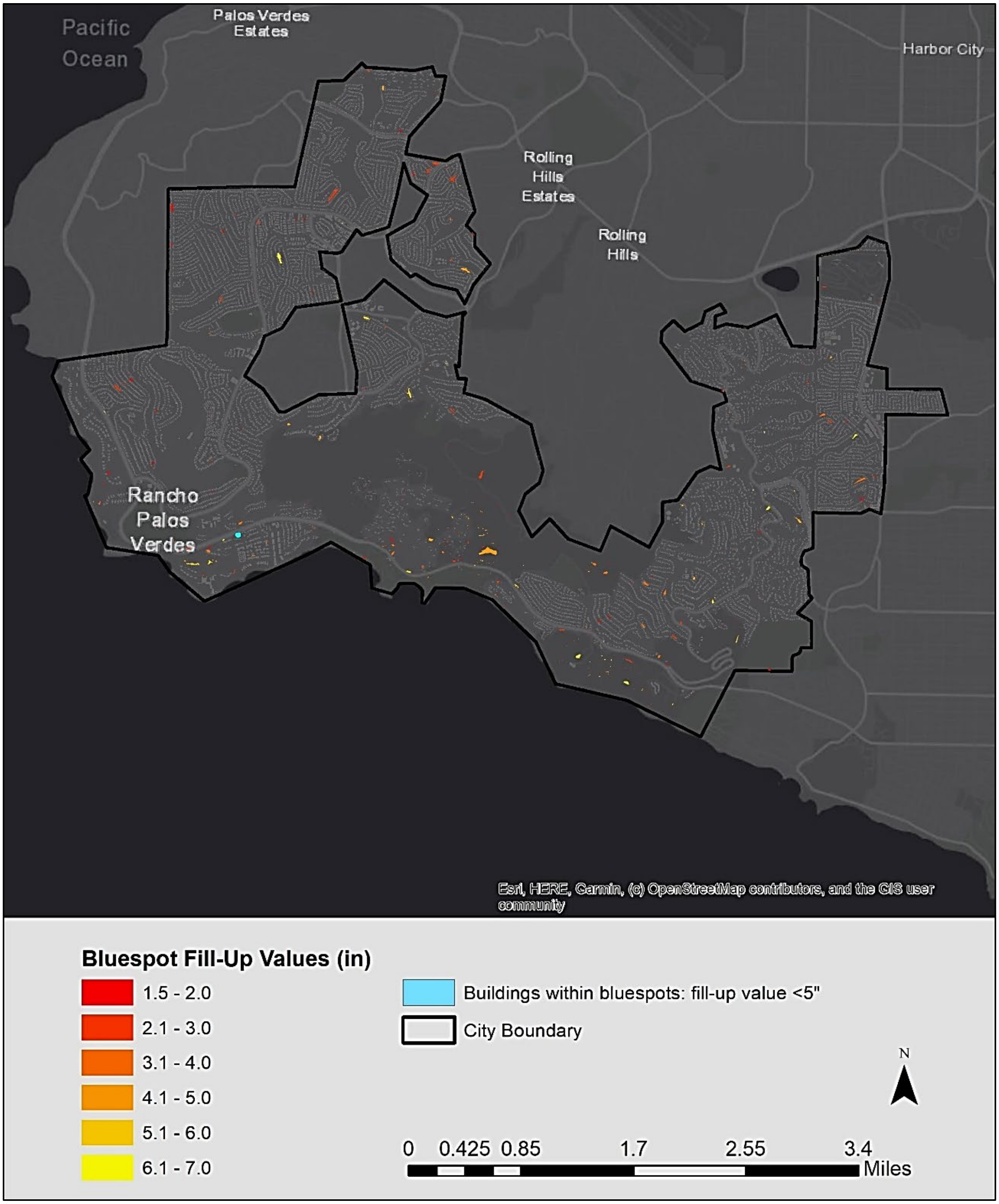
For planners and developers, bluespot maps can be used to make informed decisions about where not to build or where development should be accompanied by special landscape architecture. In areas that are already developed, bluespot maps can be used to prioritize areas for better climate-proofing.

Several assumptions and limitations affect the precision and certainty of the model results. For example, the model does not consider a building's elevation within a blue spot, nor does it consider diversion of surface runoff through drainage ditches, tubes, or other channels. In addition, it is assumed that in a cloudburst event, evaporation and soil infiltration is close to zero but that the sewer system has a capacity to absorb approximately 40 mm of rainfall per day.

Figure 9 maps bluespots by their fill-up value[3], and highlights buildings that fall within a bluespot that would need less than 5 inches to fill up -- or reach its "pour point". The model identified one building at risk of flooding during a 5-inch cloudburst. (Maps noting the location of these buildings can be found in **Appendix B.)**

[3] After adding an additional 40mm to account for the sewer system capacity

Figure 9: Areas at Risk of Flooding in a Cloudburst



Sea Level Rise Risk

Using data prepared by Unites States Geological Survey (USGS) from the Our Coast Our Future (OCOF), the SBCCOG considered the following sea level rise scenarios (including projected changes in shoreline extent, cliff position and flood extent[4]) to assess the potential impact of sea level rise on facilities, infrastructure, and residences (parcels) in the City of RPV:

- 0.75 m (2.46 ft)
- 1.25 m (4.1 ft)
- 1.75 m (5.7 ft)
- 2.00 m (6.6 ft)

Cliff Position

Cliff position projections are based on field observations including historical cliff retreat rate, nearshore slope, coastal cliff height, and mean annual wave power.[23] The cliff position projections shown in **Figure 10** assume that current coastal armoring will be maintained and 100% effective at stopping future cliff erosion ("Hold the Line"). Maps for each segment of the City's coastline can be found in **Appendix C.** The SBCCOG overlaid cliff projections with land parcels, roads and facilities to assess the potential risk associated with each sea level rise scenario **(Table 6).**

[4] 100-year storm events were considered for flood extent projections

Figure 10: Cliff Position Projections, RPV

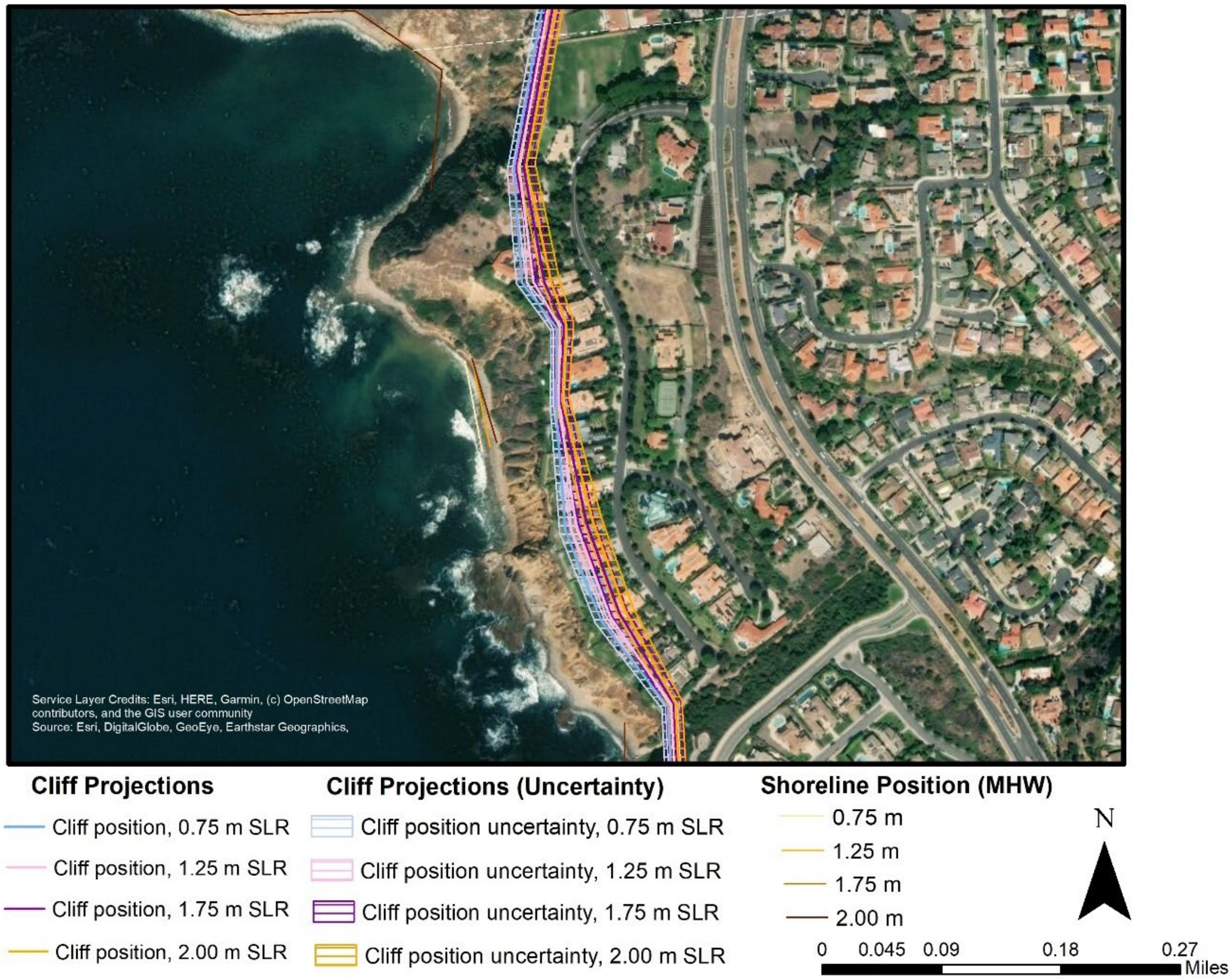


Table 6: Risk Assessment for Cliff Erosion

	Parcels		Critical Facilities				
Sea Level Rise Scenario (meters)	Total	Residential	Road (feet)	Water Main (ft)	Outfall	Water Facility	Gov. Facility
75 m	103	43	2706	6227	3	0	0
125 m	110	46	4181	6974	3	0	1
175 m	113	49	5375	8918	3	0	1
200 m	117	52	6118	8918	3	1	1

Inundation

The Hazard Exposure Reporting and Analytics (HERA) tool estimates the economic assets in areas flooded under different sea level and storm scenarios. The estimated value of parcels exposed to sea level rise inundation is listed in **Table 7.**

Table 7: Value of Parcels Exposed

Sea Level Rise Scenario (meters)	Value of exposed parcel ($)[24]
75m + 100-yr storm	$26,080,953
125m + 100-yr storm	$29,289,909
175m + 100-yr storm	$40,115,575
200m + 100-yr storm	$45,897,058

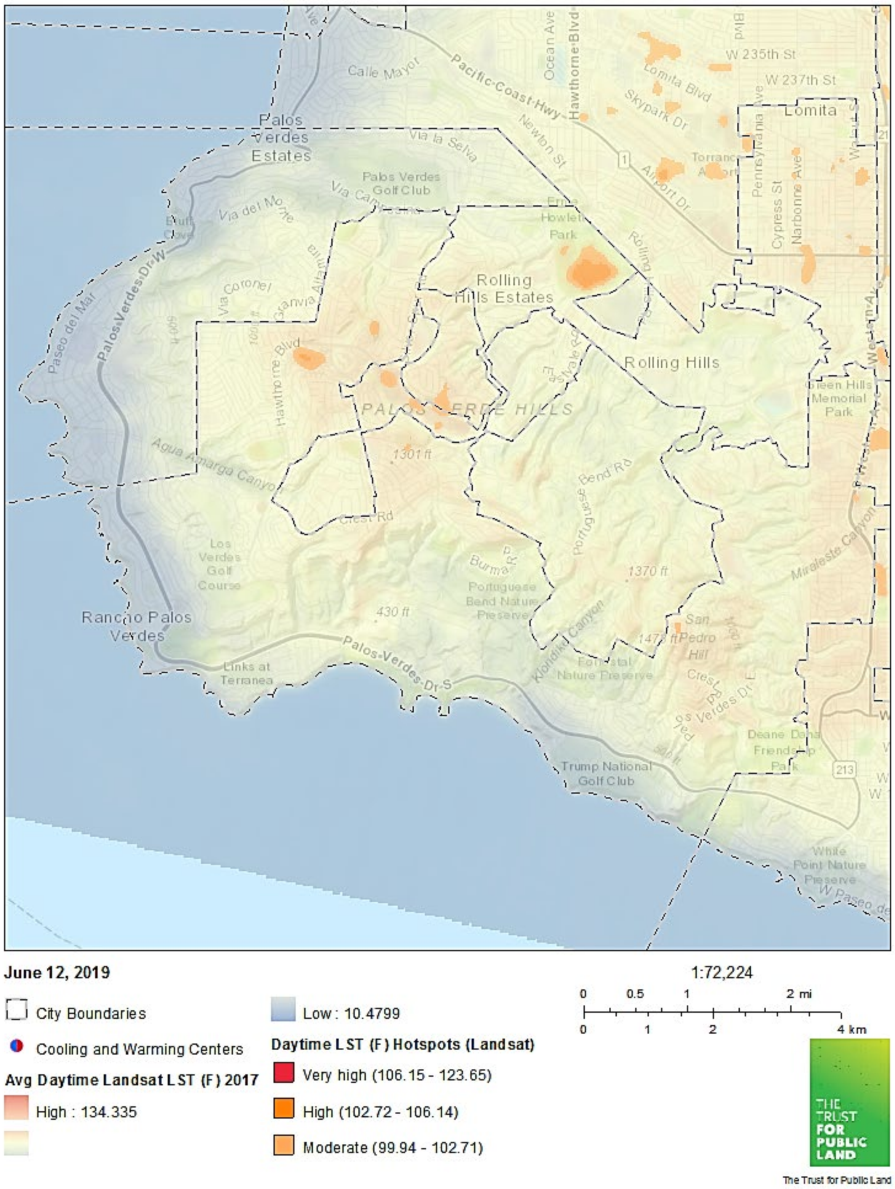
Social Vulnerability

Social vulnerability is a function of diverse demographic and socio-economic factors that influence a community's sensitivity to climate change. The SBCCOG utilized The Trust for Public Land (TPL) *Climate-Smart Cities™ Tool* to map potential hotspots and flood prone areas and overlaid those areas of heightened exposure with TPL's *Climate Equity Priority* layer, which identifies areas with greater numbers of underserved and disadvantaged populations (sensitive populations). This overlay analysis helps identify parcels most at risk to heat and flood events within the City.

Heat Risk

Utilizing land surface temperature (LST) data, **Figure 11** identifies urban heat island hotspots within the City with elevated daytime LST averaging at least 1.25 degrees Fahrenheit above the mean daily temperature during August. The results were derived from Landsat satellite data, which provides a 30m downscaled average land surface temperature over a 16-day period.

Figure 11: City of RPV Hostpot and Average Temperature



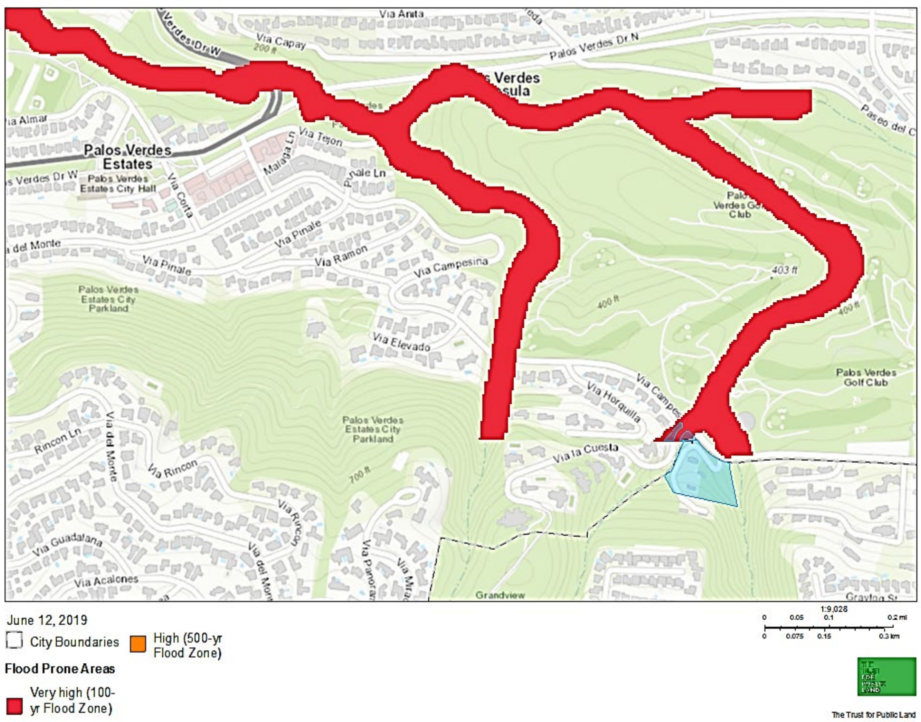
To determine heat risk, the SBCCOG overlaid the *Climate Equity Layer* (sensitivity) with the *Cool Priority* layer (hazard). The *Cool Priority layer* identifies areas where urban heat island effect is greatest. The *Climate Equity Priority* layer highlights areas where there are greater percent of sensitive populations. However, there are no parcels that fall within a *climate equity priority **and** a cool priority area*.

While there is a significant population over the age of 65, a group that tends to be more sensitive to extreme heat—this potential vulnerability is countered by high adaptive capacity evidenced by high incomes, education and access to air conditioning. Therefore, the heat risk for residents within the City is low.

Flood Risk

In addition to identifying areas of greatest risk to extreme heat, the SBCCOG utilized the TPL *Climate Smart Cities* tool to query parcels that were in a *flood prone area* and a *climate equity priority* area to identify parcels with the greatest flood risk (**Figure 12**). The flood prone area layer identifies areas within a 100-yr and 500-yr flood zone based on 2015 Flood Advisory Zones developed by FEMA.

Figure 12: City of RPV Flood Prone Area

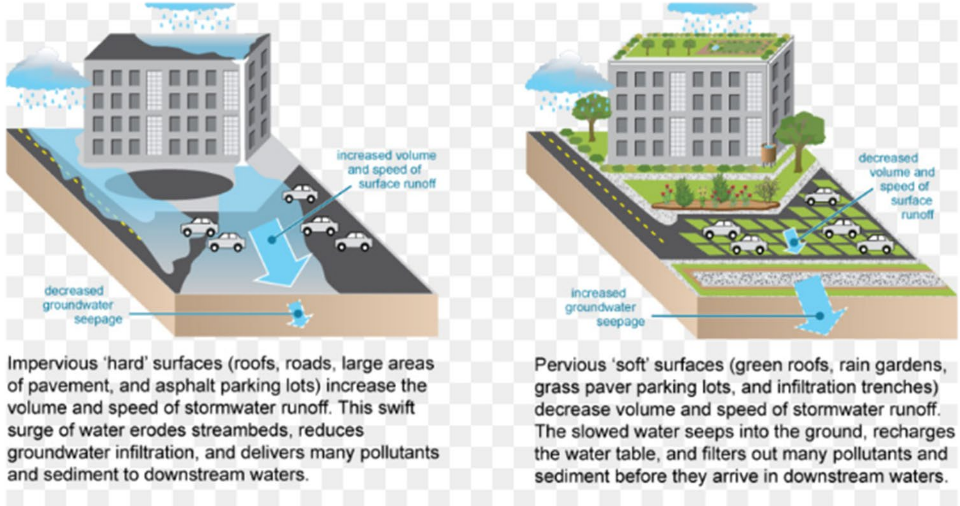


There is **only 1 parcel**[5] in the City that intersects a 100-yr flood zone (highlighted in blue, **Figure 12**).

There were no parcels in the City that fell within both a flood prone and climate equity priority area, indicating low flood risk to RPV residents.

[5] Assessor ID (APN): 7546-022-010

Green Infrastructure



Green infrastructure is an approach to water management that protects, restores, or mimics the natural water cycle. Some cities are investing in green infrastructure technology, including permeable pavement, to adapt to increasingly frequent flood events. In addition to buffering climate impacts, green infrastructure enhances social equity by building social capital, improving health outcomes, and increasing economic opportunities.

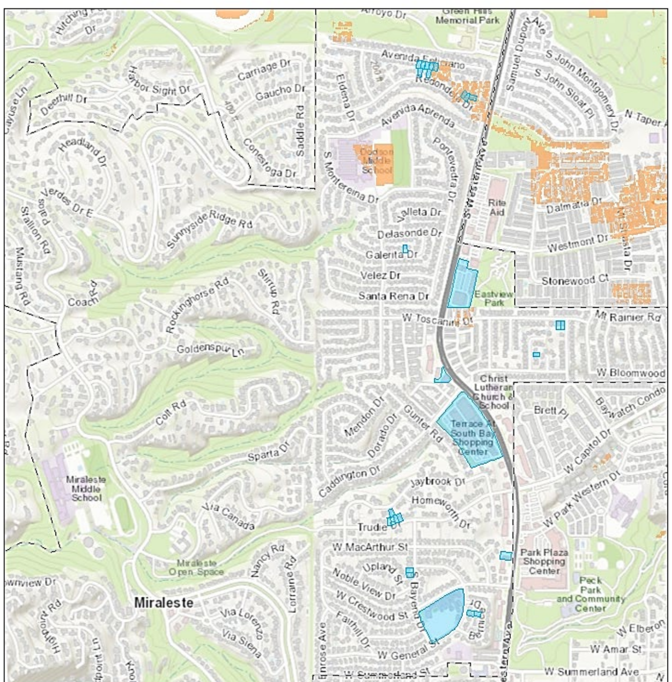


Figure 13: City of RPV Green Infrastructure

July 3, 2019

City Boundaries

Overall Absorb Priorities

Very high

High

Moderate

1:18,056

0 0.15 0.3 0.6 mi

0 0.25 0.5 1 km

THE TRUST FOR PUBLIC LAND

The Trust for Public Land Copyright 2018

The SBCCOG utilized the TPL *Climate Smart Cities* tool to query parcels that had *70% or greater impervious surface* **and** were a designated *overall absorb priority* area to identify parcels with the greatest potential urban, localized flood risk from extreme precipitation (highlighted in blue, **Figure 13**). The *overall absorb priority* layer[6] identifies areas where the potential for groundwater infiltration projects from stormwater is highest.

[6] The model was created using a weighted overlay of the following layers: Riparian areas (5%); Flood Prone areas (5%); Permeable Soils (25%); Wetland Areas (5%); Groundwater Basins (30%); Historic Channels (10%); and Slope (20%).

While the *Climate Equity Priority* map layer developed by the TPL offers a good snapshot of areas within the City that may have heightened sensitivity to climate impacts, the indicators that were used in the construction of the layer[7] do not encompass all sensitive groups. For example, while the TPL layer did not consider any parcels within the City of RPV to be a *climate equity priority*, there are a large percentage of the City's population that are over the age of 65, an indicator of sensitivity to extreme heat. Therefore, the SBCCOG, with the help of the City, selected and mapped additional indicators of social vulnerability at the block-group[8] level. These supplementary social vulnerability indicators are described and mapped in the Social Vulnerability Map Atlas (**Appendix A**).

Conclusion, Recommendations, and Next Steps

The City has taken steps to prepare for a changing climate with this preliminary vulnerability assessment that identifies areas with the highest risk, but deeper understanding and planning along with financial and human resources will be needed to fully address these changes.

Going forward, the results of this Vulnerability Assessment can be used to either:

1) Conduct a more detailed, site-specific risk analysis. For example, the city could identify attributes of buildings located in Bluespots such as building elevation, or whether a building has a basement, to determine whether flood-protection measures should be considered, or
2) Target adaptation-related investments or risk-mitigating activities.

Due to the City's location on the Palos Verdes Peninsula, RPV is uniquely vulnerable to wildfire events. The majority of the Peninsula is designated a *very high* wildfire threat. In addition, a large percent of the population is over the age of 65. People over the age of 65 are often less mobile, which can impede their ability to quickly evacuate in an emergency event. Lastly, there are only a few roads that can serve as evacuation routes down the Peninsula.

---

[7] People of color, low income population, less than high school education, linguistic isolation, population under 5, population over 64, unemployment, asthma, low birth weight, and housing cost burden,

[8] Census tracts are subdivisions of counties for which the Census collects statistical data.

One option to address these issues is the establishment of a multi-city task force or working group which would develop strategies to reduce the risk of wildfire on the Peninsula. In addition to the participation of city planners, emergency service officers, and fire departments, this task force could include other agencies such as the Palos Verdes Land Conservancy, which has knowledge on the flammability of different vegetation types, as well as representatives from Cal-fire and electric utilities. This task force would focus on devising risk-mitigating activities that would reduce the likelihood of a fire spark and speed at which fire travels, as well as devise flexible and actionable evacuation plans. For example, one strategy could include contraflow lane reversals that allow both lanes to be directed down the Peninsula for evacuation purposes.

In addition to wildfire events, the City of RPV is also vulnerable to cliff erosion. Cliff erosion poses a significant threat to many residential properties that line the cliff's edge as well as to critical habitat. Given the complexity of this risk, it is recommended that cities work with planners, affected property owners, scientific experts (USC Sea Grant, USGS), land managers, and insurance companies to develop adaptive pathways that would activate adaptive strategies (such as coastal retreat) at certain pre-determined thresholds of cliff erosion.

In 2019, the SBCCOG adopted its own Sub-regional Climate Adaptation Plan, which synthesizes the climate risks associated with regional sectors including water, energy, coastal management, biodiversity, and migration. The SBCCOG, will support the City of RPV over the coming years in developing and selecting city-specific adaptation strategies that will help mitigate local risk to residents and critical infrastructure from climate stressors identified in this vulnerability assessment.

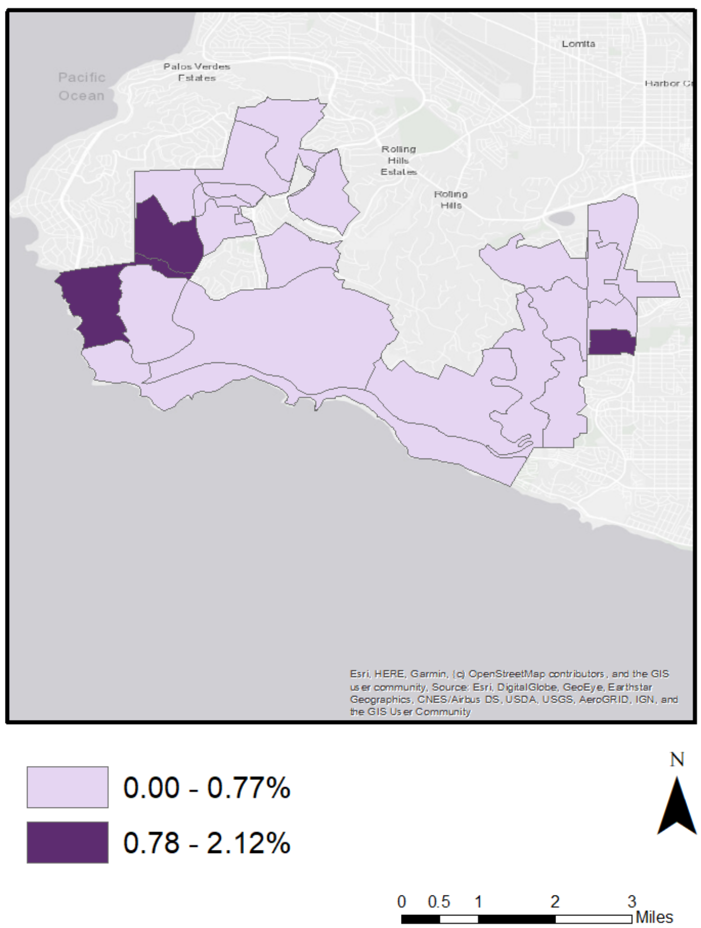
Appendix A: Social Vulnerability Map Atlas

Understanding vulnerability factors and the populations affected is critical for crafting climate change adaptation policies and disaster response strategies. This understanding is also important to achieving climate justice, which is a concept that no group of people should disproportionately bear the burden of climate impacts or the costs of adaptation. The following section provides a social vulnerability map atlas for the City of RPV utilizing American Community Survey Data (2017 5-yr estimates).

Outdoor Workers

Outdoor workers are more susceptible to heat stress, which can cause a decrease in productivity and induce health risks such as dehydration, heat stroke, and long-term damage to major organs and physiological functions. Strenuous working conditions, language barriers, exposure to chemicals, and limited capacity to protect their rights influence health outcomes exacerbated by climate change. Outdoor occupations most at risk of heat stroke include construction, refining, surface mining, hazardous waste site activities, and agriculture.[25] For this assessment, outdoor workers are represented by the percent of the population working in construction.

Percent Outdoor Workers, by block group
Source: American Community Survey



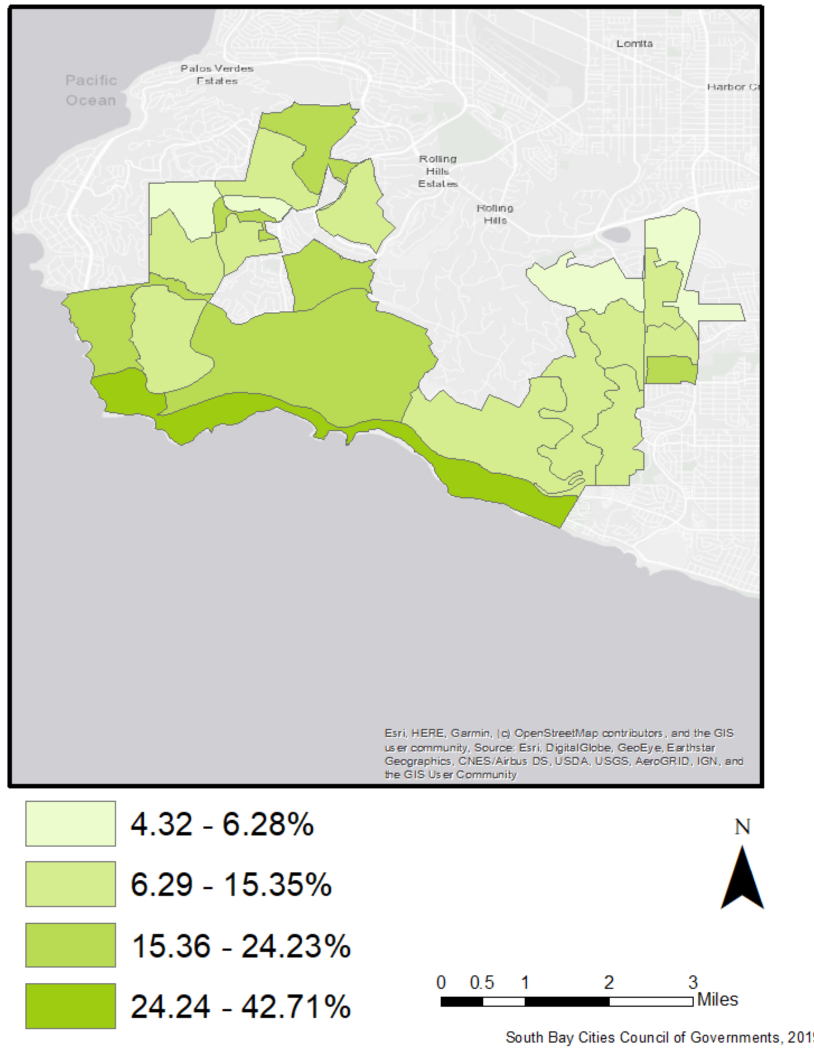
South Bay Cities Council of Governments, 2019

Elderly Living Alone

Several factors contribute to the vulnerability of elderly, people aged 65 and older, living alone including:

- Impaired muscle strength, coordination, cognitive ability, the immune system, and the regulation of body temperature (thermoregulation)[26]
- Pre-existing health conditions which can increase susceptibility to more severe consequences of climate change [27]
- Limited mobility (inability to evacuate) may increase risk of climate-related impacts.[28]
- Social isolation or dependent of care populations can be impacted more by heat waves and extreme weather events.[29]

Percent Population 65+ Living Alone, by block group
Source: American Community Survey

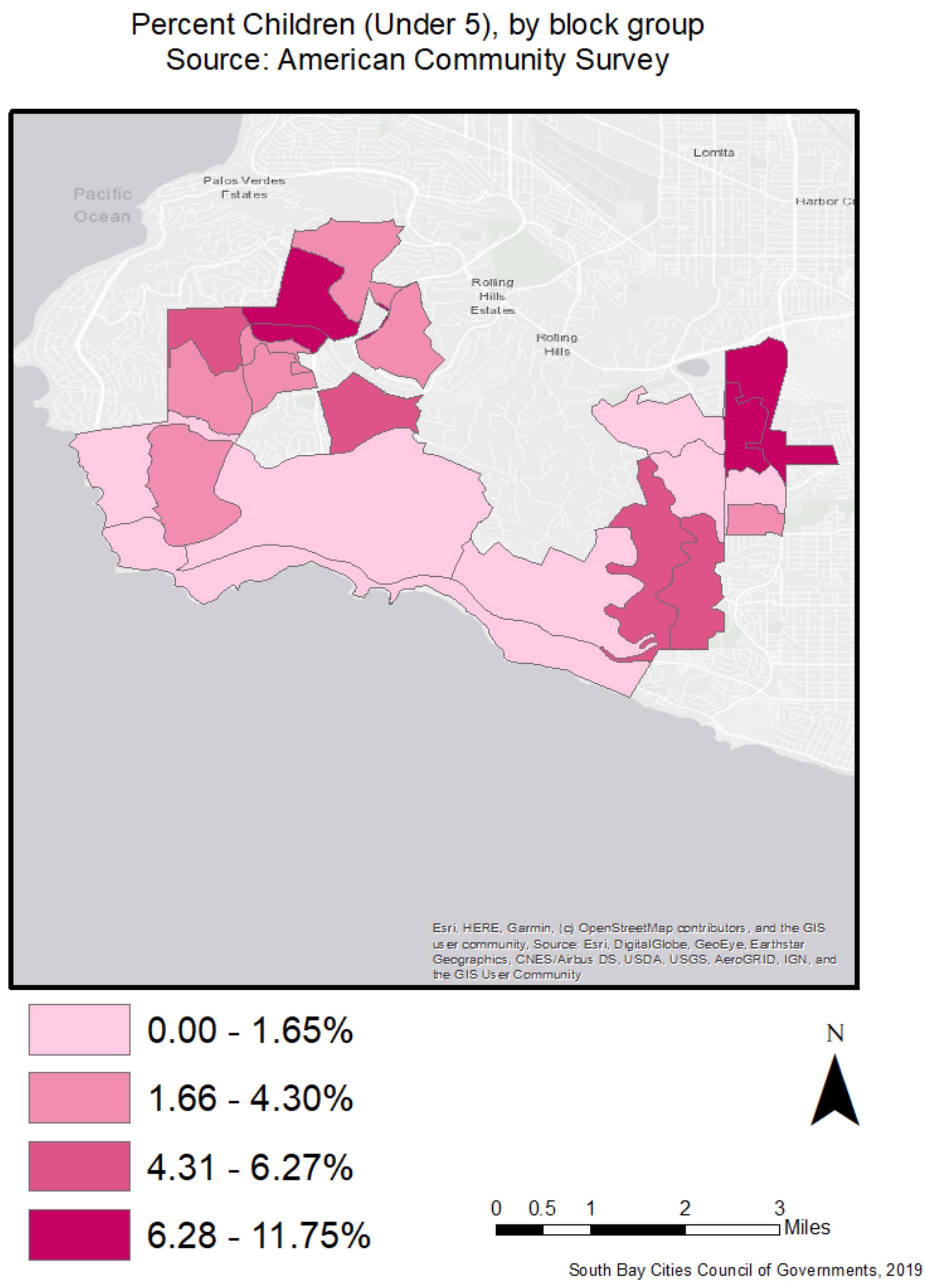


Children Under the Age of 5

Children under 5 years old are especially vulnerable to the health impacts of climate change.

Due to physiological and developmental factors, children are disproportionately impacted from the effects of heat waves, air pollution, infectious illnesses, and trauma resulting from climate change.[30]

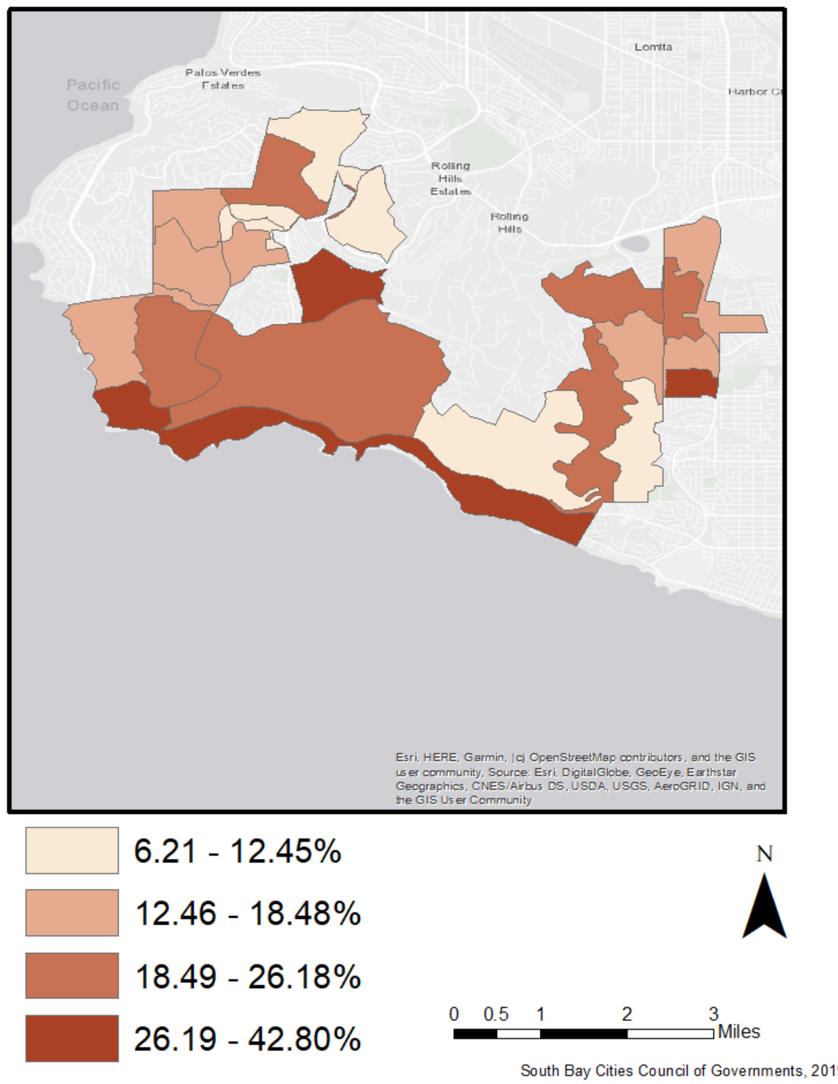
Children are dependent on their caregivers for response to extreme weather events such as wildfires and floods. Children, infants, and pregnant women are vulnerable to increased heat exposure because they may not be able to efficiently thermoregulate.[31]



Disabled Population

Disabled populations are defined in this assessment as a person with a physical or mental disability.[9]

Percent Disabled, by block group
Source: American Community Survey



Climate change is expected to cause increased hardship for persons with physical disabilities due to limited resources and mobility during the phases of evacuation, response, and recovery, and will likely affect the severity and incidence of mental disabilities and mental health problems.[32]

Persons with a physical disability have been found to be 1.22 times more likely to be unprepared for an emergency.[33]

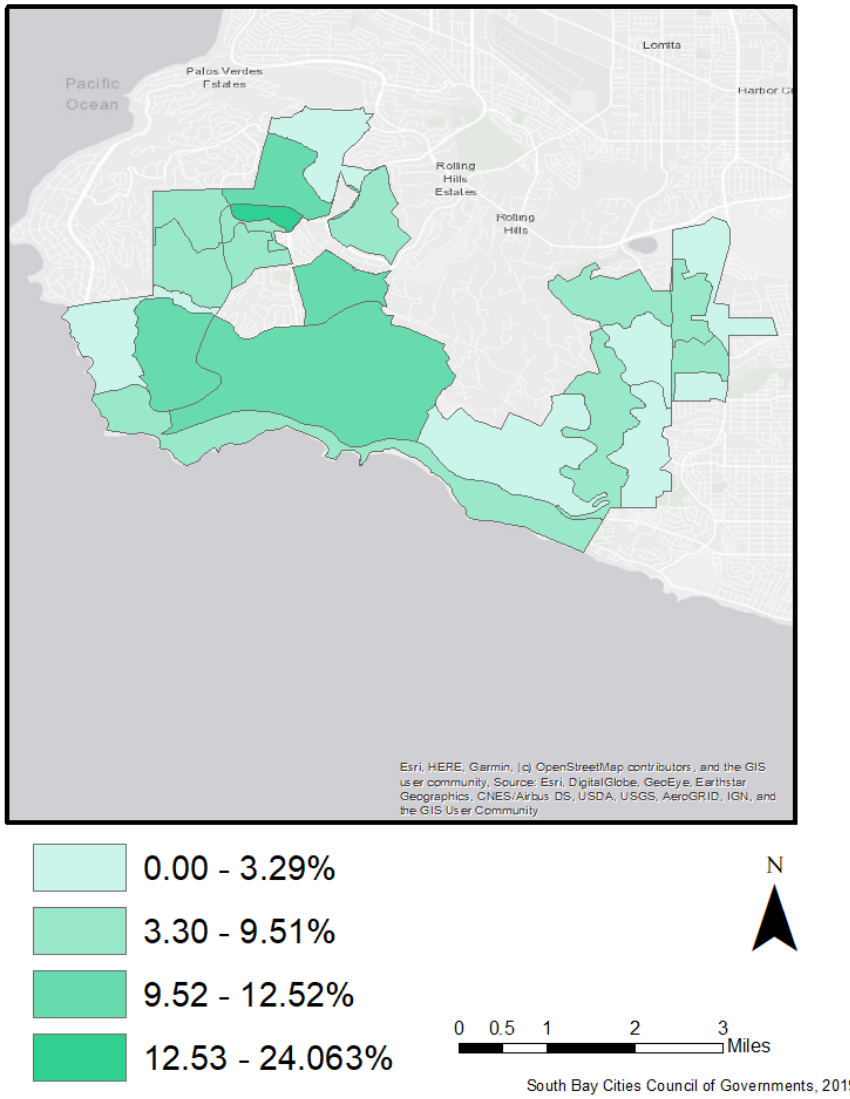
Increasing heat exposure can also worsen the clinical condition of people with pre-existing mental health problems. There are direct physiological effects of heat strain that can reduce the ability to work at full capacity and carry out daily activities, which can impact mental health as well as livelihood.[34] Dementia is a risk factor for hospitalizations and death during heat waves. [35]

[9] As defined by the US Census, a person with a physical disability has serious difficulty walking or climbing stairs. A person with a mental disability has a learning, intellectual or developmental disability; Alzheimer's disease, senility, dementia, or some other mental or emotional condition that seriously interferes with daily activity.

Linguistic Isolation

Climate change and increasing temperatures pose a serious public health concern for people who are linguistically isolated.

Percent Households Limited English, by block group
Source: American Community Survey



According to the U.S. Census, a household is linguistically isolated when all persons 14 years of age or older speak a language other than English and no one speaks English very well.

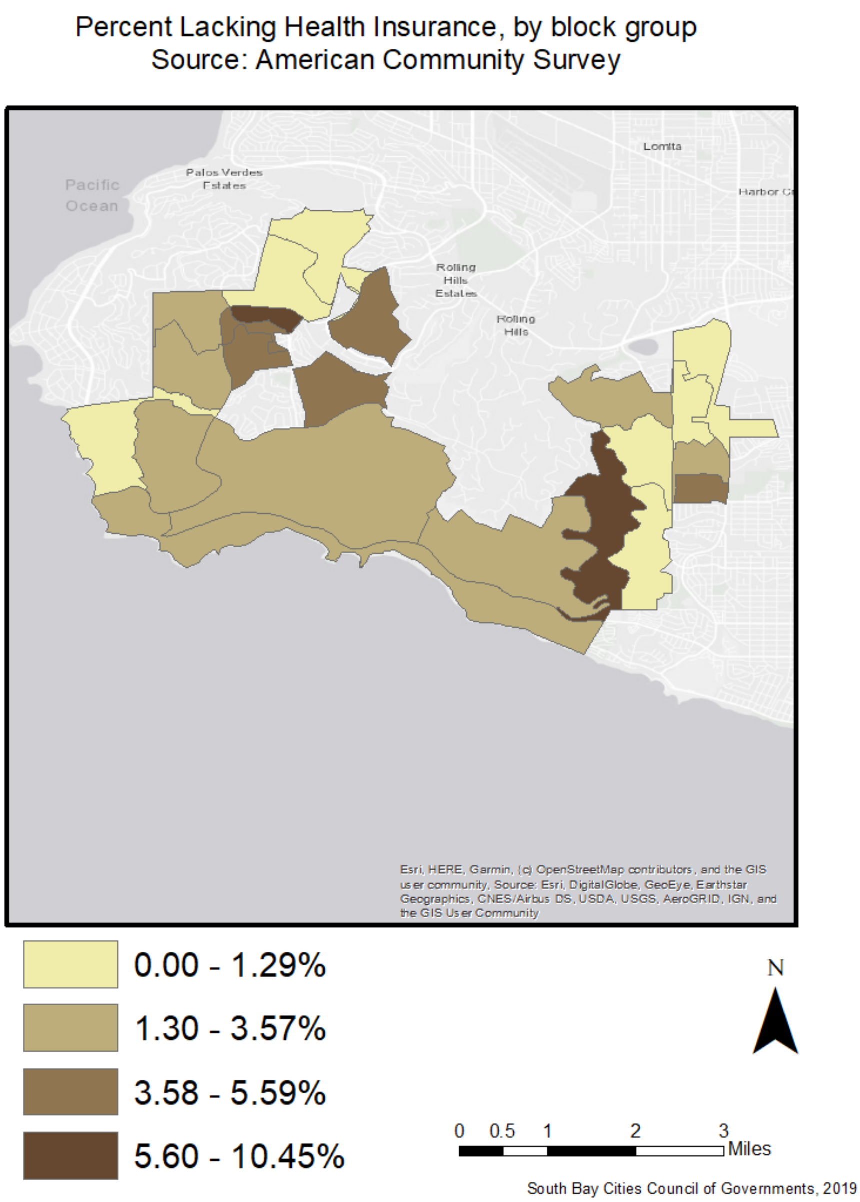
Linguistic isolation may hinder protective behaviors during extreme weather and disasters by limiting access to or understanding of health warnings.

A study of extreme heat found that people who live in linguistically isolated households were at increased risk of extreme heat-related health problems, and they are more prone to making heat distress calls to 911.[36] The study also found that isolation led to structural and financial barriers to medical care, which in turn disrupted management of chronic conditions.[37]

Population Lacking Health Insurance

Insurance coverage is a key determinant of timely access and utilization of health services, which is a fundamental pathway to improved health outcomes.

Excessive heat exposure, elevated levels of air pollutants, and extreme weather conditions such as flooding are expected to cause direct and indirect health impacts, particularly for vulnerable populations with limited or no access to health services.



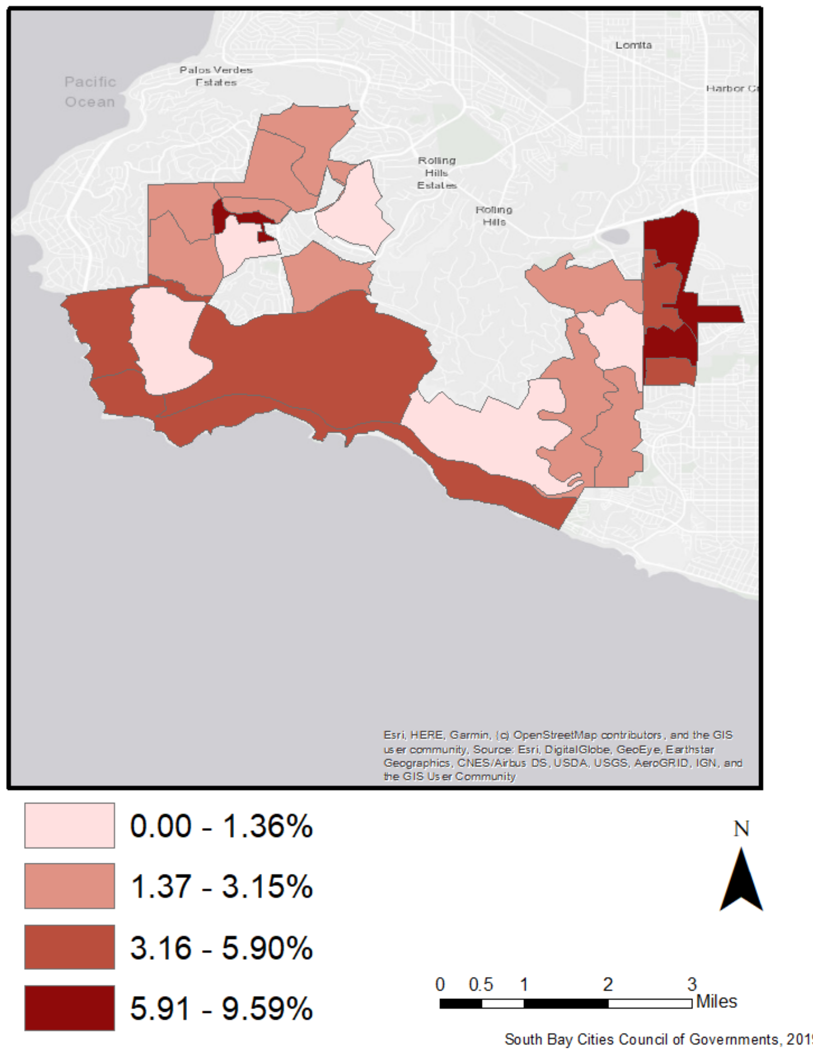
A national systematic review in 2010 found that patients who were uninsured were less likely to receive critical care services than those with insurance.[38]

Another study demonstrated increased risk of mortality among the uninsured compared with the insured and estimated 44,789 annual deaths among Americans aged 18-54 associated with lack of health insurance. [39]

Rent Burdened Population

Rent-burdened populations are measured by the percent of the population spending over 50% of their income on housing.[40]

Percent Spending Over 50% Income on Rent, by block group
Source: American Community Survey



Rent-burdened families have less savings and are often not in a financial position to pay associated costs of preparation for and recovery from natural disasters.

While 97% of homeowners purchase homeowner's insurance, it is estimated that only 37% of renters buy renters insurance,[41] putting rent-burdened populations at risk of losing all their household and personal items. In addition, rent-burdened populations have a greater risk of being displaced post-disaster.

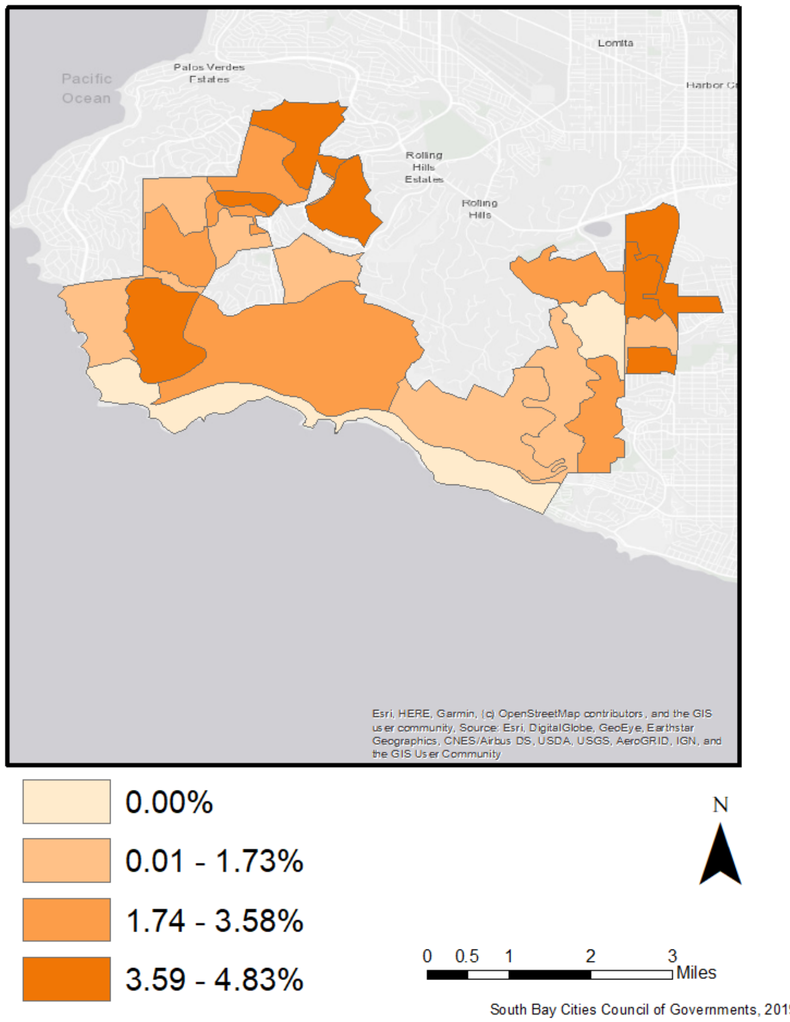
Educational Attainment

There are several reasons to expect that illiteracy and educational deficiency (measured by the percent of population without a high-school degree) can increase vulnerability to climate change related risks.

Better education typically implies better access to relevant information, such as early warnings for severe weather events.[42]

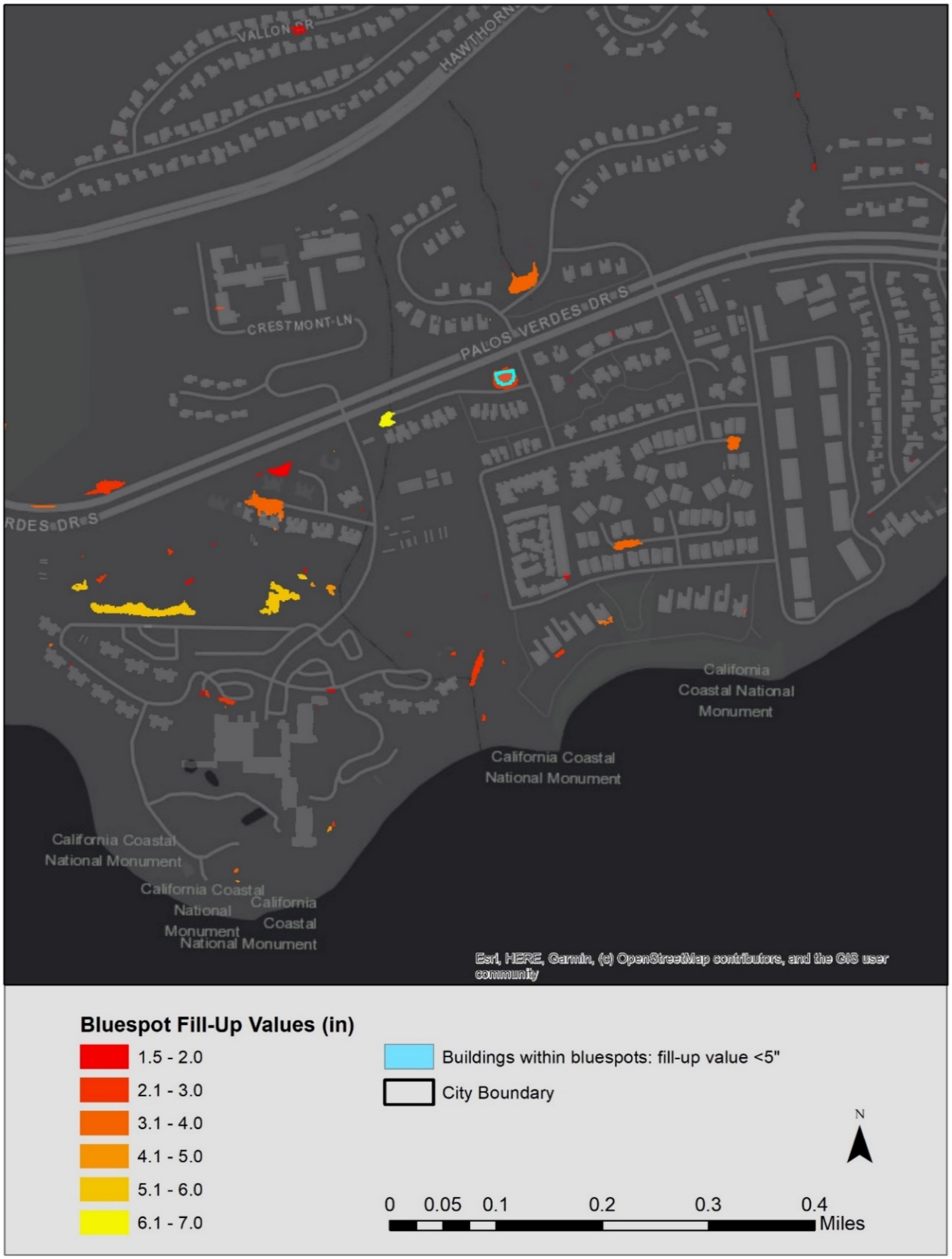
There is evidence that education also enhances cognitive skills and the willingness to change risky behavior while at the same time extending the personal planning horizon, contributing to the likelihood an individual will take steps to plan for and adapt to both climate shocks as well as slow-onset impacts.[43]

Percent Population Over 25 without High School Diploma, by block group
Source: American Community Survey

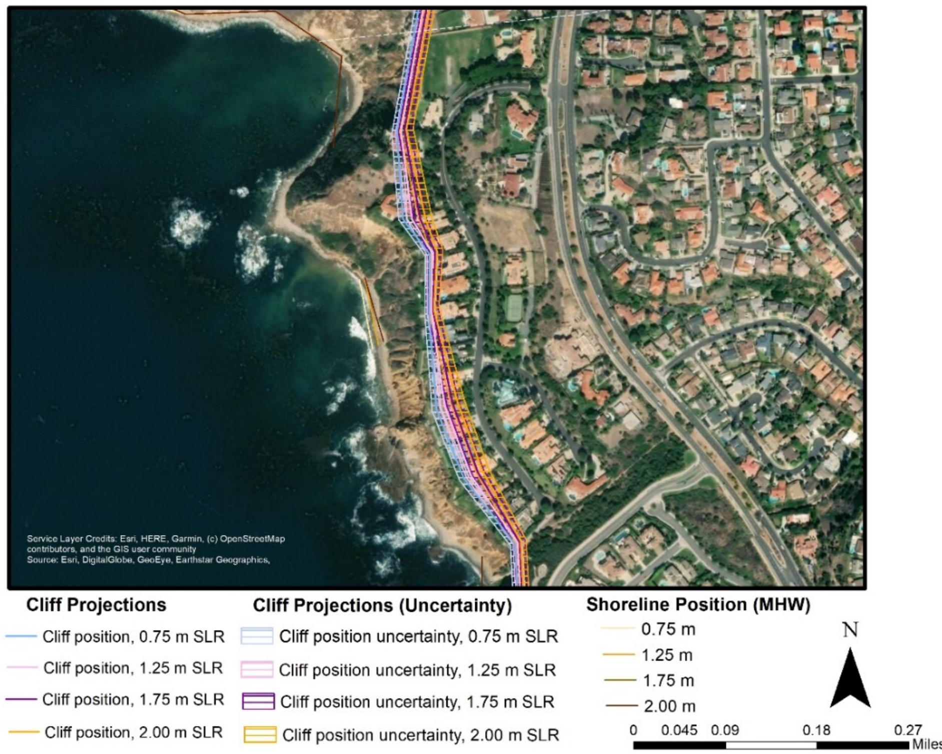


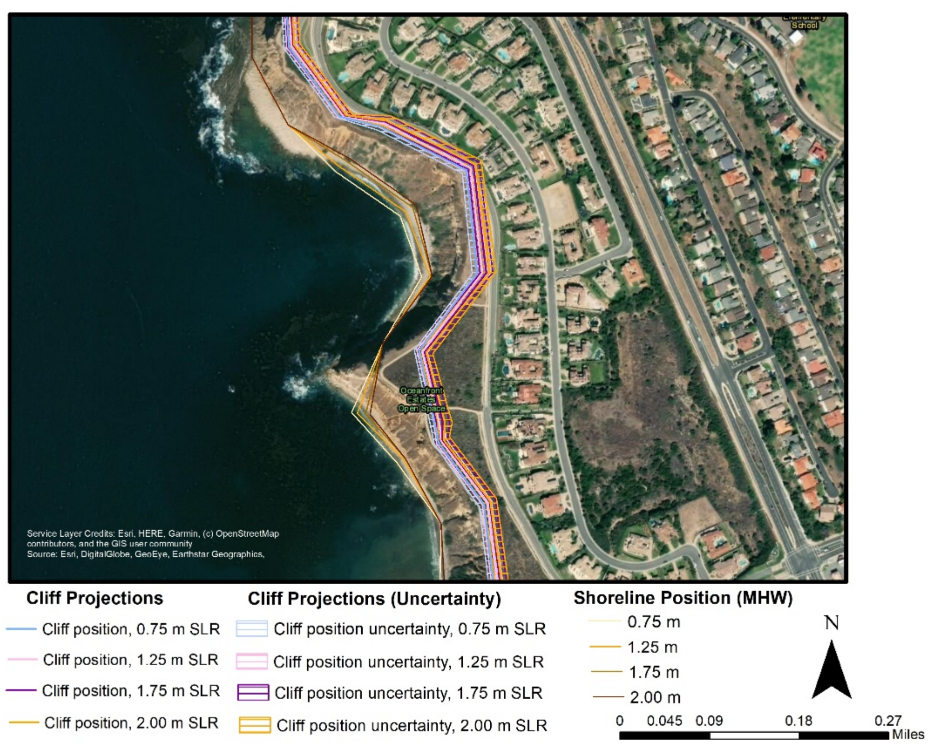
Furthermore, research findings support that education leads to better health and higher income at the individual and household level, which contributes to the capacity of an individual to better cope or adapt to the impacts of climate change.[44]

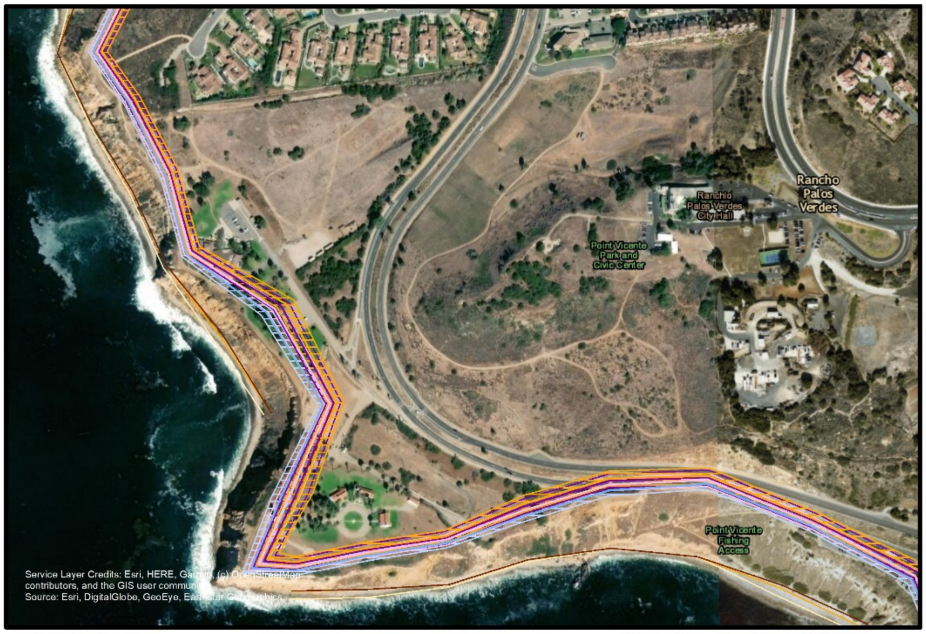
Appendix B: Bluespot Analysis—Buildings at Risk



Appendix C: Cliff Erosion Along RPV Coastline







Cliff Projections
- Cliff position, 0.75 m SLR
- Cliff position, 1.25 m SLR
- Cliff position, 1.75 m SLR
- Cliff position, 2.00 m SLR

Cliff Projections (Uncertainty)
- Cliff position uncertainty, 0.75 m SLR
- Cliff position uncertainty, 1.25 m SLR
- Cliff position uncertainty, 1.75 m SLR
- Cliff position uncertainty, 2.00 m SLR

Shoreline Position (MHW)
- 0.75 m
- 1.25 m
- 1.75 m
- 2.00 m

N

0 0.045 0.09 0.18 0.27 Miles

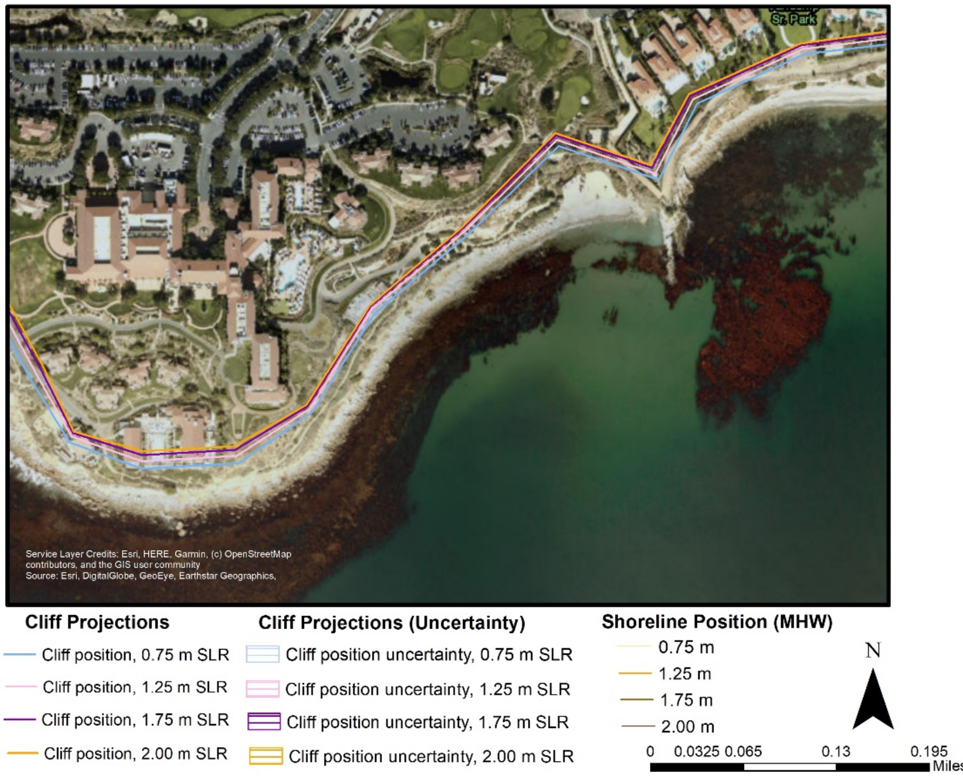
Cliff Projections
- Cliff position, 0.75 m SLR
- Cliff position, 1.25 m SLR
- Cliff position, 1.75 m SLR
- Cliff position, 2.00 m SLR

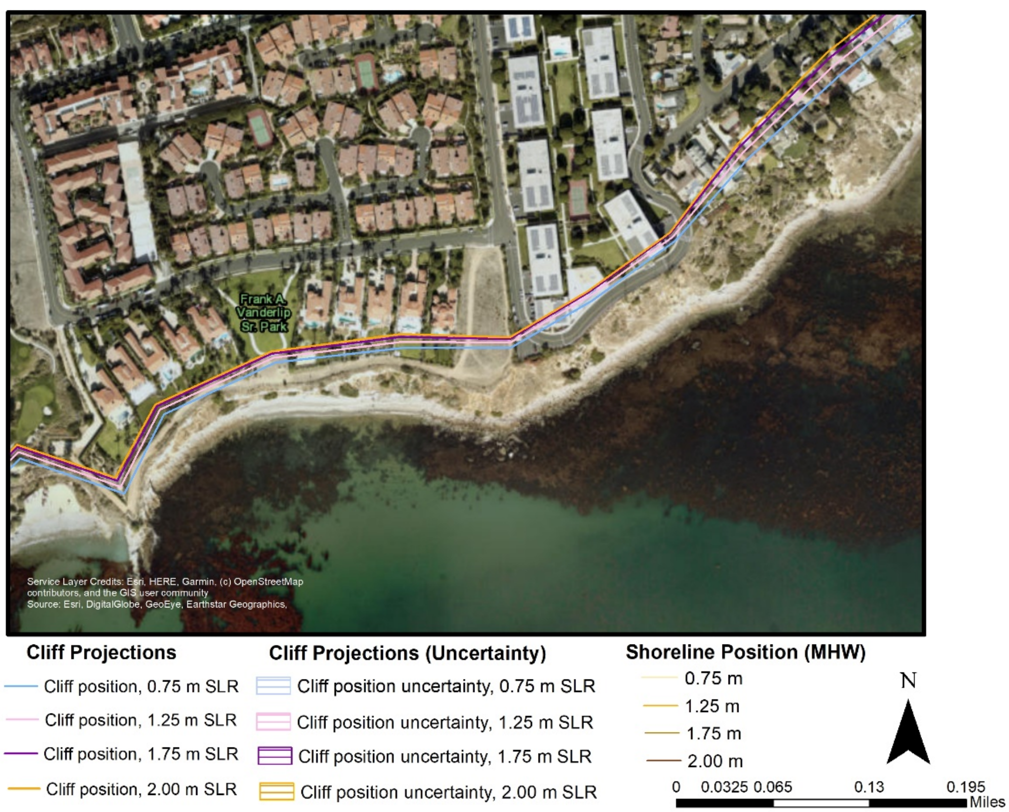
Cliff Projections (Uncertainty)
- Cliff position uncertainty, 0.75 m SLR
- Cliff position uncertainty, 1.25 m SLR
- Cliff position uncertainty, 1.75 m SLR
- Cliff position uncertainty, 2.00 m SLR

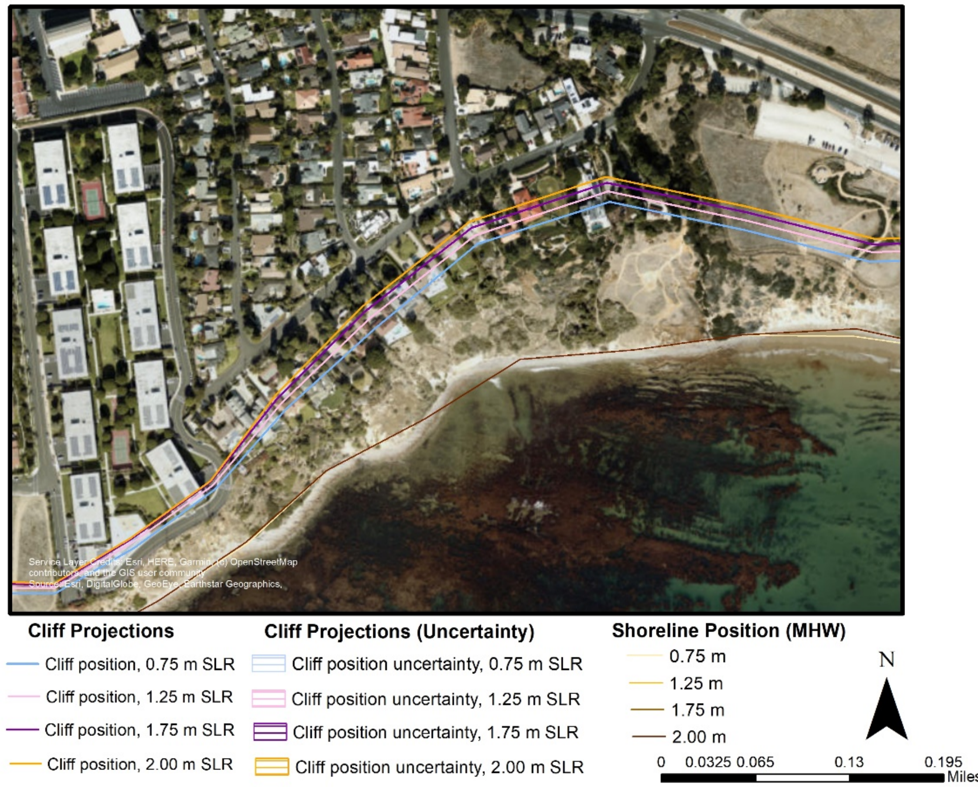
Shoreline Position (MHW)
- 0.75 m
- 1.25 m
- 1.75 m
- 2.00 m

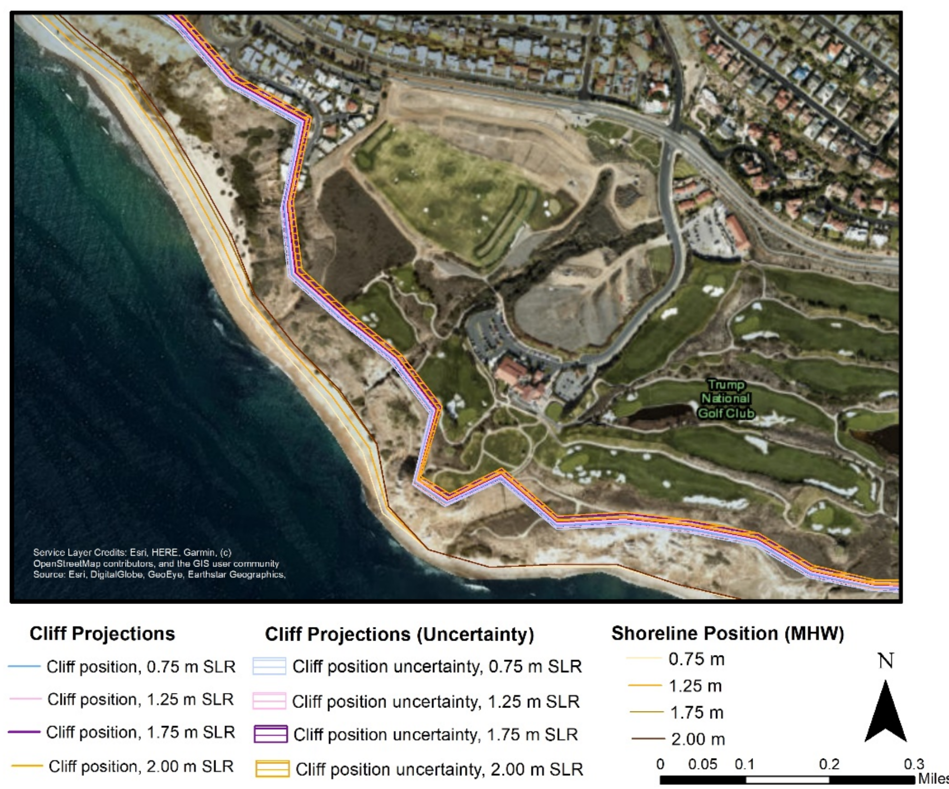
N

0 0.045 0.09 0.18 0.27 Miles


Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics,
Cliff Projections
Cliff position, 0.75 m SLR
Cliff position, 1.25 m SLR
Cliff position, 1.75 m SLR
Cliff position, 2.00 m SLR
Cliff Projections (Uncertainty)
Cliff position uncertainty, 0.75 m SLR
Cliff position uncertainty, 1.25 m SLR
Cliff position uncertainty, 1.75 m SLR
Cliff position uncertainty, 2.00 m SLR
Shoreline Position (MHW)
0.75 m
1.25 m
1.75 m
2.00 m
N
0 0.0325 0.065 0.13 0.195
Miles


Frank A. Vanderlip Sr. Park
Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics,
Cliff Projections
Cliff position, 0.75 m SLR
Cliff position, 1.25 m SLR
Cliff position, 1.75 m SLR
Cliff position, 2.00 m SLR
Cliff Projections (Uncertainty)
Cliff position uncertainty, 0.75 m SLR
Cliff position uncertainty, 1.25 m SLR
Cliff position uncertainty, 1.75 m SLR
Cliff position uncertainty, 2.00 m SLR
Shoreline Position (MHW)
0.75 m
1.25 m
1.75 m
2.00 m
N
0 0.0325 0.065 0.13 0.195
Miles


Cliff Projections
Cliff position, 0.75 m SLR
Cliff position, 1.25 m SLR
Cliff position, 1.75 m SLR
Cliff position, 2.00 m SLR
Cliff Projections (Uncertainty)
Cliff position uncertainty, 0.75 m SLR
Cliff position uncertainty, 1.25 m SLR
Cliff position uncertainty, 1.75 m SLR
Cliff position uncertainty, 2.00 m SLR
Shoreline Position (MHW)
0.75 m
1.25 m
1.75 m
2.00 m
N
0 0.0325 0.065 0.13 0.195
Miles


Trump National Golf Club
Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics,
Cliff Projections
Cliff position, 0.75 m SLR
Cliff position, 1.25 m SLR
Cliff position, 1.75 m SLR
Cliff position, 2.00 m SLR
Cliff Projections (Uncertainty)
Cliff position uncertainty, 0.75 m SLR
Cliff position uncertainty, 1.25 m SLR
Cliff position uncertainty, 1.75 m SLR
Cliff position uncertainty, 2.00 m SLR
Shoreline Position (MHW)
0.75 m
1.25 m
1.75 m
2.00 m
N
0 0.05 0.1 0.2 0.3
Miles

[1] C. Ramis, A. Amengual, Climate Change Effects on European Heat Waves and Human Health,
Editor(s): Dominick A. Dellasala, Michael I. Goldstein, Encyclopedia of the Anthropocene, Elsevier, 2018, Pages 209-216, ISBN 9780128135761, https://doi.org/10.1016/B978-0-12-809665-9.09798-6.

[2] C. Ramis, A. Amengual, Climate Change Effects on European Heat Waves and Human Health,
Editor(s): Dominick A. Dellasala, Michael I. Goldstein, Encyclopedia of the Anthropocene, Elsevier, 2018, Pages 209-216, ISBN 9780128135761, https://doi.org/10.1016/B978-0-12-809665-9.09798-6.

[3] CEC (California Energy Commission). 2019. Cal-Adapt: Exploring California's Climate Research. http://cal-adapt.com

[4] CEC (California Energy Commission). 2019. Cal-Adapt: Exploring California's Climate Research. http://cal-adapt.com

[5] CEC (California Energy Commission). 2019. Cal-Adapt: Exploring California's Climate Research. http://cal-adapt.com

[6] Lucy, Michael. "The Wind Is Slowing Down." *Cosmos*, 10 May 2018, cosmosmagazine.com/climate/the-wind-is-slowing-down.

[7] LA County Comprehensive Floodplain Management Plan. Tetra Tech, LA County Department of Public Works, Final (2016). Web: https://dpw.lacounty.gov/wmd/nfip/FMP/documents/Los%20Angeles%20County%20FMP%20Final%20-%20No%20appendices.pdf

[8] USGCRP. 2009a. *Global Climate Change Impacts in the United States*. New York: Cambridge University Press.

[9] Jin, Yufang, Michael L. Goulden, Nicolas Faivre, Sander Veraverbeke, Fengpeng Sun, Alex Hall, Michael S Hand, Simon Hook and James T Randerson. 201. Identification of two distinct fire regimes in Southern California: implication for economic impact and future change. IOP Publishing Ltd. Environmental Research Letters, Volume 10, Number 9. Published 8 September 2015.

[10] LA County Comprehensive Floodplain Management Plan. Tetra Tech, LA County Department of Public Works, Final (2016). Web: https://dpw.lacounty.gov/wmd/nfip/FMP/documents/Los%20Angeles%20County%20FMP%20Final%20-%20No%20appendices.pdf

[11] Wang et al. El Nino and the related phenomenon Southern Oscillation (ENSO): The largest signal in interannual climate variation. PNAS September 28, 1999. Web: https://doi.org/10.1073/pnas.96.20.11071

[12] Cai, W. *et al.* Increasing frequency of extreme El Nino events due to greenhouse warming. *Nature Climate Change* **4**, 111-116, doi:10.1038/NCLIMATE2100 (2014).

[13] Mendez, F. J., et al. "Analysis of the interannual variability of tropical cyclones striking the California coast based on statistical downscaling." *American Geophysical Union, Ocean Sciences Meeting 2016, abstract# A54B-2719*. 2016.

[14] Mendelsohn et al. The impact of climate change on global tropical cyclone damage. Nature Climate Change, http://dx.doi.org/10.1038/nclimate1357 (2012); published online 15 January 2011.

[15] https://www.ioes.ucla.edu/wp-content/uploads/UCLA-CCS-Climate-Change-Sierra-Nevada.pdf

[16] Walton, D., A. Hall, N. Berg, M. Schwartz, and F. Sun (2016), Incorporating snow albedo feedback into downscaled temperature and snow cover projections for California's Sierra Nevada, J. Clim., doi:10.1175/JCLI-D-16-0168.1, in press

[17] 2010 Urban Water Management Plans. The complete list of UWMPs is available from the California Department of Water Resources. Retrieved from http://www.waterhub.ucla.edu/watersources.html

[18] Westerling, A & Gershunov, Alexander & R. Cayan, Daniel & Barnett, Tim. (2002). Long lead statistical forecasts of area burned in western U.S. wildfires by ecosystem province. International Journal of Wildland Fire. 11. 257-266. 10.1071/WF02009.

[19] Keeley, J.E. *Impact of antecedent climate on fire regimes in coastal California*; 2004; Article; Journal; International Journal of Wildland Fire

[20] Dennison, P.E., M.A. Moritz, and R.S. Taylor, 2008. Examining predictive models of chamise critical live fuel moisture in the Santa Monica Mountains, California. International Journal of Wildland Fire, 17, 18-27. Published, 2008.

[21] Keeley, J. E., and H. D. Safford. 2016. Fire as an ecosystem process. Chapter 3 in: H. Mooney and E. Zavaleta, editors. Ecosystems of California. University of California Press, Berkeley, California, USA.

[22] Keeley, J. E., and H. D. Safford. 2016. Fire as an ecosystem process. Chapter 3 in: H. Mooney and E. Zavaleta, editors. Ecosystems of California. University of California Press, Berkeley, California, USA.

[23] Barnard, P.L., Erikson, L.H., Foxgrover, A.C., Limber, P.L., O'Neill, A.C., and Vitousek, S., 2018, Coastal Storm Modeling System (CoSMoS) for Central California, v3.1: U.S. Geological Survey data release, https://doi.org/10.5066/P9NUO62B

[24] Hazard Exposure Reporting and Analytics. Department of the Interior United States Geological Survey, https://www.usgs.gov/apps/hera/ ; updated online 16 March 2017s

[25]Schulte, Paul A., HeeKyoung Chun, "Climate Change and Occupational Safety and Health: Establishing a Preliminary Framework", *Journal of Occupational and Environmental Hygiene,* vol. 6, no. 9, pp. 542-554, 2009, https://doi.org/10.1080/15459620903066008.

[26] Basu, Rupa "High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008", *Environmental Health*, vol. 8, no. 40, 2009, https://doi.org/10.1186/1476-069X-8-40.

[27] Hansen, Alana, et al. "Older persons and heat-susceptibility: the role of health promotion in a changing climate", *Health Promotion Journal of Australia,* 22 Spec No. S17-20, 2011, DOI:10.1071/he11417.

[28] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds. "Climate Change Impacts in the United States: The Third National Climate Assessment", *U.S. Global Change Research Program,* ch. 9, doi:10.7930/J0Z31WJ2.

[29] Nitschke, Monica, et al. "Risk factors, health effects and behaviour in older people during extreme heat: a survey in South Australia" *Int J Environ Res Public Health*, vol. 10, no. 12, pp. 6721-33, 2013. https://doi.org/10.3390/ijerph10126721

[30] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds. "Climate Change Impacts in the United States: The Third National Climate Assessment", *U.S. Global Change Research Program,* ch. 9, doi:10.7930/J0Z31WJ2.

[31] Basu, Rupa "High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008", *Environmental Health*, vol. 8, no. 40, 2009, https://doi.org/10.1186/1476-069X-8-40.

[32] White, Glen W., et al. "Final Report Findings of the Nobody Left Behind: Preparedness for Persons with Mobility Impairments Research Project", *Research and Training Center on Independent Living, University of Kansas*, 2007, http://www2.ku.edu/~rrtcpbs/findings/Final%20Report%20NLB%20July%202007.pdf.

[33] Smith, Diane L., Stephen J. Notaro, "Personal emergency preparedness for people with disabilities from the 2006-2007 Behavioral Risk Factor Surveillance System" *Disability and Health Journal*, vol. 2, no. 2, pp. 86-94, 2009, https://doi.org/10.1016/j.dhjo.2009.01.001.

[34] Swim, Janet, et al. "Psychology and Global Climate Change: Addressing a Multi-faceted
Phenomenom and Set of Challenges", *American Psychologist*, vol. 66, no. 4, pp. 241-50, 2009, DOI: 10.1037/a0023220.

[35] World Health Organization Centre for Health and Development. Climate change exposures, chronic diseases and mental health in urban populations - a threat to health security, particularly for the poor and disadvantaged: World Health Organization; 2009.
[36] Uejio, Christopher K., et al. "Intra-urban societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability", *Health & Place*, vol. 17, no. 2, pp. 498-507, 2011, https://doi.org/10.1016/j.healthplace.2010.12.005.
[37] Kessler, Ronald C. "Hurricane Katrina's Impact on the Care of Survivors with Chronic Medical Conditions", *Journal of General Internal Medicine*, 2007, DOI:10.1007/s11606-007-0294-1.
[38] Fowler, Robert A., et al. "An Official American Thoracic Society Systematic Review: The Association between Health Insurance Status and Access, Care Delivery, and Outcomes for Patients Who Are Critically Ill", *American Journal of Respiratory and Critical Care Medicine*, vol. 181, no. 9, pp. 1003-11, 2010, DOI: 10.1164/rccm.200902-0281ST.
[39] Wilper, Andrew P., et al. "Health Insurance and Mortality in US Adults", *Research American Journal of Public Health*, vol. 99, no. 12, pp. 2289-95, 2009, www.ncbi.nlm.nih.gov/pmc/articles/PMC2775760/.
[40] Kushel MB, Gupta R, Gee L, Haas JS. Housing instability and food insecurity as barriers to health care among low-income Americans. *J Gen Intern Med*. 2006;21(1):71–77. doi:10.1111/j.1525-1497.2005.00278.x
[41] Insurance information institute(n.d.). Retrieved from https://www.iii.org/fact-statistic/facts-statistics-renters-insurance
[42] [42] Moser, S. C., and J. A. Ekstrom. 2010. A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences of the United States of America* 107:22026-22031. http://dx.doi.org/10.1073/pnas.1007887107.
[43] Neisser, U., G. Boodoo, T. J. Bouchard, A. W. Boykin, N. Brody, S. J. Ceci, D. F. Halpern, J. C. Loehlin, R. Perloff, R. J. Sternberg, and S. Urbina. 1996. Intelligence: knowns and unknowns. *American Psychologist* 51:77-101. http://dx.doi.org/10.1037/0003-066X.51.2.77
[44] Becker, G. S. 1993. *Human capital: a theoretical and empirical analysis, with special reference to education*. 3rd edition. The University of Chicago Press, Chicago, Illinois, USA.