Vulnerability and Adaptation to Sea-Level Rise: An Assessment for the City of Hermosa Beach

Report prepared for Raimi & Associates
as part of the Existing Conditions Report
developed for the General Plan Update
for the City of Hermosa Beach

September 2014

Julia A. Ekstrom, Ph.D.
and
Susanne C. Moser, Ph.D.

Susanne Moser Research & Consulting
Santa Cruz, CA

PHOTO: AERIAL VIEW OF THE HERMOSA BEACH COASTLINE1

Contents

Part A: Vulnerability Assessment

Part B: Coastal Adaptation Options

Acknowledgments:

The authors wish to express their thanks for the opportunity to work on this project. Thank you to all those who helped with obtaining relevant data and reports and also for review comments on an earlier draft. Any omissions, oversights or interpretations in the final report are those of the authors.

Part A: Vulnerability Assessment

1. Introduction: Goals, Context and Background

1.1. Goals and Context

Flood risks from coastal storms and sea-level rise constitute two important threats to coastal cities in California and around the world. They can negatively affect public safety, economic activity and human well-being unless residents, businesses and local government take appropriate preparatory actions. With climate change, these risks can be expected to increase, requiring additional adaptive actions to prevent harm and damages to the city.

This study takes an in-depth look at these risks for the City of Hermosa Beach, CA. The goals of this study are threefold: (1) to provide up-to-date information about sea-level rise and its associated flood risks to the City of Hermosa Beach; (2) to examine where in the city and in what ways infrastructure, the built environment, business activity and city residents are vulnerable to these growing risks; and (3) to explore how the City of Hermosa Beach can address these risks through appropriate preparatory and adaptive actions through its Local Coastal Program and other mechanisms.

The City of Hermosa Beach has had a focus on green development, sustainability and climate action for several years, and has decided to update the Coastal Land Use Plan (CLUP) as part of the 2014 General Plan Update. The City is working on developing a certified Local Coastal Program (LCP) to reflect the changing risks to its coastal areas and to develop appropriate policies and actions to avoid or minimize the risk of disaster and harm to its residents, infrastructure and the local economy.

This study, conducted as part of the Existing Conditions Report that lays the foundation for the City's General Plan Update currently underway, provides requested information so that the City can consider the risks arising from climate change and, particularly, from sea-level rise into its long-term planning and related decisions. The particular focus here is on flood risk, emergency response, public health, and development in areas that are already at risk from coastal flooding and that may additionally be at risk in the future.

At the same time that the City is updating its General Plan/Coastal Land Use Plan and its LCP, the California Coastal Commission has released Draft Guidance on how to assess and how to address sea-level rise risks in local communities (California Coastal Commission, draft of December 2013).[2] This more specific guidance follows on (and is consistent with) previous guidance from the Ocean Protection Council (2011)[3] on sea-level rise scenarios to use in planning and development by coastal communities and state agencies. While only advisory, the City of Hermosa Beach should expect that the Coastal Commission – in the process of reviewing and approving the updated CLUP – will take a careful look at any underlying documentation as to whether or not risks and vulnerabilities have been assessed and whether or not the City is considering the best available science on sea-level rise, coastal hazards, and adaptation. The assessment presented here is thus in accordance with the Commission's guidance (as currently conceived, pending further updates over the next few months) and is offered in partial fulfillment of the required information for a CLUP Update. It is also consistent with common planning standards used in hazards mitigation planning. We illustrate how we have followed the guidance to the extent possible with this document.

This study was conducted between October 2013 and February 2014, providing a first-time assessment of sea-level rise vulnerability (social and infrastructure) based on existing information from secondary data sources, such as City and County planning documents, other assessments related to vulnerable segments of the city (and, in some cases, the county's) population, newspaper articles about past floods, Census 2010 data, American Communities Survey Census 2008-2012 data, as well as the best available science on sea-level rise, coastal hazards in California, and on climate change. These data and information sources were compiled and synthesized to provide a vulnerability assessment for the City. No primary data were collected for this study due to time and budget constraints for this project. Yet, it aims to show the value of using available data that enable planners to incorporate social and infrastructure vulnerability into thinking about climate adaptation for the City. This report also points to additional information and processes that may be useful in developing future assessments that can further improve the scientific foundation for further LCP updates and ongoing coastal management decisions.

It is important to note that this report does not provide new projections of sea-level rise, including no new flood and coastal erosion modeling, for the region. It was outside the scope and budget for this report to conduct such new research. Instead, existing scientific projections of sea-level rise were applied to the City of Hermosa Beach, and the implications explored for vulnerable areas and populations in the city. The best available science and best available spatial data are described in Section 3.1 "Sea-level rise."

In Part B, this study examines the existing LCP, its provisions to address coastal hazards and changing coastal conditions, and then provides a series of suggestions – based on best practices and available science about adaptation approaches to date – that can be considered in the process of updating that plan to account for the changing risks to Hermosa Beach's shorefront. An analysis is provided as to which LCP sections require attention to sea-level rise, and possible adaptation options are described.

Adapting to climate change is a continual process, however, and the underlying social, economic and ecological science – just like physical climate change science – is not static. Relevant science thus should be updated regularly as adaptation planning continues in the future and as additional information becomes available. Thus, any potential new policies that the City chooses to adopt should be written in ways that allow for this ongoing updating with best available science.

1.2 Background

> ***For every dollar spent on disaster risk reduction, four to ten dollars are saved in avoided damages.***

In 2008, California's then-Governor Schwarzenegger signed Executive Order S-13-2008 that required the California Natural Resources Agency to coordinate the development of a statewide Climate Adaptation Strategy. Following this executive order, the state completed its first statewide adaptation strategy in December 2009,[4] which is currently being updated (a draft of this update, entitled *Safeguarding California: Reducing Climate Risk, An Update to the 2009 California Climate Adaptation Strategy*, was released in December 2013 and will be finalized in 2014). Partially in response to the State's first adaptation strategy,[5] several regions and communities across California have initiated studies and planning processes to better understand how climate change will affect their areas and determine how to reduce and prepare for these impacts.[6]

Hermosa Beach, in its desire to plan ahead and ensure the city's prosperity, safety, and beauty as well as its residents' welfare while also becoming sustainable and resilient vis-à-vis climate change, is thus one of a growing number of California (and US) cities that sees these goals not as mutually exclusive, but instead as mutually supportive. As experiences like Hurricane Sandy in October 2012 illustrate vividly, and as well-established science documents, it pays off to prepare for disaster mitigation before extreme events strike. For every dollar spent on disaster risk reduction, four to ten dollars are saved in avoided damages.[7] It is also often cheaper and more beneficial in non-monetary terms to work *with* nature than against or without her to safeguard against storm surges, floods and excessive runoff, extreme heat and water shortages.[8] This vulnerability assessment for the City of Hermosa Beach thus is to support the City's update of its General Plan in 2014 and to provide input into how to revise its LCP in ways that incorporate sea-level rise and related risks in line with the Coastal Commission's guidance.

For years, the State of California has supported science that has improved our understanding of how sea-level rise from climate change could affect our coastlines. Increased erosion of cliffs and beaches, increased levels of flooding and storm surge, shifts in storm tracks, loss of wetlands and saltwater intrusion into coastal groundwater reservoirs are among the impacts expected as sea level continues to rise.[9] The best available science on these issues is used in this report.

For example, the California Ocean Protection Council's (OPC) updated guidance from 2013 is based on the best available climate and sea-level rise science: it used an assessment of the state of science commissioned from the National Research Council by Governor Schwarzenegger (Executive Order S-13-08) along with his counterparts in Oregon and Washington. The report (completed in 2012) now serves as the basis for state planning efforts along the entire West Coast from the Canadian to the Mexican border.

2. Key Concepts Use in this Report

2.1 Vulnerability

To be consistent with statewide adaptation efforts, in this report we employ the same basic terminology as is used in the State of California's 2009 Climate Adaptation Strategy.[10]

Vulnerability – in the most general sense – describes a system's susceptibility to harm or change. Vulnerability is the combined result of exposure, sensitivity, and adaptive or response capacity and, as such, a function of the character, magnitude, and rate of the climate change hazard to which a system is exposed, as well as of non-climatic (social and environmental) characteristics of the system, which determine its sensitivity and adaptive capacity. This assessment focuses primarily on ***social vulnerability,*** which points to the factors that make certain groups of people more susceptible to harm than others. Thus, we describe the social and economic characteristics of the City of Hermosa Beach that are associated with lower adaptive capacity and higher sensitivity to flood events in areas potentially exposed to flooding and inundation from sea-level rise.

Additionally, we discuss the vulnerability of infrastructure (incl. public facilities, public spaces, private homes and business establishments, streets, and other) that is potentially exposed to flooding with increased sea-level rise. We highlight challenges that Hermosa Beach and neighboring coastal areas already do – and increasingly may – endure during winter storms, the severity of which sea level is expected to exacerbate.

The three dimensions commonly used to describe and understand the vulnerability of a system are described further below as they are essential to the analysis conducted in this study.

2.1.2 Exposure

First, ***exposure*** is the nature and degree to which a system experiences a stress or hazard.[11] Exposure captures whether or not someone or something is *at risk* from a particular hazard. Examples of such ***hazards*** familiar in coastal areas include

- coastal flooding of the beach, buildings and roadways during storms,
- erosion of beaches, cliffs and bluffs, and
- salt water intruding into coastal groundwater aquifers.

Depending on the sensitivity (discussed below) of the exposed natural and human built environment, exposed areas may then experience certain ***impacts***, such as

- impaired drainage backing up storm water into streets and homes,
- damage to beachfront property and recreational facilities,
- loss of some portion of the beach, and
- in the worst case, human injuries and loss of life.

Many of the hazards that drive these impacts can be expected to be exacerbated by climate change and a rise in sea level.

The levels of exposure from a stressor or hazard, however, often are not distributed evenly across a geographic space or across human populations (e.g., coastal areas will be more exposed to storms, but less to extreme heat compared to inland areas).
It is also important to note that climatic hazards can be one-time extreme events or slower, creeping problems that are chronic in nature, which can make the occasional extreme event have more disastrous impacts. For example, a heavy rainfall event – a temporary extreme – coinciding with a lunar high tide may cause some small amount of flooding at present. It might cause even more flooding if it occurs in an El Niño winter, when sea level is already considerably elevated. However, if the same type of event sometime in the future is combined with a gradual increase of sea level, i.e., with an increase in the baseline above which the

storm occurs – it could create unprecedented flood levels and result in costly damage. Thus while gradual sea-level rise and associated slower changes in sediment movement may be hard to perceive, they become significant multipliers of the flood risks faced in a particular area over time.

In summary, how exposure is distributed across space and populations, and the nature of the climate perturbation, are important inputs for understanding local-level vulnerability. Section 3 on climate change (specifically sea-level rise) summarizes the best available science at present on what threats the city and county may be exposed to in the future.

2.1.2 Sensitivity

The second dimension of vulnerability is ***sensitivity***, which refers to the degree to which a person, structure or system will be impacted by a given stressor, change or hazard.[12] The greater the sensitivity, the bigger the impact of a hazardous event. The effect can be direct (e.g., the damage to a single-story home in a low-lying coastal area with no flood-proofing) or indirect (e.g., non-climatic stresses – such as loss of income – may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stresses).[13] Thus, the sensitivity of a system is not just the result of climate-related hazards, but also influenced by non-climatic stresses. For example, those with existing illnesses may be more sensitive than healthy adults to water-borne bacteria that may spread during flooding. In short, people already under significant amounts of stress for health, economic, or psychosocial reasons may be more susceptible to additional climate-related health stresses.

2.1.3 Adaptive Capacity

The third dimension of vulnerability is ***adaptive capacity***. This term encompasses the ability to cope with extreme events, to make adaptive changes over time, or to transform more fundamentally, including the ability to moderate potential damages (negative consequences) and to take advantage of opportunities (beneficial consequences) that may arise from climate change.[14] People who have a greater adaptive capacity, even if they are at risk of experiencing a hazard and have a certain sensitivity to it, may still end up with an overall lower vulnerability than similarly exposed and sensitive populations with a more limited capacity to prepare for and recover from the hazardous event or adapt over time.

While there are a number of ways to measure and evaluate adaptive capacity (and the scientific community does not agree on just one), this concept relates to the degree to which the system can prepare for and adapt to change in order to deal with a stressors or change. Adaptive capacity can be assessed on any level of organization, from the individual to the municipal, national or international levels. In this report we focus on the individual, neighborhood, and community (i.e., municipal) levels.

The factors that tend to increase adaptive capacity include economic resources, highly functional institutions, adequate infrastructure, availability of technological options and capacities, sufficient information and high levels of education and skill among decision-makers and stakeholders, significant social capital among community members, and equity in the access to these resources and capacities. These definitions of exposure, sensitivity and adaptive capacity illustrate why in this report we focus extensively on the social characteristics of the city's population and economic sectors.[15]

2.2 Adaptation and Resilience

The term adaptation commonly refers to any adjustment in natural systems (natural reactive responses to change in an ecosystem such a grassland, forest or wetland) or in human systems (reactive and proactive, planned and ad hoc efforts in a household, a city, a business, or a nation) in response to actual or expected climatic stimuli or their effects. Goals of adaptation can vary but generally aim to minimize harm or take advantage of beneficial opportunities that may arise in the course of climate change. In this report, we refer to ***adaptation*** as including all those adjustments in planning, management and decision-making that a government entity, business, or private citizen might make to prepare for and deal with the impacts of climate change.

Another term frequently heard in the context of disaster preparedness and adaptation to climate change is ***resilience.*** Depending on scientific discipline and field of practice, resilience means different things to different people. In the California State Adaptation Strategy, resilience is defined as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change." This definition combines two different interpretations of the term. On the one hand, resilience is sometimes understood as a *characteristic of a system* that allows it to function a certain way, namely to withstand and recover from extreme events and disruptions more quickly and easily. Others understand it as a desirable end state or *outcome* of adaptive efforts, namely that a system or community is less vulnerable than it was prior to the efforts it made to prepare for and adapt to change. Thus, in the former interpretation, a community would be called more resilient if it focused its adaptation efforts mostly on building up its adaptive capacity so that in the event of a disaster, it could recover more quickly. In the latter interpretation, a community would be called more resilient if it focused its efforts primarily on reducing its exposure or strengthened its protection and reduced other concurrent stressors (i.e., reduced its sensitivity).

Because climate conditions are not static but will continually change over time, such adaptive efforts cannot be undertaken just once but have to be monitored for continued ***effectiveness*** and augmented as needed. Thus in order to remain resilient in the face of continual change, vigilance, monitoring, learning, and periodic reviewing are required, so as to enhance or change strategies commensurate with the changing conditions. Ideally, then, adaptation efforts are focused on all three dimensions of vulnerability (exposure, sensitivity, and adaptive capacity) and are periodically reviewed and updated so as to maintain and increase a community's resilience over time.

> ***The rate of sea-level rise over the next several decades may be as much as four to nine times larger than that observed over the 20th century.***

3. Flood Risk and Sea-Level Rise Projections for Hermosa Beach

3.1 Sea-Level Rise and Expected Impacts on Hermosa Beach

Sea-level rise – largely a result of warming ocean waters and melting ice caps – is among the most certain consequences of climate change, although considerable uncertainty remains over the exact extent of rise both globally and along different stretches of the coastline. Over the past century, sea level has risen by approximately 7 inches along the California coast, which is consistent with the observed global average.[16] While an oceanographic oscillation of currents (Pacific Decadal Oscillation) in the Pacific Ocean has temporarily suppressed sea level from rising significantly along the West Coast of the United States since the 1980s, scientists currently see this phase coming to an end, and thus agree that sea-level rise along the U.S. West Coast will resume a pace consistent with the global average in coming decades.[17] A 2012 study by the National Research Council, specifically commissioned by the states of California, Oregon, and Washington and several federal agencies to assess the state of sea-level rise science for the West Coast, concluded that sea level along Southern California's coast will rise up to about 12 inches by 2030, 2 feet by 2050, and 5.5 feet by 2100.[18] While there remain scientific uncertainties around these "best estimates," the biggest of which concern human choices around energy use and emissions of heat-trapping gases to the atmosphere as well as the behavior of the world's major ice sheets (Greenland and West Antarctica), the consensus among experts expressed in the NRC report is that the rate of sea-level rise over the next several decades may be as much as four to nine times larger than that observed over the 20th century.[19]

Along the coast of Hermosa Beach and the entire coastline of Los Angeles County, sea-level rise could lead to the following impacts:

- **Increased erosion of beaches** that are either already retreating or maintained in place by sand replenishment;
- **Increased risk of bluff failures and retreat** and consequent damage to the Pacific Coast Highway, other critical transportation routes along the coast, or build structures on top of bluffs;

- **Coastal flooding with higher storm surges and flood elevations** during coastal storms, potentially flooding valuable transportation, commercial, energy, wastewater, and residential infrastructure in low-lying areas;
- **Permanent inundation** of the few remaining or restored coastal wetlands, as well as beaches and other low-lying areas in LA county;
- **Reduced capacity to absorb runoff** and drain it away from inland areas as sea-level rise elevates the coastal groundwater levels; and
- **Saltwater intrusion into coastal groundwater basins** from which freshwater is drawn to serve regional (residential and commercial) water users.

Scientists estimate that by the end of the 21st century, the extremely high flood levels currently associated with "100-year" flood events (i.e. those floods that have a 1% chance of occurring in any one year) will occur on average once per year along California's coast.[20,21] A major storm in 2100 that has a 1% chance of occurring at that time, by contrast, would produce much higher flood elevations than a present-day 100-year storm, and thus reach much farther inland, a case discussed in more detail in Section 3.2 below.

3.1.1 Coastal Flooding with Sea-Level Rise

Long-term sea-level rise raises the baseline on top of which coastal areas will experience all the short-term natural variability they already experience. This short-term variability ranges from daily tidal movement, to the monthly lunar highs and lows, to seasonal storm-related elevation of water levels, and interannual variability related to the El Niño Southern Oscillation or the Pacific Decadal Oscillation, which also affect sea level.

In fact, both the 2012 National Research Council report and the OPC Sea-Level Rise Guidance emphasize, that "most of the damage along the coast in the near term is expected to be caused by storms, in particular, the confluence of large waves, storm surges, and high astronomical tides during a strong El Niño."[22] The National Research Council report also warned that, "Large El Niño events can raise coastal sea levels by 10 to 30 cm [~4-12 inches] for several winter months [above average sea level]."[23] Such events therefore should be considered in addition to sea-level rise.

For the next several decades, sea level is projected to rise by the following amounts (

Table **1**):

TABLE 1. SEA-LEVEL RISE PROJECTIONS (BASELINE: 2000)

Time Period	Projected Sea-level rise*
2000 – 2030	4 to 30 cm (0.13 to 0.98 ft)
2000 – 2050	12 to 61 cm (0.39 to 2.0 ft)
2000 – 2100	42 to 167 cm (1.38 to 5.48 ft) (or: up to ~66inches)

Source: NRC (2012)[24]
* Projections for all points south of Cape Mendocino.

To put these figures into perspectives: The upper end of the projected range of sea-level rise between 2000 and 2030 (12 inches) is nearly double the sea-level rise experienced in the entire 20th century (7 inches), or roughly since Hermosa Beach was incorporated as a City. Scientists expect sea-level rise to accelerate over time, such that sea level in the future decades will rise at even faster rates than in the very near term.

In the face of uncertainty, communities should use scenario planning and adaptive management techniques.

Sea-level rise scenarios reaching out to 2100 may appear too far in the future to be relevant to current planning. However, 85 years (to 2100) is not beyond the lifetimes of many structures in place already or built today (the Coastal Commission assumes 75-100 years), nor beyond the lifetime of some of Hermosa Beach's youngest residents. Moreover, and importantly, sea-level rise will not stop in 2100, but is expected to continue to rise. The ultimate amount of sea-level rise depends in large measure on the choices society makes today and in the years ahead about how much more heat-trapping gases are emitted into the atmosphere, how sensitively the climate will respond to these emissions, and how fast the ice will melt from the major land-based ice masses of the world in Greenland and Antarctica in response to the warming.

3.1.2 Scenario Planning in the Face of Uncertainty

Regardless of the uncertainties described above, it is prudent to assume that sea level along the California coastline will continue to rise, rise at an accelerating rate, and continue to rise beyond this century. Regardless of the exact rate in coming decades, Hermosa Beach can no longer expect the relatively stable sea level or slow sea-level rise of the past.

But as Table 1 makes clear, future sea level cannot be predicted with perfect certainty. To account for the uncertainties, scientists instead give a range of projections and cannot – at this time – attach a numerical likelihood to these figures to suggest which of the projections are more or less likely to unfold. It should be noted, however, that society is currently on an emissions path that is consistent with the highest emissions scenarios underlying the projections of future warming and sea-level rise. In other words, global total emissions are currently putting society on the path of the hottest of possible futures and thus also on track for the fastest rising, high-end sea level. In fact, two independent scientific studies released in mid-May 2014 found that the West Antarctic Ice Sheet has been irreversibly destabilized and will add tens of feet over the next several hundred years to the global sea level, making a rise in the next 85 years toward the upper end of the projected range more likely.[25]

The Coastal Commission recognizes these uncertainties, and gives clear guidance on how communities should proceed: use scenario planning and adaptive management techniques.[26]

For general planning purposes the Coastal Commission recommends using more than one sea-level rise scenario. For specific projects and permit applications it recommends that communities consider at least one lower and the high-end projection from the best available science (currently, the National Research Council report). This is also consistent with OPC Guidelines, which strongly advises that, “Future sea level will be a starting point for project design considerations. Where feasible, consideration should be given to scenarios that combine extreme oceanographic conditions on top of the highest water levels projected to result from [sea-level rise] over the expected life of a project.”[27]

One way to understand this guidance is to estimate (a) how frequently extreme sea levels will be observed in the future, and (b) for how long these extreme sea levels will last. As explained above, extreme sea levels occur when storm surge, high tides, and other conditions coincide to elevate sea level above the normal average baseline. By comparing current conditions against those during future storms when sea level is also higher, the implications become tangible: In Figure 1 below, the black line shows historically observed variations in *extreme* sea level at La Jolla, California (1960-2000) and projected forward to 2100. An "extreme" sea level, as defined here, is one so high that it is observed in only 0.01% of all cases over the historical record (what scientists call the "99.99th percentile"). The black line suggests that by 2020, the most extreme sea levels of the past will move outside the historical range. They will be regularly exceeded by even higher extremes, and by the end of this century these rare extremes are expected to be nearly 4 feet higher than at present – a flood level that would reach considerably farther inland than a 4 feet lower flood.

The second interesting information that can be gained from this graph comes from the light blue bars in Figure 1. Each vertical bar represents the number of hours per year during which the extreme sea level is experienced in that location, i.e. for how long that level is exceeded ("hours of exceedance"). The baseline (at zero) marks the historical average, and all bars above that baseline indicate a longer-than-average experience of extreme sea level. If a typical year has 365 days or 8,760 hours, and that extreme sea level is exceeded for about 2,250 hours (or more than 90 days per year) by 2100, then end-of-century La Jolla would be exposed to flood risk from this elevated sea level for practically the entire winter season.

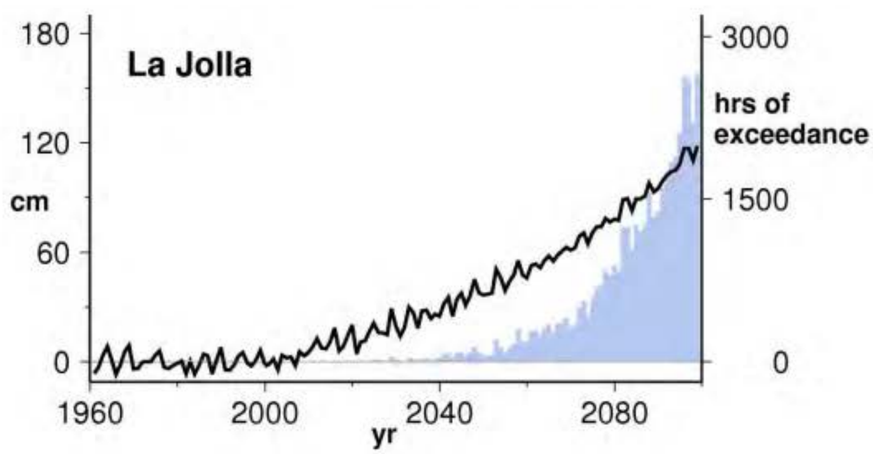


FIGURE 1.CHANGE IN EXTREME SEA LEVEL ELEVATIONS AS SEA LEVEL RISES. THE BLACK LINE SHOWS HISTORICALLY OBSERVED VARIATIONS IN EXTREME SEA LEVEL AT LA JOLLA (1960-2000) AND PROJECTED FORWARD TO 2100. AN "EXTREME" SEA LEVEL IS ONE SO HIGH THAT IT IS OBSERVED IN ONLY 0.01% OF ALL CASES OVER THE HISTORICAL RECORD (THE "99.99TH PERCENTILE"). BY 2020, THE MOST EXTREME SEA LEVELS OF THE PAST WILL BE REGULARLY EXCEEDED BY EVEN HIGHER EXTREMES. THE NUMBER OF HOURS/YEAR DURING WHICH SUCH EXTREME SEA LEVELS WILL BE OBSERVED IN LA JOLLA ARE SHOWN IN LIGHT BLUE BARS. PROJECTIONS ARE BASED ON SEA LEVEL HOURLY MODEL COMPUTATIONS USING MODELED (GFDL CM2.1) SIMULATION FOR THE HISTORICAL PERIOD AND THE SRES A2 EMISSIONS SCENARIOS. PROJECTED SEA-LEVEL RISE IS BASED ON VERMEER AND RAHMSTORF (2009).

Source: Cayan et al. 2012[28]

Given these realities and the best available science currently available, the analysis conducted for Hermosa Beach in this study thus started out from the assumption to use the low and the high-end projections of sea-level rise, combined with the 100-year flood, for the following reasons:

- **Cost-effectiveness** – It is more cost-effective for the City to have at its finger tips the analysis ultimately needed for permit applications, rather than base its General Plan and CLUP update on one set of scenarios and requiring a different set for day-to-day management in the future.
- **Prudence** – If the city uses a high-end sea-level rise scenario for its general planning purposes and can illustrate that its current and future coastal management approaches will safely and adaptively address the highest risks, it uses the most prudent, reassuring and forward-looking approach.
- **Consistency with common hazard mitigation standards** – The 100-year flood event is the most commonly used flood hazard mitigation standard, e.g. by the Federal Emergency Management Agency (FEMA) and its flood maps, as well as in state hazard mitigation planning. Thus, to ensure consistency with these common standards, we used 100-year flooding data rather than flood maps for a smaller event. Moreover, because the Coastal Commission applies a 75-100 year planning horizon for siting decisions (the actual average lifetime of structures rather than merely the length of a typical mortgage), we used projections for 2100, rather than merely for the year 2050.

Available data for an analysis using these two scenarios and flooding event restricted what was feasible for the purposes of this assessment, as explained in the next section.

3.2 Design Flood Maps with Sea-Level Rise Used in this Assessment

Data integrating the National Research Council's high-end scenario of 66 inches of sea-level rise above 2000 levels with flooding were not available at the time of this study, thus the highest *available* scenario was used instead. The Pacific Institute, with funding from the California Energy Commission as part of the California's Second Climate Change Assessment (2009), used a simplified approach to modeling the 100-year flood on top of 55 inches of sea-level rise (essentially a still-water inundation model using the best available topographic elevation data).[29] A map showing areas at risk of this flooding scenario is shown in Figure 2. It represents the best spatial information available for evaluating the extent of the 100-year flood risk with sea-level rise for the City of Hermosa Beach at this time.

As indicated above, the Coastal Commission Draft Guidance recommends the use of multiple scenarios for a vulnerability assessment. However, only the 100-year flood data with 55 inches of sea-level rise was available for Hermosa at the time of this study. The Ocean Protection Council and other entities have awarded research funds to the US Geological Survey to generate 100-year flood maps for the Los Angeles region (including Hermosa Beach) with several scenarios of sea-level rise, expected at the earliest in early 2015 (or as late as 2016). We recommend using those data when they become available and combining them with the social vulnerability analysis conducted for this study (or an updated version).

Figure 2. Extent of the 100-year flood in Hermosa Beach after 55 inches of sea-level rise (red), respectively, based on modeling performed by the Pacific Institute (2009). Additional land would be at risk of flooding with the higher sea-level rise scenario (66 inches by end of the century) recommended by the National Research Council 2012. View of map in Google Earth from aerial vantage point overlaying the City's building footprint (white).

4. Geography and History of Flooding

4.1 Physical Geography

4.1.1 Current Climate and Topography

To place future flood risk in perspective, it is important to examine Hermosa Beach's past experience with major floods, and place the flood risk in the context of the City's physical and human geography.

The City of Hermosa Beach encompasses 1.43 square miles with approximately 2 miles of coastline, located in the southern portion of Santa Monica Bay in Los Angeles County (Figure 3). The city is nestled between two other beachfront cities: Redondo Beach to the south and Manhattan Beach to the north.

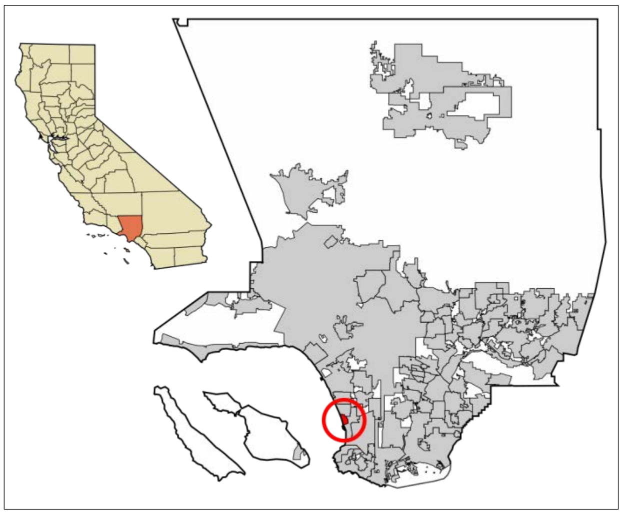


FIGURE 3. GEOGRAPHIC LOCATION OF THE CITY OF HERMOSA BEACH WITHIN LA COUNTY
Source: Wikimedia Commons

One of the sunniest spots in the U.S. (325 days of sunshine on average per year), Hermosa Beach's mild air and water temperatures are key to making it one of the great beach cities of southern California, and a desirable recreational destination for people from hotter inland areas. Its average air temperature in the summer is 74°F and 55°F in winter. Average water temperatures across the seasons range from 60°F in the summer to 50°F in the winter.[30] Rainfall in the Los Angeles area has historically been highly variable. Rainfall totals in the City of Hermosa Beach range widely from nearly no rainfall to more than 3 feet/year (for example, the City measured just 4.35 inches in 2001-2002 on one end of the spectrum, and 38.2 inches in 1883-1884 at the other extreme[31]). The region is also heavily affected by monsoons/summer tropical storms, usually in El Niño years.

The average elevation of the city is close to sea level, approximately 50 feet,[32] gradually rising from sea level at the waterfront to just over 200 feet along its eastern, inland boundary[33] (Figure 4). The city itself is built on a massive sand dune that hugs the coastline.[34] The city's coastline includes one pier and no breakwaters. In the 1960s an artificial reef off Hermosa Beach was built out of quarry rock, one street car, several car bodies, and cement blocks[35] to support recreational fishing. A co-benefit of this reef, originally just meant to enhance local fishing opportunities, is its ability to reduce wave action as storm waves approach the coastline. This may help reduce coastal erosion, now and in the future, of Hermosa's famous beach.

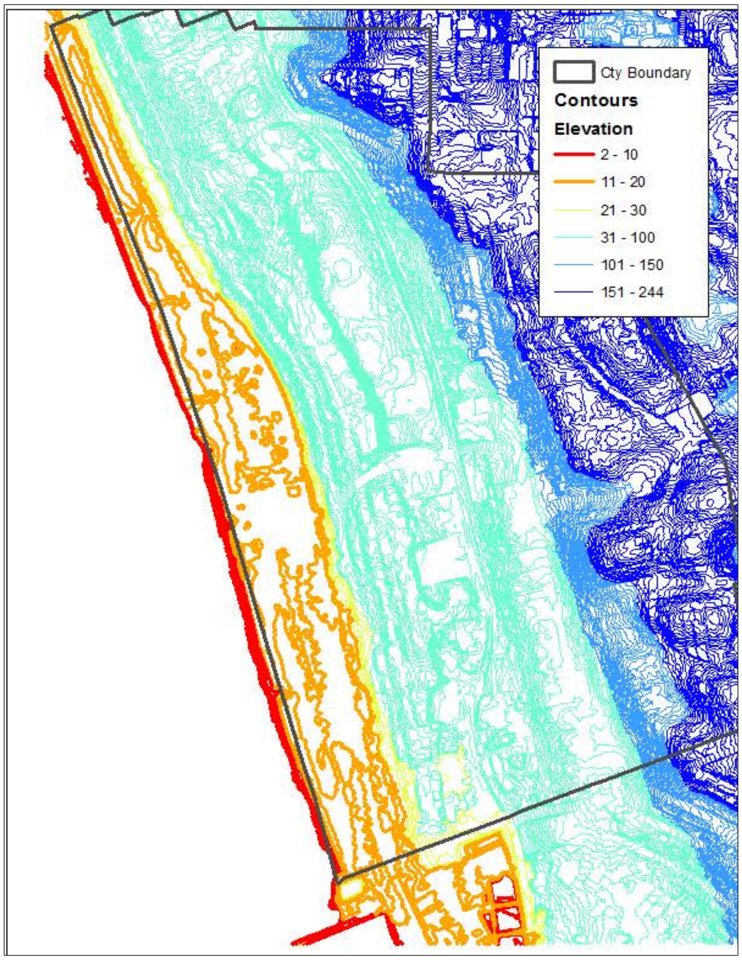


FIGURE 4. ELEVATION MAP OF THE CITY OF HERMOSA BEACH (IN FEET ABOVE SEA LEVEL). RED ORANGE AND YELLOW COLORS INDICATE THE AREAS CLOSEST TO SEA LEVEL, INDICATING HOW THE SOUTHERN PORTION OF THE CITY HAS A GREATER AREA AT LOWER ELEVATIONS BEFORE THE LAND RISES ABOVE 30 FEET.
Source: City of Hermosa Beach[36]

4.1.2 Shoreline Stability and Beach Width

The U.S. Geological Survey has undertaken a study of shoreline stability and physical vulnerability[1] to shoreline change for the entire Pacific Coast shoreline.[37] As a first approximation of the risk of shoreline change, it is valuable to consider their findings. Figure 5 shows that the stretch of shoreline south of Los Angeles to the Palos Verdes Peninsula is one of *very high physical vulnerability* to shoreline change. This high vulnerability to shoreline change can be attributed in large part to the very soft substrate the areas has been built on (sand dunes), and the reduction of sediment influx into the Santa Monica Littoral Cell due to intense build-up of the region and the reduction of river discharge into the bay.[38]

[1] The authors of that study defined vulnerability differently than is commonly used here in this study. The physical vulnerability they describe is a measure of the susceptibility of the shoreline to change (erode or accrete) in response to historical sea-level rise and wave action. This physical vulnerability depends on shoreline geology, geomorphology, regional coastal slope, the rate of historical relative sea-level rise, observed shoreline erosion and accretion rates, tide range and mean wave height.

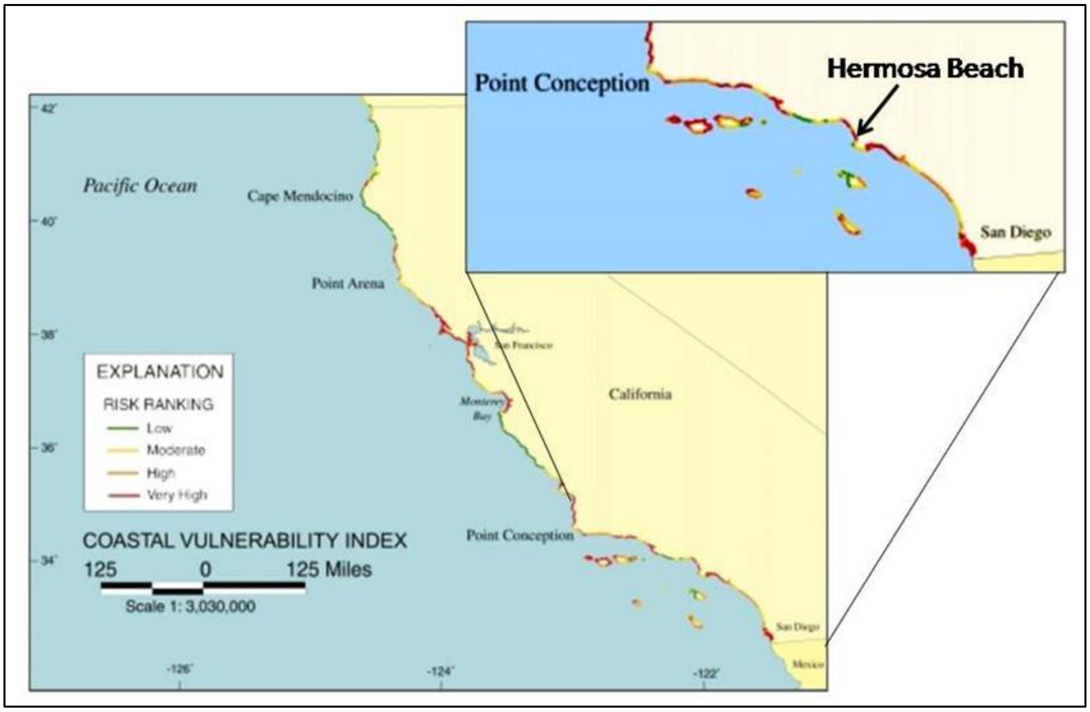


FIGURE 5: THE USGS COASTAL VULNERABILITY INDEX FOR THE COAST OF CALIFORNIA, WITH AN EMPHASIS ON THE HERMOSA BEACH AREA, SHOWS THAT THE SHORELINE SOUTH OF LOS ANGELES HAS A VERY HIGH VULNERABILITY OF ERODING.

Source: Map excerpt created from Thieler and Hammer-Klose (2000)[39]

However, over the last century, there has been heavy sand replenishment at neighboring beaches of Santa Monica Bay, though not directly at Hermosa Beach. The California Beach Restoration Study (2002)[40] reports that Hermosa Beach gained an additional 250 feet in beach width because of the sand replenishment contributed to the shoreline in the bay between 1935 and 1990.[41] It reports that the beaches of Santa Monica Bay, especially those in the central and southern areas of the bay, would not be the same wide stable beaches[42]i f it were not for the opportunistic[43] replenishment undertaken to protect LA's Hyperion Sewage Treatment Plant.[44] Moreover, King Harbor in Redondo Beach, just south of Hermosa Beach's southern boundary appears to serve as a sediment trap that prevents sand from being eroded along the shoreline and lost down Redondo Canyon (Figure 6).

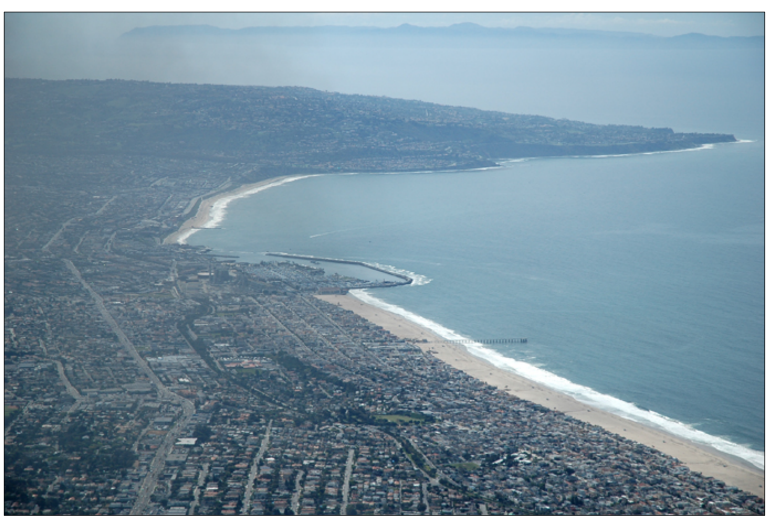


FIGURE 6. AERIAL PHOTO OF HERMOSA BEACH LOOKING SOUTH AS IT RUNS INTO KING HARBOR IN REDONDO BEACH. THE HARBOR SERVES AS A SEDIMENT TRAP FOR THE SAND ALONG HERMOSA BEACH'S SHORELINE, SAFEGUARDING IT FROM BEING SEASONALLY ERODED.

Source: Image Science and Analysis Laboratory, NASA Johnson Space Center[45]

The OPC's Sea-Level Rise Guidelines as well as the Coastal Commission's Sea-Level Rise Guidance advise communities to consider local shoreline dynamics in assessing their future risks. Site-specific information about the near-shore current and erosion dynamics that affect Hermosa's sand distribution should be considered when planning for sea-level rise. This requires, however, a more detailed technical/engineering study of sediment supply and dynamics in order to model how sea-level rise could affect local erosion of beaches and coastline. Such a study was beyond the scope of this study.

To the extent future coastal erosion increases as a result of sea-level rise and related changes in sediment dynamics, and if future beach replenishment is not maintained, Hermosa Beach should expect a reduction of the protective beach buffer in front of the city. As a result, future flooding and storm surge could have a more destructive and farther-inland reaching impact than if the beach remains stable. In the absence of having such a detailed engineering study, the estimates of inland flooding under the higher sea-level rise scenario used here thus may not fully capture the extent of potential risks to the city.

4.1.3 Past Flooding Experience

Currently, none of the city's land is within a Federal Emergency Management Agency (FEMA) 100-year floodplain as currently defined[46]; however, City documents report frequent winter flooding, especially in El Niño years. The City's Hazard Management Plan (2005) describes Hermosa's risk of flooding due to its physical geography as follows:

> "...the towering mountains that give the LA region its spectacular views also wring a great deal of rain out of the storm clouds that pass through. Because the mountains are so steep, the rainwater moves rapidly down the slopes and across the coastal plains on its way to the ocean...higher ridges often trap eastern-moving winter storms. Although downtown LA averages just fifteen inches of rain a year, some mountain peaks in the San Gabriels receive more than forty inches of precipitation annually."[47]

The City's 2005 Hazard Management Plan refers to the City of Hermosa Beach as having "chronic seasonal flooding" problems due to its geography and historic climate. Though the Pier Avenue Improvement Project has addressed some flooding issues, as sea level continues to rise due to climate change, heavy rainfall cannot runoff as easily. Thus, regardless of whether the pattern of seasonal rainfall changes in the future, sea-level rise alone can be expected to exacerbate local flooding conditions when heavy rainfall events occur.

4.2. Demographics and Economy

4.2.1 Population

In 2012 the U.S. Census reports that the City of Hermosa Beach had a total population of 19,773, which reflected a small population growth of about 1.3% (approximately 260 persons) since the last major Census year, 2010. The city's youngest population segment (0-5 years) is smaller (5.1%) than the statewide average of 6.8%. Similarly, the proportion of the population that is 65 years and older is only 9%, while the statewide average is slightly higher at 11.4%.

The vast majority of the population is white (86.8%) – considerably higher than the statewide average of 57.6%. Based on the 2010 U.S. Census only 8.4% of the population is Hispanic or Latino (compared to 37.6% statewide), and 5.7% is Asian. Less than 1.5% of the city's population is African American, American Indian, Native Hawaiian or Pacific Islander.[48]

4.2.2 Economy

As a beachfront bedroom community, the resident population of Hermosa Beach of just under 20,000 is quite small. Property tax is the City's largest single source of revenue with the median home price just over $1 million in fiscal year 2010-11.[49] Accommodation and food service sales also make a significant contribution to the City's economy with a reported $100,593,000 in annual sales in 2007 (the most recent available Census report).[50]

Most residents are employed outside of the city, commuting on average approximately 30 minutes to reach work. Only 5.7% of residents actually work in Hermosa, while 94.3% commute to other places, many to LA.[51] In 2012, the Southern California Council of Government reported there were 6,800 jobs in Hermosa in 2012, 778 of which (or 11.4%) were in the retail sector. Leisure jobs made up 27.5% of the jobs in Hermosa, with an average annual income of only $24,000, which is considerably lower than the average per capita income of Hermosa's residents ($71,215) (Figure 7). The median household income is $100,696, again, considerably higher than the state average of $61,400.[52]

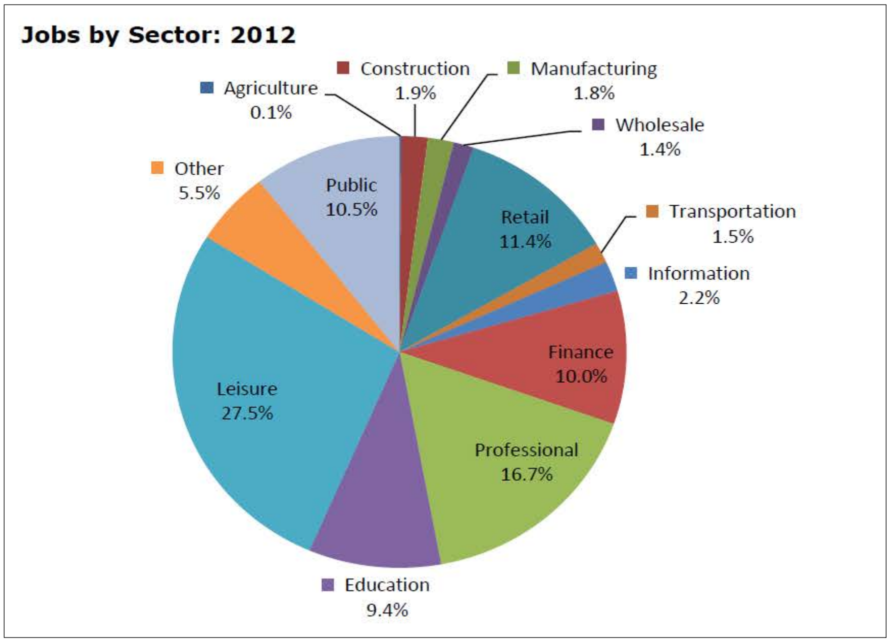


FIGURE 7. DISTRIBUTION OF JOBS ACROSS DIFFERENT ECONOMIC SECTORS IN HERMOSA BEACH

Source: SCAG[53]

While the resident population is relatively small, the city attracts a high visitor population throughout the year. In December 2010, there were 94,300 visitors to the beach, multiplying about ten-fold in the summer (with up to 939,000 beach visitors in July 2010), with a total of more than 3.7 million visitors in the 2010-11 fiscal year.[54] These numbers point to the crucial dependence of the city on the beach economy, and thus on the presence of the beach and the forward-looking management of its coastal infrastructure.

5. Social Vulnerability

5.1 Introduction

Climate change could jeopardize the safety of Hermosa Beach residents as well as the stability and strength of the city's economy, unless adaptation measures are implemented to prevent such potential social and economic harm. This section focuses first on social vulnerability, and in particular the specific population characteristics in those portions of the city exposed to an increased coastal flood risk as sea level rises.

Approximately 1,000 residents of Hermosa Beach live within the 100 year floodplain with 55 inches of sea-level rise.[55] We assessed the population characteristics across the whole city here for three key reasons: (1) the extent of flooding may reach further into the city with 66 inches of sea-level rise (upper range projected by the National Research Council, see Section 3.1.1), (2) extreme flooding at even lower levels of sea-level rise can affect the functionality of key city infrastructure (e.g., road flooding, drainage backups), and (3) important commercial activity happens within the potential flood zone, potentially causing city-wide impacts. Assessing the social vulnerability for the entire city will also facilitate integration of this assessment with updated flooding data when they become available.

Some segments of a community's population tend to be more socially vulnerable to flooding than others. The most important factors shaping social vulnerability include:

- Income and poverty
- Race
- Females as head of household
- Age
- Housing type (percent rentals)
- Physical and mental illnesses and disabilities
- Transient populations

These characteristics are associated with a higher sensitivity and/or lower adaptive capacity of populations exposed to flooding and sea-level rise, and thus should be taken into account in emergency and disaster response/recovery planning as well as in adaptation planning (

Table 2).

TABLE 2. SOCIAL VULNERABILITY FACTORS OF SIGNIFICANCE DURING AND AFTER HAZARDOUS EVENTS

Social impacts of hazard exposure often fall disproportionately on the most vulnerable people in a society – the poor, minorities, children, the elderly, and the disabled. These groups often have the fewest resources to prepare for a flood, live in the highest-risk locations in substandard housing, and lack the knowledge or social and political connections necessary to take advantage of resources that would speed their recovery. Some of the most commonly referenced vulnerability characteristics are summarized in the table below.

Vulnerability Factor	During Event	Recovery
Low income/Poverty Level	Lack of resources may complicate evacuation	Lack of resources may hinder ability to recover
Elderly/Very Young	Greater difficulties in evacuation, more health and safety issues, potential for higher loss of life	May lack resources, willingness, ability to rebound
Disabled	Greater difficulties in evacuation, special health and safety issues, potential for higher loss of life	Lack of facilities and medical personnel in aftermath may make it difficult to return
Female-headed Households	Lack of resources and special needs may complicate evacuation	Lack of resources may hinder ability to recover
Minorities	Lack of influence to protect interests; lack of connections to centers of power or influence	Lack of influence to protect interests; lack of connections to centers of power or influence
Occupants of Mobile Homes/ Renters	Occupy more vulnerable housing	Potential displacement with higher rents
Transient/Homeless	Difficult to locate and provide information to; difficult to estimate numbers	

Source: Dunning and Durden (2013)[56]

These factors – to the extent they are relevant in Hermosa Beach – are explored in the following sections.

5.2 Income and Poverty

Lower income often correlates with lower access to the necessary resources to prepare for or evacuate in the case of a disaster, or to invest in actions required to adapt to climate change (e.g., moving out of a flood plain, elevating living space in one's house above a given flood elevation, purchasing sump pumps, or acquiring insurance to better cope with floods).

Overall the city's population is highly educated, has a relatively high income, and very low rate of poverty (3.6%, as defined by federal standards that apply nationwide). Median household income for years of 2008-2012 was $100,696, which falls between that in Hermosa's two coastal neighboring cities of Redondo Beach

($98,816) and Manhattan Beach ($134,445).[57] As

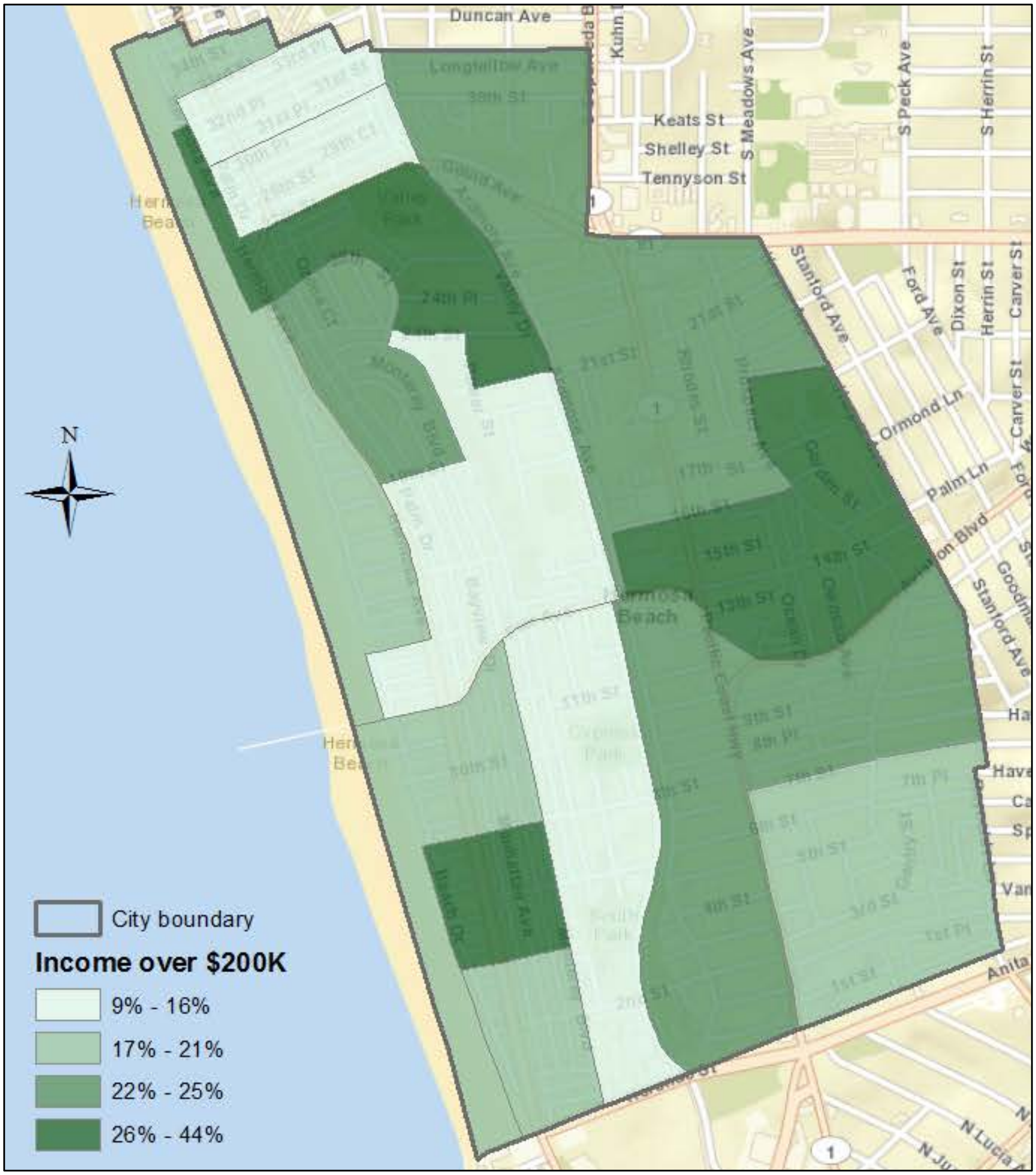


Figure **8** shows, in general, higher income households reside in the northern coastal portion of the city, where houses directly line the Strand.

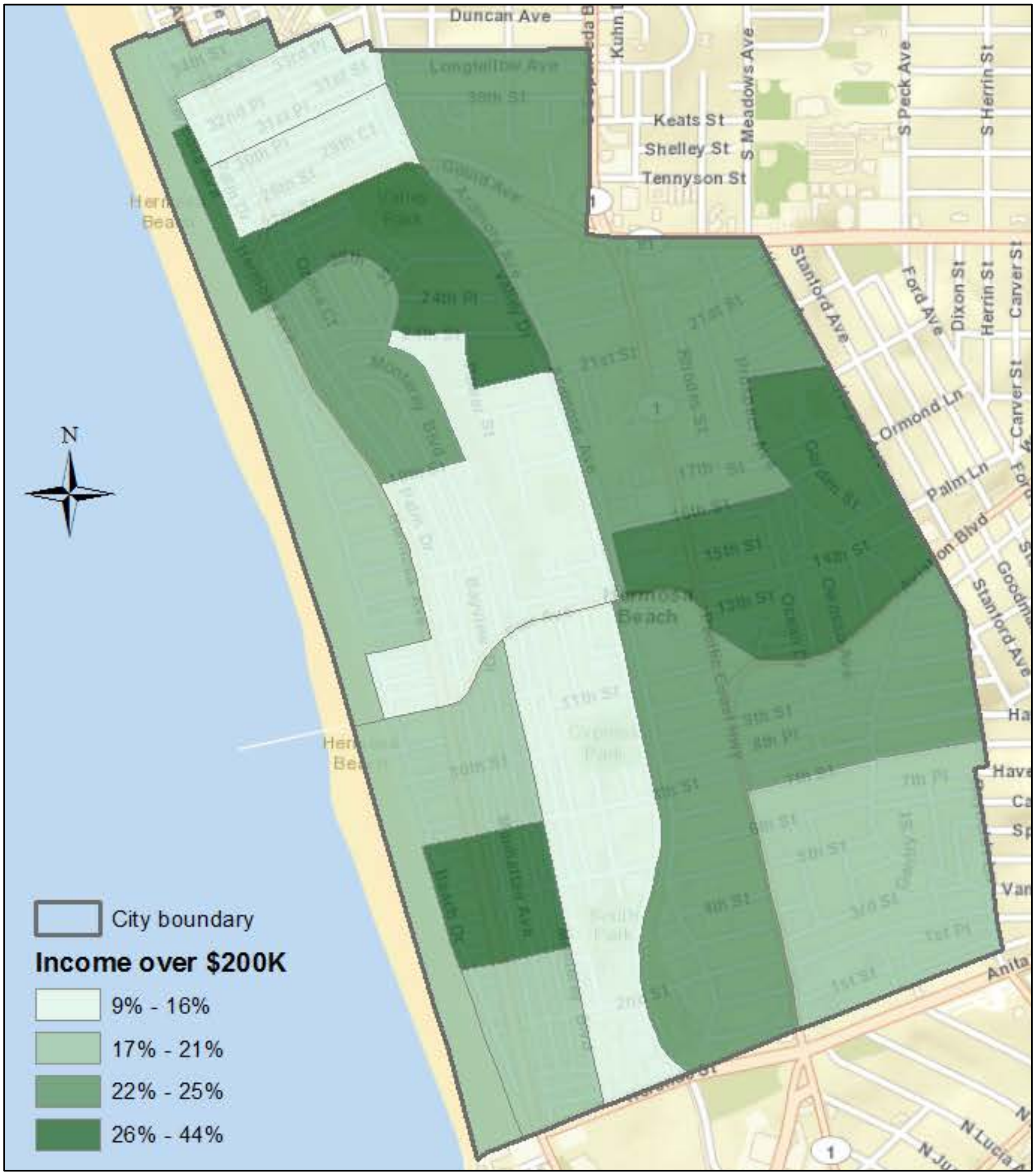


FIGURE 8. AVERAGE ANNUAL PER CAPITA INCOME (LEFT) AND PERCENT OF HOUSEHOLDS WITH AN INCOME GREATER THAN $200,000 PER YEAR (RIGHT) BY CENSUS TRACT OF HERMOSA BEACH

Source: Based on data from the ACS 2008-2012.[58]

Although residents enjoy relatively high household incomes, the cost of living in Hermosa Beach is also high compared to other areas in the Los Angeles region, California, or the nation. Many residents may struggle economically even though this is not directly apparent from the Census statistics on income. According to the Southern California Association of Governments (SCAG)[59], approximately 37% of homeowner households and 41% of renter households in Hermosa Beach were paying more than 30% of their income towards housing costs (Table 3). When renters pay more than 30% of their household income to housing costs, this is referred to as an 'overpayment' burden. The most severe overpayment burden, where renters pay 50% or more of their gross income towards housing costs, is experienced by 1,341 households in Census Block Groups adjacent to the southern beachfront of the city (Figure 9).

Having to spend a large part of one's monthly income on housing can limit discretionary resources for such things as flood-proofing, insurance, or putting some money away as emergency savings (e.g., to repair and reconstruct after a flood event). This implies that households with overpayment burdens may require special assistance to undertake individual, household level adaptations.

TABLE 3. OVERPAYMENT BURDEN BY TYPE OF HOUSING TENURE

Housing Payment Level (% of gross income)	Renters		Owners	
	Households	Percent	Households	Percent
Less than 30%	2,954	59%	2,648	63%
30-34%	366	7%	318	8%
35-39%	473	10%	289	7%
40-49%	410	8%	275	7%
50% or more	691	14%	650	15%
Not available	96	2%	56	1%
Totals	4,990	100%	4,236	100%

Source: Hermosa Beach Housing Element Technical Report 2013[60]

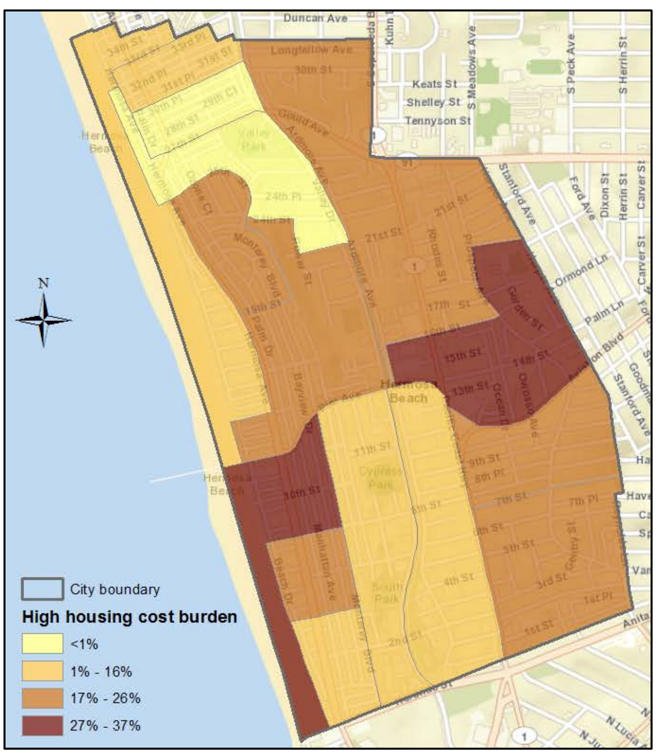


FIGURE 9. PROPORTION OF RENTER-OCCUPIED HOUSING UNITS IN HERMOSA BEACH, WHOSE RENT COSTS 50% OR MORE OF THEIR GROSS HOUSEHOLD INCOME (SHOWN BY BLOCK GROUP)

Source: Based on data from ACS 2008-2012.[61]

5.3 Women as Heads of Household

One segment of the population, often closely aligned with the spatial distribution of low income, involves women as heads of the household. Women's capacity to prepare for flooding, cope with, or evacuate during flooding or associated hazards during a large storm, and recover afterward is particularly impaired when they have lower earnings, are the sole providers for their household (and no spouse is present), and especially when they also have children.[62] Evacuating during a flood can be especially difficult for those who have young children.

Figure 10 shows the percentage of the population in Hermosa Beach (by Census Tract) that has females as heads of household. This population is relatively low overall (compared to other areas of LA County), but is slightly higher than city average on the northern side of the city and is up to 16% in the southwest area of the city. According to the City's Housing Element (2013), female-headed households "make up a significant portion of households that are below the poverty level."[63]

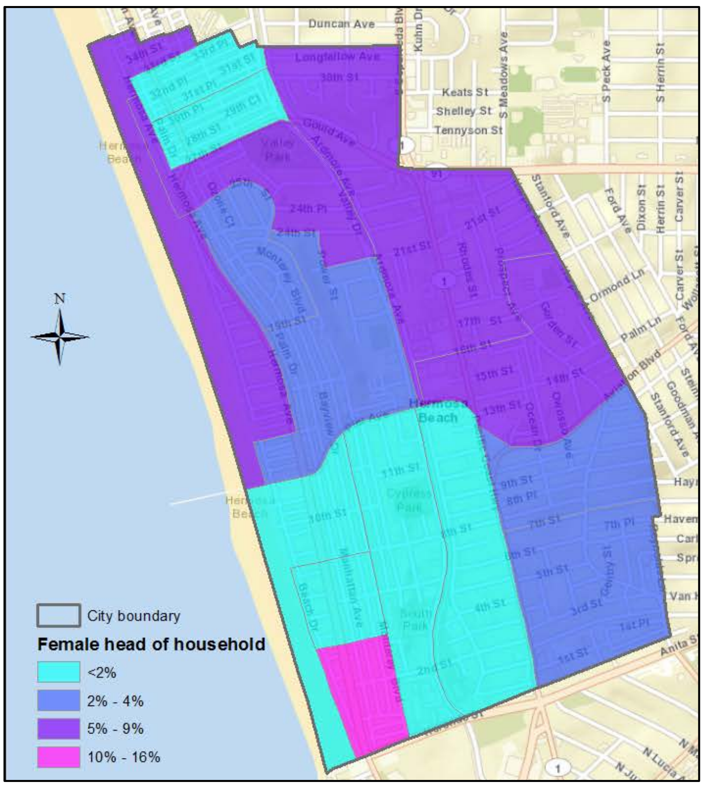


FIGURE 10. PERCENTAGE OF THE POPULATION WITH FEMALES AS HEADS OF HOUSEHOLD

Source: Based on Census ACS 2008-2012.[64]

5.4 Age and Populations with Limited Mobility

Age can play a role in coping and adaptive capacity as well, as it affects mobility and dependence on others. Infants, for example, are less able to protect themselves from or escape extreme conditions (e.g., in extreme heat or during flood events) and depend on others for special assistance in times of emergency. Similarly, the elderly are considered to be more vulnerable than younger adults in emergency situations because of possible mobility challenges or other pre-existing health impairments. Moreover, they may be less connected to email, social media or other typical public outreach tools that inform residents about preparing for disasters and taking emergency actions.

Because cooler summers and better air quality tend to attract older populations to coastal communities all along California's coastline, including in the greater Los Angeles area, there are higher concentrations of older residents along the coast throughout the county. In Hermosa Beach, the highest proportion of elderly residents is in the northern part of the city and in an inland area south of Aviation Boulevard, but all along the beach front residences, the Census estimates that up to 16% of the population is 65 years and older, as shown in Figure 11).

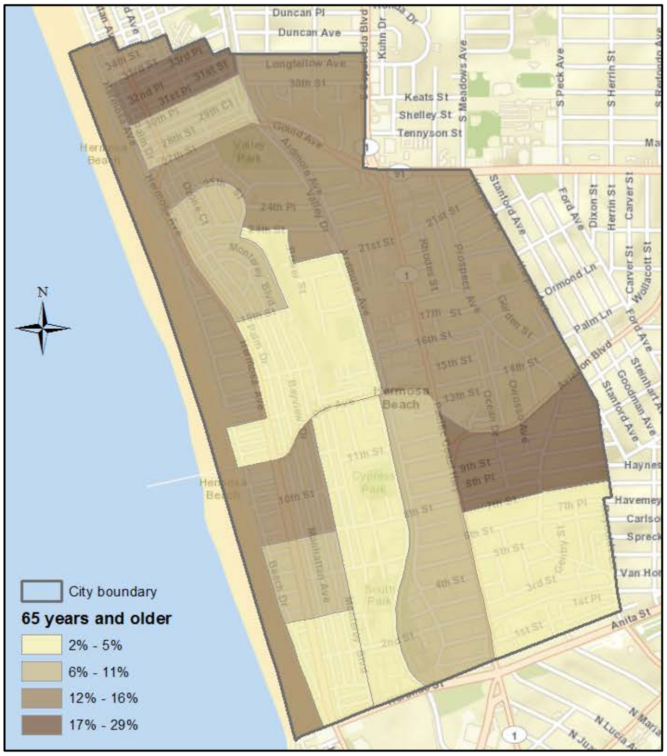


FIGURE 11. MAP SHOWING CONCENTRATION OF PEOPLE 65 YEARS OLD AND OLDER.

Source: Based on ACS 2008-2012 data.[65]

Special attention and services are needed to meet the communication and mobility needs of older residents, as well as of those with pre-existing health conditions (see Section 5.6 below), which may inhibit the responsiveness of these populations to emergency warnings. On the other hand, some retired community members, while still active, healthy and mobile, might have the time and interest in engaging in community affairs and thus be strong assets in community efforts to develop and decide on adaptation strategies.

5.5 Housing Type and Home Ownership

5.5.1 Home Ownership vs. Renting

Housing also tends to be a factor in people's ability to prepare, respond to, recover from flood events as well as in their ability to engage in household-level adaptation activities. Home ownership versus renting points to possible income differences. However, with regard to adaptive capacity, it also indicates how much control individuals have over their housing, e.g., to make structural adjustments to their home for flood protection. According to the ACS 2008-2012 Census, home ownership in the city is only 46%, which is lower than the 56% ownership on average statewide (and still lower than neighboring beachfront cities). Out of the 9,320 total households in the city, 54% of them are renter-occupied housing units,[66] but homeownership can vary considerably from block group to block group (see also Figure 9 above). Interestingly, a higher percentage of housing units (about 67%) are renter-occupied in the Census Block Groups that are directly adjacent to the beach, whereas fewer units (41%) are rented in the eastern inland portion of the city. Along the southern coastal portion of the city, up to 76% of homes are renter-occupied, which is also the area that is most prone to flooding as sea level rises (Figure 12).[67]

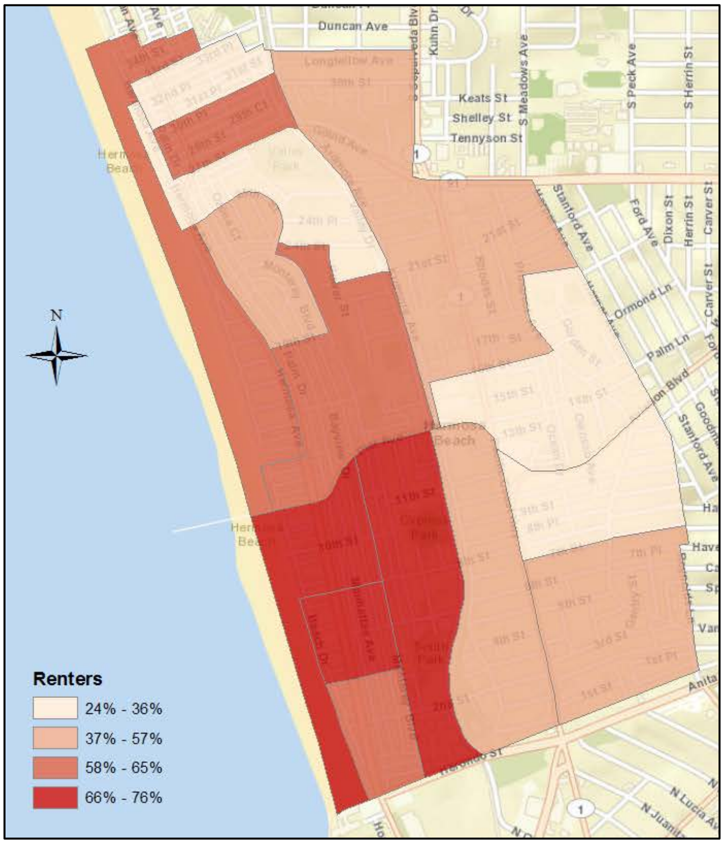


FIGURE 12. PERCENTAGE OF HOUSEHOLDS IN EACH CENSUS BLOCK GROUP THAT ARE RENTED
Source: American Community Survey (2008-2012).[68]

5.5.2 Homelessness

Another population that is at a major disadvantage during a disaster or other hazardous event includes those people without a permanent home. Homeless individuals living in coastal areas could be directly exposed to flood events because of living in the streets or in a parked vehicle. Very little information is usually collected to document the location and living situation of this population, making it difficult for emergency response during a disaster to find and help this population. Public education, awareness campaigns and pre-disaster planning often do not reach this population, and the homeless often do not have adequate means to move to alternative locations.

Per the Los Angeles Homeless Services Authority's 2011 Homeless Count Report, there are 35 unsheltered adult homeless persons in Hermosa Beach. A homeless resources website[69] with one homeless youth shelter within the city[70] and several nearby shelters for the homeless suggests that there is a needy population to be concerned about.

As with all special-needs populations, especially, when housed in group shelters, emergency planning must pay special attention to the evacuation and recovery needs should the need arise. The City's current (2005) Hazard Mitigation Plan makes a few references to special needs populations, but only includes hazard mitigation action items in reference to earthquake preparedness – not flooding – to assist these special needs populations in an emergency. For a comprehensive approach to emergency preparedness, these populations should be included in future analysis on flooding risk and pre- and post-disaster planning.

5.6 The Mentally and Physically Impaired

Populations with physical and mental disabilities are of special concern for disaster planning and emergency response, and should also be considered in long-term planning. People with physical and mental illnesses can have a greater sensitivity to high levels of stress during disasters, and will require personalized attention during the crisis. Importantly, it is not necessarily the most disabled that are of greatest concern for the purposes of emergency response, as they are most likely to already receive ongoing assistance. By contrast, those among the impaired and disabled who – under normal circumstances – can handle life quite independently or with only minimal help, may require the most *additional* assistance when distress is high.

Permanent relocation for adaptation purposes may be equally stressful, and appropriately involving those affected in relevant decision-making and planning may be particularly challenging, but ethically required. Existing illnesses or disabilities may impair individuals' mental and/or physical abilities to adequately respond during an extreme event and also make it difficult to recover. Facilities providing services for those with mental health issues and physical disabilities need to have a plan that is coordinated with the local emergency response, have pre-determined shelters to go to during a disaster, and ensure that emergency response is educated about the special needs of these populations (e.g., they may require more personnel and special assistance during an evacuation). It is important for emergency responders to know where these people reside, whether they live on their own or rely on a group living facility.

The City General Plan documents the portion of the city's residents who are disabled, though it does not reveal where in the city they reside. The City's Housing Element Technical Report (2013) documents that approximately 15% of adults aged 16-64 years have some type of disability that prevents them from working.[71] Such limitations could inhibit or slow these individuals' ability to get out of the flood zone in case of an emergency. Not working and thus being financially dependent or limited in means also limits those individuals ability to take pro-active flood preparedness or adaptive measures. Similarly, as many as 22% of adults over 65 years have physical limitations, and approximately 14% of those 65 years and older have a vision or hearing limitation that may reduce their ability to act swiftly and safely in case of a flooding emergency (Table 4).

Since location data of where disabled populations residence is not easily available, and may be privacy-protected, it is up to the City or organizations representing the interests of these populations to ensure that they are aware of where the disabled live, the nature of their disability, and what special needs they may have in an emergency (e.g., wheelchair accessibility). Moreover, for long-term adaptive planning, the City and these organizations would need to take special care in addressing the special needs of these populations.

TABLE 4. PREVALENCE OF DISABILITY BY TYPE OF DISABILITY IN CITY OF HERMOSA BEACH

Persons with Disabilities by Age – Hermosa Beach		
Disability by Age	**Persons**	**Percent**
Age 5 to 15 - total persons	1,228	--
Sensory disability	0	0.0%
Physical disability	27	2.2%
Mental disability	45	3.7%
Self-care disability	27	2.2%
Age 16 to 64 - total persons	7,340	--
Sensory disability	181	2.5%
Physical disability	318	4.3%
Mental disability	212	2.9%
Self-care disability	51	0.7%
Go-outside-the-home disability	239	3.3%
Employment disability	1,125	15.3%
Age 65 and over* - total persons	1,248	17.0%
Sensory disability	170	13.6%
Physical disability	273	21.9%
Mental disability	132	10.6%
Self-care disability	165	13.2%
Go-outside-the-home disability	219	17.5%

Source: 2000 Census, SF3 Tables P8 and P41
Note: Totals may exceed 100% due to multiple disabilities per person

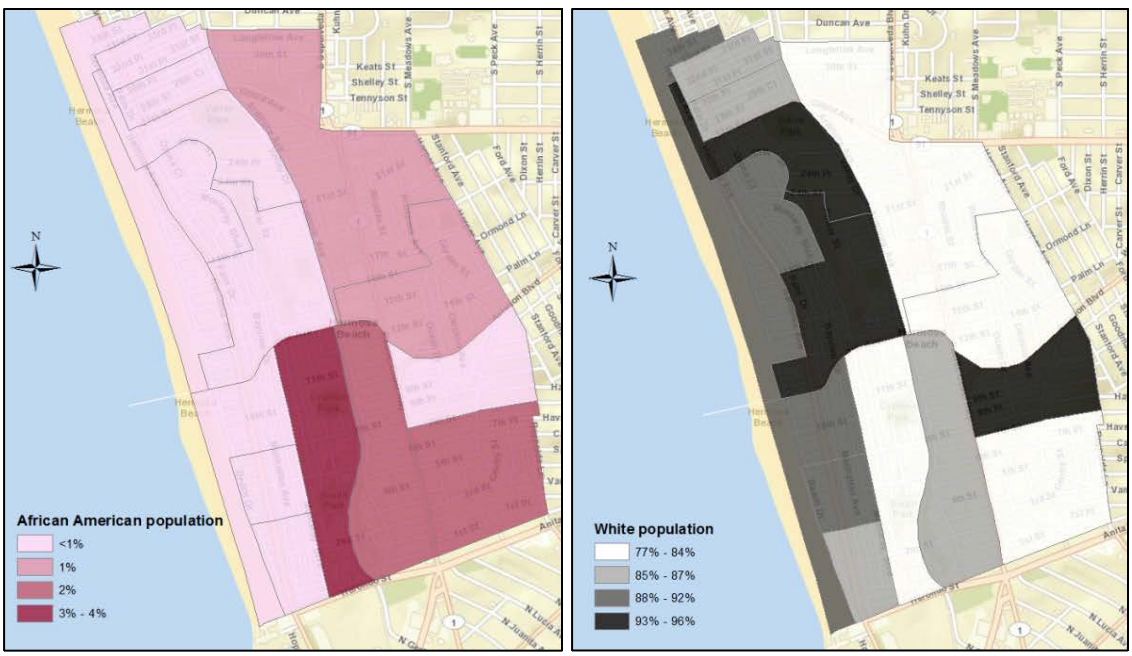
Source: General Plan, Housing Element City of Hermosa Beach 2012, based on Census 2000 data.

5.7 Race

Studies of public health and vulnerability to disasters repeatedly indicate that minority populations tend to have lower capacity for responding to disasters and adapting to climate change than non-Hispanic whites.[72] This was well illustrated in New Orleans after Hurricane Katrina where African Americans were less likely and able to evacuate and were then hit hardest in terms of trying to rebuild their lives in the aftermath of the disaster. In neighboring City of Los Angeles, recent failures of emergency response in San Pedro and Wilmington during the January 2010 flood also demonstrate the importance of assistance during flooding events to be designed to the particular needs of different demographic groups in the community. In 2010 many residents in the San Pedro and Wilmington communities were flooded out of their homes and needed shelter. The American Red Cross opened a shelter in a local home for the elderly, but the flood victims did not know about the shelter and those who did were not comfortable going there. Since very few came to the shelter, it was closed pre-maturely based on the assumption that no one needed assistance. Instead, the flood victims who were mostly of Hispanic/Latino descent, many of whom were undocumented and did not speak English, went to a local non-profit social services agency (the Toberman Settlement House/Neighborhood Center) that is set up to work with Spanish-speaking and low-income communities. However, this center was not prepared to accommodate flood victims. The experience shows the value – and necessity – for emergency response planners to get to know and understand the community prior to the emergency event, in order to be better able to meet the needs of the population when a disaster arises.[73]

Figure 13 shows the distribution of African American, Hispanic/Latino, Asian American, and Pacific Islander/Native American segments of the population. Within Hermosa Beach, there are very high concentrations of Hispanic/Latino populations residing in two areas of the city: just east of Hermosa Ave. in the northern part of the city and just east of Armdore Ave. in the central part of the city. Asia-Americans are most concentrated in the southern portion of the city.

Whether or not any of these populations require special attention in emergency response planning (e.g., second language assistance, educational materials in other languages than English) could not be obtained during this study, but should be carefully assessed in the City's hazard mitigation planning efforts. For example, to enable effective public participation in adaptation planning efforts the City may need to provide relevant information in other than English languages and offer linguistic assistance in public meetings.



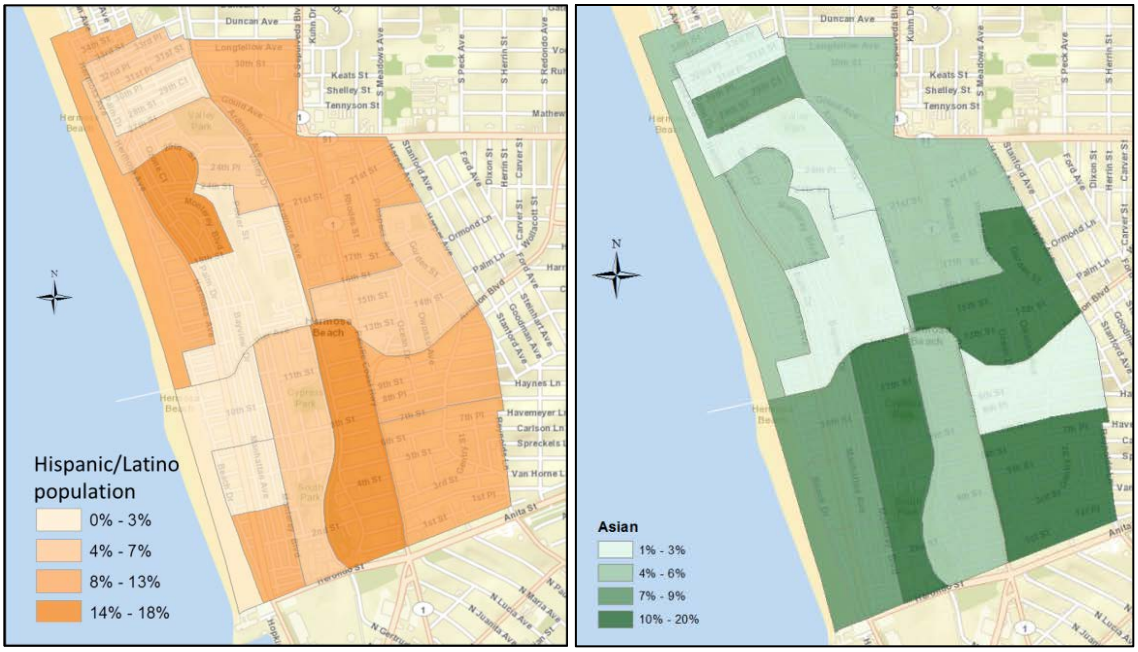


FIGURE 13. THE GEOGRAPHY OF RACE IN HERMOSA BEACH BY PERCENTAGE OF THE TOTAL POPULATION.

Source: ACS Census 2008-2012.[74]

5.8 Summer Daytime Visitors

The City's Hazard Mitigation Plan recognizes that the visitor population, especially that in the summer, is an important segment of the population of Hermosa Beach. According to the Plan, "on a typical summer day, beach goers increase the City's population by as many as 50,000. This influx of population from under 20,000 to 70,000 creates a particularly challenging scenario for the City's emergency response agencies."[75]

This boost in the local population is of greatest concern during the summer time and must be considered with hazards that can occur at that time (e.g., extreme heat, air pollution, and fires, as well as earthquakes and other human-made hazardous events, such as toxic spills, or other accidents that can occur at any time). During the winter time, when the worst flooding can be expected, the visiting population is much smaller, making the visitor boost a lesser concern in flood mitigation and emergency preparedness. It is conceivable, however, that wintertime visitor populations may grow in the future as climate warming creates conditions that encourage beach visits and vacations even during the calendar winter months. Adequate localized, and seasonally distinguished population projections that take the effects of climate warming into account are not available. Thus, this issue should be revisited periodically with counts of visitors across the seasons and time series of such data, showing potential shifts and growth in visitor numbers in hand.

An indirect impact on the number of visitors, and thus the beach economy of the City, however is important to consider. If beaches erode increasingly as a result of sea-level rise and related changes in sediment dynamics (and are not compensated for through beach replenishment), and beach- and tourism-related infrastructure is damaged during winter storms and not adequately restored, summer visitor numbers may decline, as they relate to perceived beach quality and perceived public safety. Again, as there are no data available projecting visitor populations forward in time accounting for these indirect impacts of climate change, the prudent approach is to carefully track changes in seasonal visitor populations and reconsider disaster preparedness and emergency response plans as changes in visitor populations indicate a need for such an update.

5.9 Summary: An Integrated View of Social Vulnerability

5.9.1 Introduction

An integrated view of vulnerability that takes all the influential factors discussed above into account is the ultimate goal of a social vulnerability analysis. In the case of Hermosa Beach, the frequently used statistical method to produce such an integrative Social Vulnerability Index (SoVI) is not appropriate, however, given the small number of Census Block Groups, and a considerable number of underlying factors that do not show much variation across the city.

Before providing such an integrated view of social vulnerability in Hermosa Beach, it is important to note that social vulnerability indices are *relative* measures. So, for example, if such a vulnerability analysis were conducted for Hermosa Beach and its northern and southern coastal neighbors, any differences in social vulnerability observed would be based on a comparison of factors among the three cities included in the analysis. If, on the other hand, the analysis were conducted for the entire County of Los Angeles, then the conditions across a much larger number of communities would be captured, and Hermosa Beach's social vulnerability would be assessed relative to those wider conditions.

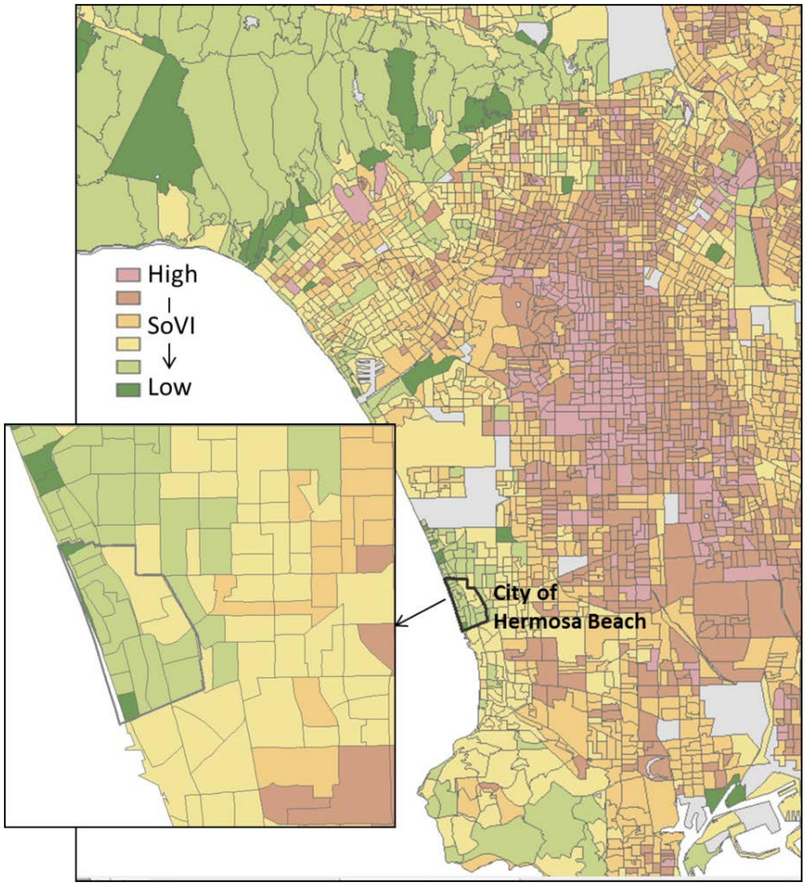
5.8.2 Hermosa Beach's Social Vulnerability in the Context of LA County

Figure 14 shows the results of just such a social vulnerability analysis. It covered the entire County of LA, and shows that the SoVI scores for the City of Hermosa Beach (here magnified) are low to very low. That particular SoVI analysis used 30 demographic variables, related to income, poverty, dependent age groups, race, language ability, education, and several others. For most of these characteristics, Hermosa Beach – compared to the LA Port area and central LA – has a comparatively high income, low poverty, low percentages of dependent age groups, low racial diversity, high English speaking abilities, and high education, all of which together contribute to the low social vulnerability score.

While it may appear at first glance that it is of limited practical concern for the specific planning purposes of the City of Hermosa Beach, what conditions prevail in communities beyond its direct influence and jurisdiction, those conditions do matter in important ways. The City should be aware of this larger context as high social vulnerability elsewhere affects locally important county affairs and locally available county services, e.g.:

- economic activity and thus the tax base
- social justice and civil peace
- intra-county population displacement and relocation
- public health
- availability of county-wide services during emergencies.

The LA countywide collaboration of jurisdictions participating in regional adaptation planning (LARC) offers an important opportunity to remain aware of these contextual hotspots of vulnerability and to jointly identify cross-jurisdictional opportunities to reduce social vulnerability overall.



[

FIGURE 14. RESULTS OF THE SOCIAL VULNERABILITY INDEX (SOVI) ANALYSIS CONDUCTED FOR LOS ANGELES COUNTY, BASED ON 2000 CENSUS BLOCK GROUP LEVEL DATA.76 BECAUSE THE SOVI IS A RELATIVE INDICATOR OF SOCIAL VULNERABILITY, IN THIS ANALYSIS HERMOSA BEACH IS SHOWN TO HAVE MOSTLY LOW AND SOME MEDIUM VULNERABILITY COMPARED TO OTHER AREAS OF THE COUNTY, SUCH AS SOUTH-CENTRAL LA WITH, FAR GREATER SOCIAL VULNERABILITY.

Source: Ekstrom and Moser (2013)[77]

5.9.3 Local Social Vulnerability in Hermosa Beach

To produce a locally specific picture of social vulnerability (i.e., one that only takes into account the conditions within the city's jurisdiction), relevant demographic factors for that area must be integrated. Because of the small size of the city, with only 16 Census Block Groups, the range of appropriate statistical techniques to do so is limited, however. Typically, the SoVI method uses principal components analysis to cluster all the variables into groupings whose resulting scores are summed to arrive at the final SoVI score.[78] Principal component analysis could not be used with such a small sample. Instead we calculated a social vulnerability score with a simpler method and narrowed and fine-tuned the field of potential variables to a smaller set of population characteristics for which spatial information is available and which demonstrated some variation among Census Block Groups (Figure 15).[79] Census variables reflecting key issues discussed above – such as age, income/poverty, and mobility – included in the resulting social vulnerability score are:

- proportion of the very young and elderly (combined)
- proportion of non-white population
- females as heads of household
- proportion of renter-occupied units
- proportion of unoccupied housing units (vacancy)
- proportion of households earning less than $75,000
- proportion of households earning more than $200,000
- median gross rent

- proportion of population employed in the service sector
- proportion of population without a vehicle
- proportion of renters with overpayment burden (with housing costs of 50% or more of household income)

The score does not explicitly include such issues as homelessness or disability, as data for these characteristics are either unavailable altogether or not available in a spatially referenced way. Thus, these population characteristics have to be considered independently.

The resulting integrated view of social vulnerability for Hermosa Beach (Figure 15) shows that the block groups that score as "high vulnerability" are located along the beachfront of the city, extending inland into the city's midsection. A section in the northern coastal part of the city is the least socially vulnerable, which is consistent with the demographic characteristics described earlier (Sections 5.2-5.7). Those block groups scoring highest (i.e. as the most vulnerable) show overall a pattern of high proportion of the population having female heads of household and earning less than $75K per year. Two of the top three block groups (based on their overall vulnerability scores) are in the flood zone with 55 inches of sea-level rise. The block group scoring as most vulnerable is just east of the Strand, bordered on the south by Herdono St. This score is dominated by a high proportion of female heads of household, high vacancy rate of housing units, and a relatively high proportion of households earning less than $75K. The second most vulnerable block group is inland, not exposed to the 100-year flood with 55 inches of sea-level rise. The third most vulnerable block group (located along the Strand in the southern part of the city) is dominated by income-related and home ownership related factors: a relatively low proportion of households earning $200K, high proportion of households earning less than $75K, and high proportion of renter-occupied units.[80] The fourth and fifth highest-scoring vulnerable block groups (marked as "highly vulnerable" in pink on the map) are dominated by low income (households earning less than $75K).

FIGURE 15. SOCIAL VULNERABILITY SCORES, BASED ON A SUBSET OF POPULATION CHARACTERISTICS TYPICALLY USED IN A SOVI ANALYSIS, ARE SHOWN FOR THE 15 CENSUS BLOCK GROUPS OF THE CITY OF HERMOSA BEACH. VARIABLES INCLUDED IN THE SCORE ARE: AGE, WEALTH AND POVERTY, RACE, PERSONS PER HOUSEHOLD UNIT, EMPLOYMENT SECTOR, PERCENT OF HOUSEHOLDS WITHOUT A VEHICLE, PERCENT OF UNOCCUPIED HOUSING, PERCENT OF RENTERS, PERCENT HOUSEHOLDS OVERBURDENED WITH HOUSING COSTS, AND MEDIAN GROSS RENT
Source: Based on data from the ACS 2008-2012.[81]

Overlaying the flood risk map with demographic data, we find that an estimated 1,000 residents live within the area exposed to a 100-year flood risk with 55 inches of sea-level rise. Overlaying the flood risk map with the social vulnerability map reveals an integrated picture of which socially vulnerable areas are also exposed to flooding with sea-level rise. Most of the most socially vulnerable areas are along the beachfront, which are also most likely to experience flooding. Overall the demographic variables explaining why these areas within the projected floodplain (west of Hermosa Ave) score as also highly socially vulnerable relate mainly to income, home and vehicle ownership, and females being heads of households.

As will be detailed more in Part B of this report, it is important to consider these underlying factors in devising targeted emergency preparedness and adaptation alternatives. While overall social vulnerability indices like produced here provide a useful overview and help focus on priority areas (i.e., the most vulnerable areas), the underlying factors provide more specific input into the types of measures that could help the specific populations. For example, low income populations (incl. households with female heads of household) may need assistance programs, whereas wealthier populations in flood-exposed areas may benefit more from incentive programs; property owners who rent housing units in the current and future flood zone could prevent harm to their renters through structural measures taken on their properties, so reaching them with relevant information and incentive programs may be more important than targeting just the renters.

Importantly, as the next section on infrastructure vulnerabilities will show, targeting those who have actual decision-making authority over certain preparedness and adaptive measures is key to ensuring that disaster preparedness and adaptation actually gets implemented. In some instances these measures require long lead times and thus should not be put off; in other instances measures can have immediate benefits, regardless of future climate change impacts. Taking those measures sooner rather than later is the key to avoiding and reducing impacts from flooding as sea-level rises.

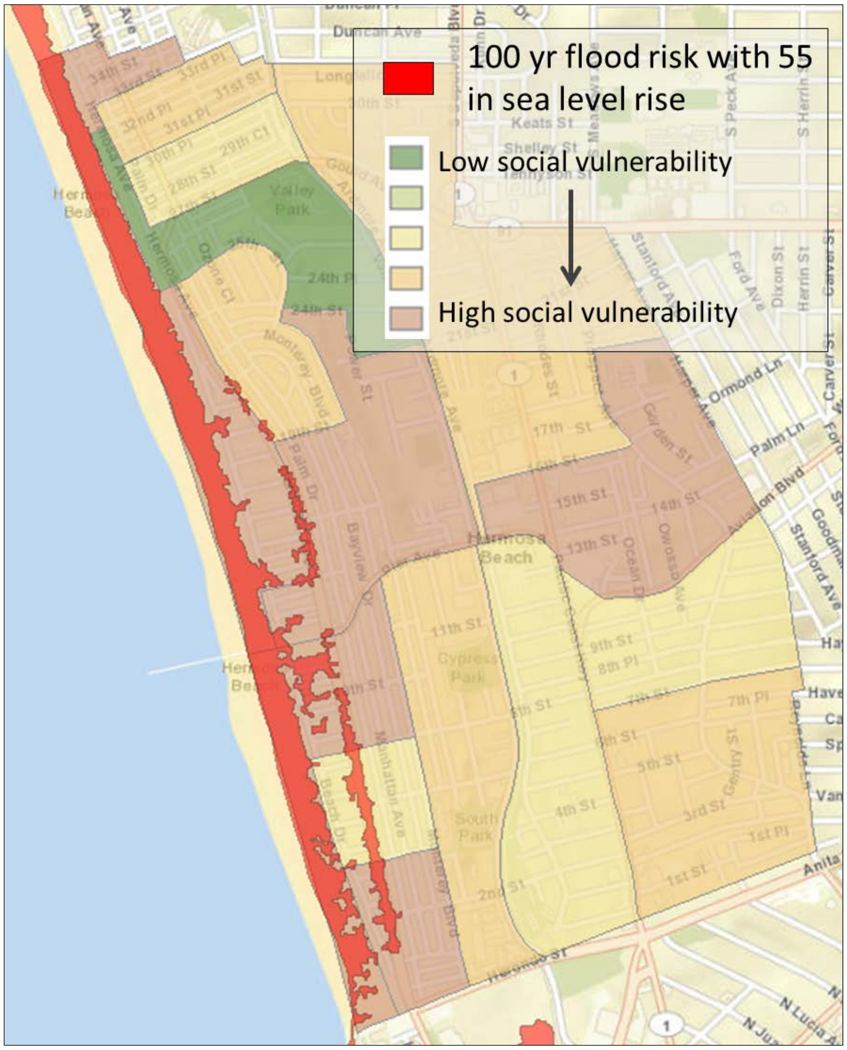


FIGURE 16. 100 YEAR FLOOD RISK WITH 55 INCHES OF SEA LEVEL RISE OVERLAIN WITH THE MAP OF INTEGRATED SOCIAL VULNERABILITY FOR HERMOSA BEACH. CONSTRUCTED WITH CENSUS DATA FROM ACS 2008-2012 AND 100 YEAR FLOOD MAP WITH 55 INCHES OF SEA LEVEL RISE MAP FROM PACIFIC INSTITUTE (2009)

6. Critical Community Infrastructure and Services

6.1 Introduction

In addition to *direct* exposure to coastal flooding and storm surge with accelerating sea level-rise, residents and employees of coastal communities may also be at risk of, and *indirectly* affected by, impairment of critical infrastructure and community services. If floods damage, destroy or temporarily interrupt infrastructure such as roads, water- or energy-related installations, residents would be without these critical services. The most important types of infrastructure to consider include the following:

- evacuation and other transportation routes
- ports
- the Los Angeles International Airport
- emergency response systems
- electricity
- underground utilities, including energy-related facilities, transmission, and transformers
- communication

- water supply, drainage or sewage treatment, and
- salt water barriers protecting coastal groundwater basins

Impairment of such services causes costly disruptions of local economic activity, interference with the daily life of residents, and jeopardizes their safety, health and well-being. It is typically the destruction and disruption of these critical services that turn flooding events into widespread disasters, sometimes with long-lasting consequences.

As a result of the infrastructure impairment listed above, communities can face "domino effects" of multiple failures that are difficult to predict and quantify, but are commonly experienced in case of disaster, including disrupted access to food and prescription medicines, risk of salinization of coastal groundwater (typically an irreversible loss), and interruption of personal lives and business activity due to the loss of electricity.[82]

Below we provide a glimpse of some of the connections between infrastructure and service functionality with particular reference to how these could exacerbate stressors to already vulnerable populations. Critical infrastructure is located within the 100-year flood zone (with 55 inches of sea-level rise), as shown in Figure 17, such as the Pier, numerous buildings, streets, parking lots etc.) Figure 18 gives a close-up view of one section of the city, where future flooding could cause significant disruptions unless adaptive measures are taken.

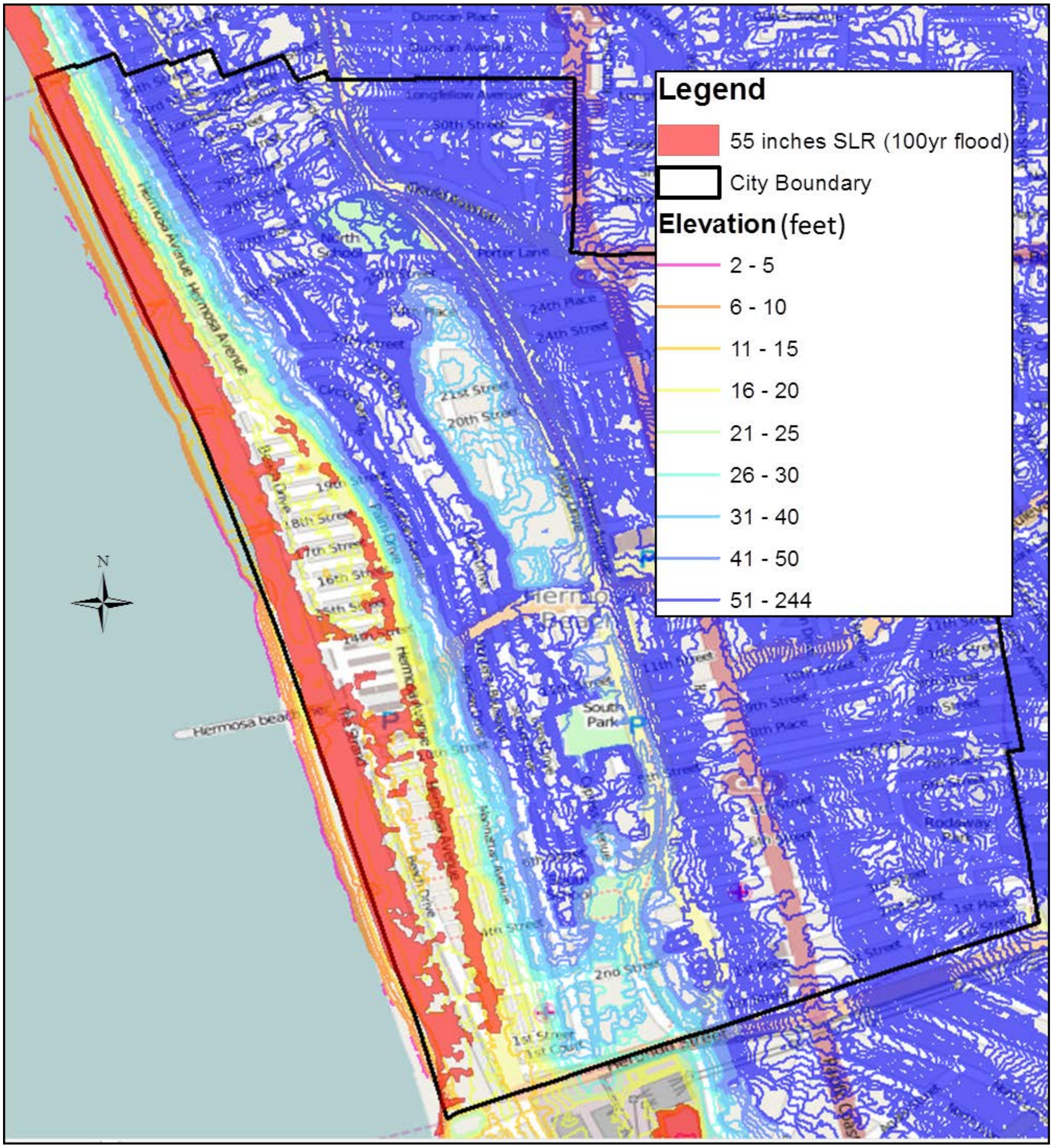


FIGURE 17. THE EXTENT OF THE 100-YEAR FLOOD AFTER 55 INCHES OF SEA-LEVEL RISE INTO THE CITY OF HERMOSA BEACH OVERLAIN ON AN ELEVATION MAP

FIGURE 18. OBLIQUE AERIAL VIEW OF AN AREA NEAR THE HERMOSA PIER EXPOSED TO THE 100-YEAR FLOOD WITH 55 INCHES OF SEA-LEVEL RISE. THE AREA IN RED MARKS THE AREA AT RISK OF FLOODING, BASED ON MODELED PROJECTIONS BY THE PACIFIC INSTITUTE (2009).

Below we discuss specific risks to infrastructure and services in the areas at risk from future flooding, including to the City's water-related infrastructure, buildings, the Pier, the Strand, city roads and emergency response facilities and systems.

6.2 Water Infrastructure: Drainage, Sewage Treatment and Supply

6.2.1 Storm Runoff and Sea-Level Rise

As sea level rises storm water drainage will be increasingly impaired, leading to a growing risk of urban street flooding during intense rain events. Most of the land (more than 90%) is covered with impermeable surface (mostly asphalt), preventing water from filtering into the ground, and instead rushing down streets and potentially overloading the wastewater system. While the City has separate storm sewers (MS4) and sanitary sewers, the large amounts of surface runoff may flow into the sanitary sewer system. As it backs up, untreated wastewater can spill into city streets and become a major public health threat. Moreover, higher groundwater elevations due to sea-level rise can increase infiltration and inflow into the aging sanitary sewer system which can also contribute to sanitary sewer overflows.

The region receives the majority of its rain in heavy, short-duration storms. This problem is already familiar to Hermosa's residents and recognized in public emergency preparedness documents. According to the Hazard Mitigation Plan (2005), "a severe winter storm has the potential to disrupt the daily driving routine of hundreds of thousands of people. Natural hazards can disrupt automobile traffic and shut down local and regional transit systems."[83]

Climate change is expected to worsen these existing problems. As the runoff from intense storms rushes toward the ocean, it is met by increasingly higher sea levels. While wind and waves are currently not estimated to increase with climate change off the California coast, storms as strong as those experienced historically with higher sea levels will cause higher storm surges.[84] Thus, more coastal flooding and intense runoff from inland areas will combine to cause more severe street flooding, scour and damage to roads, culverts, and water related infrastructure. Such damage will also reach further inland than at present because of the higher sea level.[85]

6.2.2 Storm Water Infrastructure

The city has begun implementing retrofit and green street projects within its right of way to effectively increase the permeability of the developed areas to allow for increased infiltration and a reduction of stormwater runoff to the MS4 storm water drainage system. Among several related projects, in 2011 the city completed a major urban runoff water quality project that retrofit a 50-acre area within the downtown commercial district along Pier Avenue. The project allows water to filter through the sand into its coastal groundwater aquifer, rather than be lost to coastal waters.[86] According to the City's Housing Element:

> "In addition to best management practices (BMPs) implemented through its regional storm water discharge permit, the City also requires infiltration basins, when appropriate, with new developments. The City has adopted rules to allow and encourage pervious surfaces and also adopted Cal-Green building standards in 2010 exceeding state requirements by requiring increased permeability or infiltration in connection with new development. The City has installed an award-winning infiltration project in the downtown area, which should serve as a model for other areas."[87]

This upgrade and related regulatory measures – whether or not taken with foresight vis-à-vis climate change – have the following adaptive co-benefits:

- reduction of surface runoff and thus of the risk of street flooding, especially in areas also experiencing flooding from storm surge; and
- counteracting saltwater intrusion as the infiltrating freshwater pushes back the saltwater plume.

To the extent the city maintains its storm water system in good repair, it helps to counteract the growing risks from high-intensity rainfall and runoff events made more challenging by climate change and sea-level rise.

6.2.3 Sewer System

According to the City's Housing Element (2013), the current sewer system already needs rehabilitation:

> "… significant deficiencies in the sewer system exist and rehabilitation is necessary, and new development may require offsite improvements. In 2009 the City Council approved Sewer System Master and Management Plans identifying the cost to repair the 80-year-old system at $9 million over 10 years."[88]

Several areas of the current sewer lines are at risk of being additionally stressed from future floods as sea level rises. Most of the exposed parts of the sewer system are in the southern portion of the city. These include portions along Hermosa Ave. at 21st St, from 18th St. to 14th, and from Pier Ave. south to 1st St. and along Beach Dr. at 20st St. (Figure 19).

FIGURE 19. SEWER LINES AT RISK OF FLOODING DURING A 100-YEAR FLOOD AFTER 55 INCHES OF SEA-LEVEL RISE (MAIN MAP); AND CLOSE UP OF SEWER LINES IN THE SECTION OF HERMOSA BEACH NEAR THE PIER (INSERT). SEWER LINES WHERE FLOODING IS PROJECTED AFTER 55 INCHES OF SEA-LEVEL RISE ARE HIGHLIGHTED IN BRIGHT RED.

Source: City of Hermosa Beach (sewer line, streets, and building footprints), Pacific Institute (100-year flood map with sea-level-rise)

In addition, the sewer pump station at the north end of the city is also located very close to the coast and thus exposed to increased storm flooding. As the city upgrades its sewer system, it will be important to assess whether increased flood risks over the lifetime of the new sewer system might diminish its expected functionality, and thus whether it would be more prudent and more cost-effective to build a safety factor into the planned system upgrade, especially in the high-risk areas in the southern part of the city and for the sewer pump station.

6.2.4 Coastal Groundwater, Water Infrastructure and Saltwater Intrusion

Groundwater aquifers and water-related infrastructure can be at risk of saltwater intrusion as sea level rises. Thus, another water-related infrastructure of concern includes the seawater barrier in the city (and outside the city) that – if compromised – could lead to practically irreversible salinization of the groundwater basins (Figure 20). No information could be found for this study about how sea-level rise could put the West Coast Barrier Project (or other Barrier Projects in the region) at risk. However, it is raised here as an area requiring further investigating to identify any structural vulnerabilities that a rising sea level may cause.

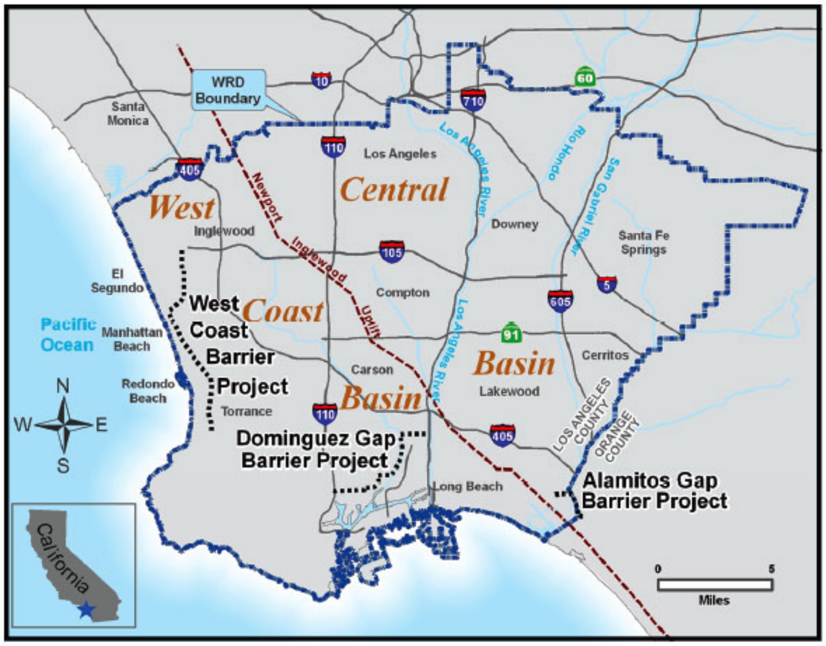


FIGURE 20. LOCATION OF SEAWATER BARRIERS (DASHED LINES) ALONG THE COAST NEAR HERMOSA BEACH

Source: Water Replenishment District of Southern California[89]

Saltwater intrusion can also affect shallow infrastructure, and due to hydraulic connectivity between sea level and shallow groundwater, an increase in sea level will likely propagate to an increase in groundwater elevation. Furthermore, one possible impacts of sea level rise and associated increase in groundwater elevation is an increase in the area of liquefaction. The extent of potentially liquefiable soils is directly dependent on groundwater elevation which, in coastal areas with sandy soils such as Hermosa Beach, is affected by sea level rise. An assessment of these vulnerabilities is included in the Climate Ready grant scope of work being conducted by Geosyntec, and thus not further discussed here.

The city does not depend directly on local groundwater resources for its current water supply.[90] However, as previously discussed, the sewer system, stormwater and wastewater infrastructure could be at risk of reduced capacity due to higher coastal groundwater levels and of corrosion as salt water intrudes into the ground or washes in with the storm surge as sea level rises.[91] This would reduce the functioning and longevity of the infrastructure.[92]

6.3 Structures and Content

6.3.1 Overview of Structures and Value at Risk

When overlaying the Pacific Institute's 100-year flood risk map *without* sea-level rise over the building footprint of the city, no buildings are at risk of a coastal flood under *current* conditions. When overlaying the projected 100-year flood map with 55 inches of sea-level rise, however, there are 202 buildings[93] exposed to the flood risk (Figure 21 and Table 5). This estimate only includes currently existing buildings, and does not account for any future infill or development (which may well occur between now and 2100). Thus the estimates of structures and value at risk should be considered a low-end, conservative estimate of future structural exposure.

Based on the zoning map provided by the City, the affected structures include: 143 residential buildings; a church parking lot (at 1540 Hermosa Avenue); and 13 government owned buildings. From the 1400 block to 100 block of Hermosa Avenue, all of the exposed buildings are located in areas at less than 20ft of elevation above current sea level at ground level. Further onsite investigation is needed to determine whether these buildings are susceptible to flooding or if they are sufficiently prepared (e.g., buildings with lower levels serving as parking garages or storage areas, or building constructed with foundations that can withstand saltwater).

TABLE 5. ESTIMATES OF INFRASTRUCTURE AND VALUES AT RISK TO FLOODING WITH 55 INCHES OF SEA-LEVEL RISE IN HERMOSA BEACH

Type of Infrastructure	At risk of 100-year flood without SLR	At risk of 100-year flood with 55" of SLR	Data Source
All buildings	0	202	City shapefile overlain with Pacific Institute flood SLR risk map
Residences	0	143	Same as above
Drain pipes	Unknown, if any	10	Same as above
Planned pipes	Unknown, if any	5	Same as above
Sewer lines	Unknown, if any	0	Same as above
Replacement value of buildings and contents (in *[94] (in million of 2000 dollars)	Unknown, if any	35	HAZUS database

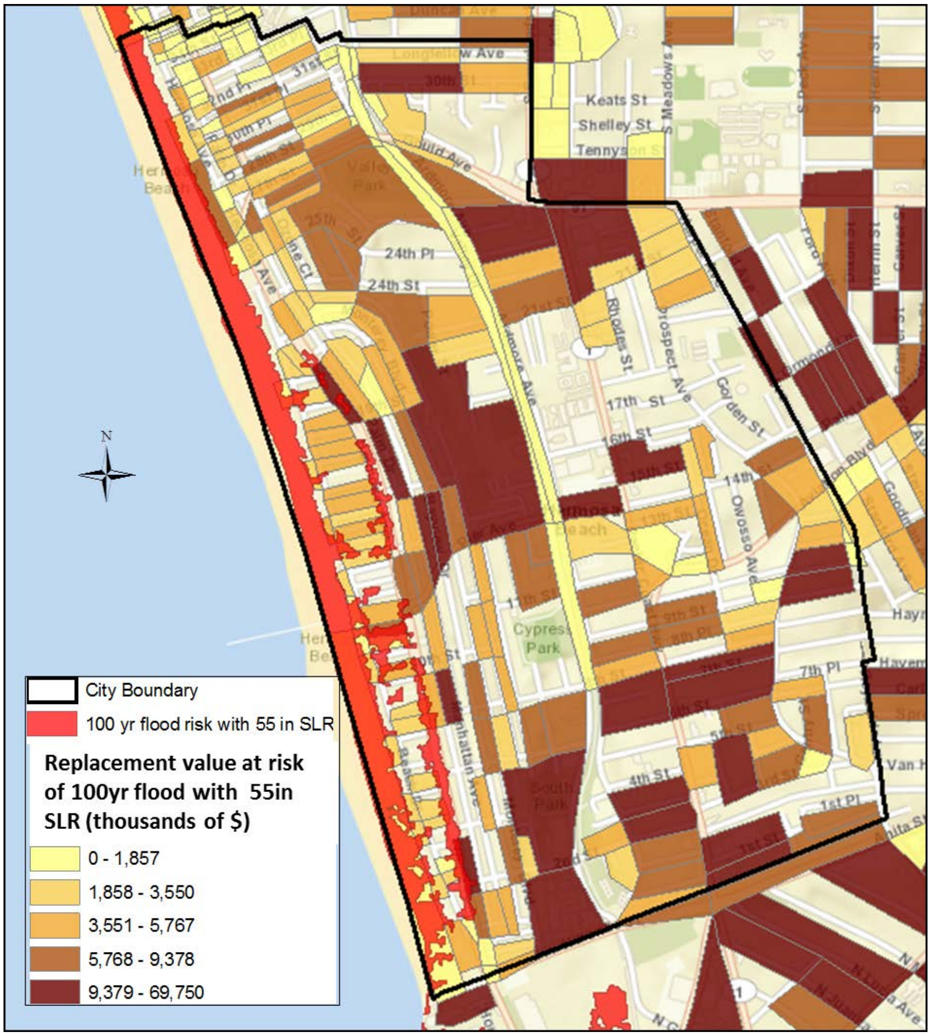


FIGURE 21. REPLACEMENT VALUE OF PROPERTY (ASSETS AND CONTENTS COMBINED) AT RISK FROM A 100-YEAR FLOOD WITH 55 INCHES OF SEA-LEVEL RISE (LEFT MAP: NORTHERN COAST OF HERMOSA; RIGHT MAP: SOUTHERN COAST OF HERMOSA).

Source: HAZUS database (2014).[95]

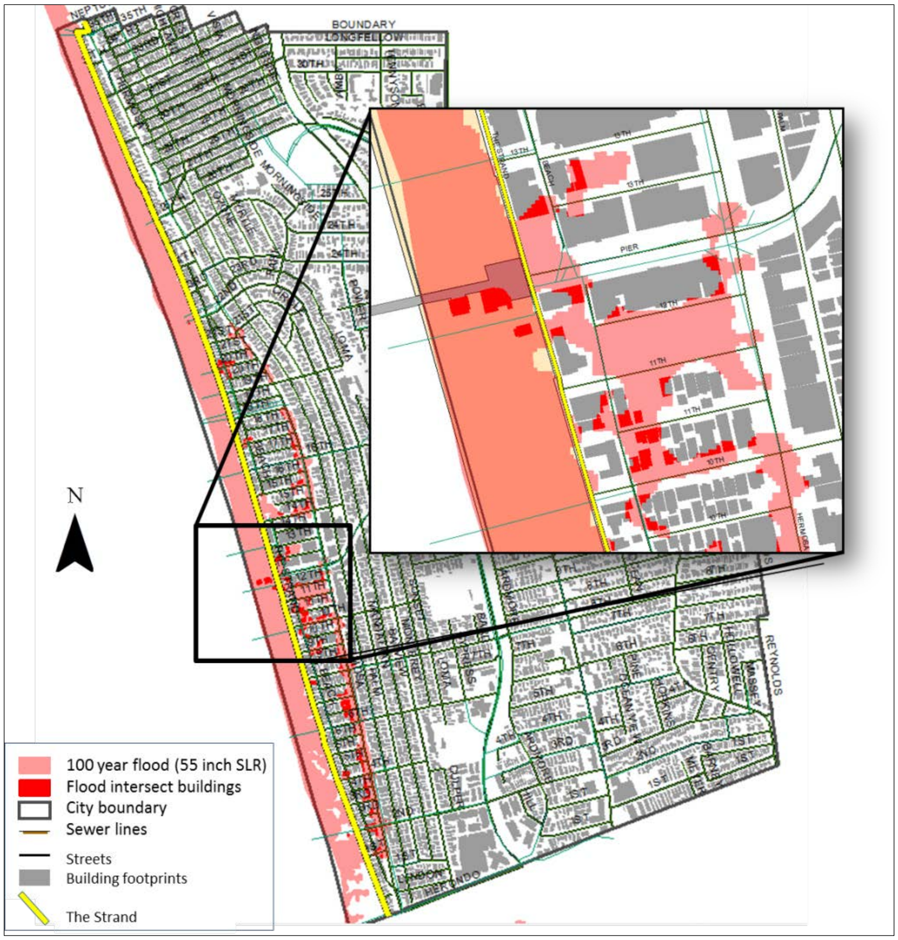


FIGURE 22. MAP SHOWING THE CITY OF HERMOSA BEACH (WITH A SAMPLE HIGHLIGHT OF THE PIER AND SURROUNDING AREA), SHOWING BUILDINGS AT RISK (BRIGHT RED) OF THE 100-YEAR FLOOD WITH 55 INCHES OF SEA-LEVEL RISE (TRANSPARENT RED). BUILDINGS NOT AT RISK ARE SHOWN IN GREY AND THE STRAND IS SHOWN IN YELLOW.

Source: Based on flood modeling by the Pacific Institute (2009) and infrastructure maps from City of Hermosa Beach.[96]

6.3.2 Iconic Shorefront Structures at Risk

According to the Hazard Mitigation Plan (2005), two important structures in the city are currently susceptible to flooding without the additional consideration of sea-level rise: the Pier and the marine Land Motor Home Park at 531 Pier Avenue.[97] The Hermosa Beach Pier, first built in 1904, is a valued recreational and tourist attraction of the city. Owned by the city, the life guard office, a public library and public restrooms are located on the pier.

As sea level rises, the Strand – another cultural icon of Hermosa Beach – will be at risk of flooding. The Strand, built in the early 1900s, demarcates the boundary between the beach and the buildings of the city and is designed and used as a pedestrian and bicycle path along the beach. Single household residences are adjacent to the Strand in the northern portion of the city with more commercial properties located next to it in the central and southern part of the city (Figure 23).

FIGURE 23. THE STRAND IN HERMOSA BEACH WITH RESIDENCES ADJACENT TO THE BEACH.
Photo: SameerKhan, Source: Wikimedia Commons (2005)[98]

The flood risk to all of these culturally and economically important land marks will increase as sea level rises because of direct floodwater and wave impact and the impaired city drainage (higher maximum water levels, see discussion above and Figure 22).

6.4 Roads and Emergency Response

6.4.1 Streets and Emergency Routes

The ability of individuals to evacuate an at-risk or affected area in an emergency and that of First Responders to rapidly enter it is critically dependent on functional roads. Any lack of access to fire or police stations or impairment of the most direct transportation routes (due to flooding) increase the risk of additional injury and loss of life. Flooding – even temporarily from heavy rainfall, combined with increasing sea level and coastal storm surge – can lead to delays or lack of access to certain areas for emergency responders.

The primary major emergency routes for the City of Hermosa Beach are on the eastern side of the city (Pacific Coast Highway), as shown in Figure 24. But to exit those areas most prone to coastal and inland street flooding, emergency service vehicles, residents and visitors rely first on city streets. As Figure 2 (and Figure 18 in a close-up of one particular area) showed, Hermosa Avenue and many cross streets on the seaward side of Hermosa Avenue could be impassable in a major flood with 55 inches of sea-level rise. Drainage problems could worsen street flooding, making it difficult for first responders to enter or for residents to evacuate these flood-prone areas.

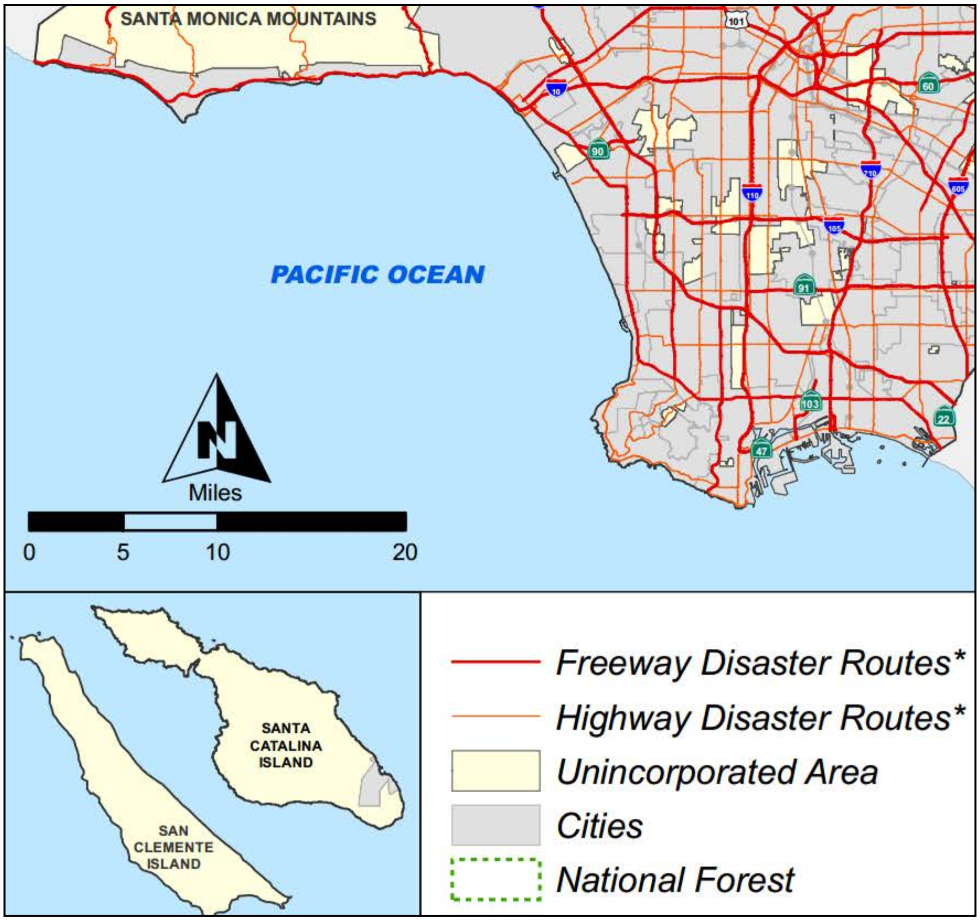


FIGURE 24. EMERGENCY ROUTES IN LOS ANGELES COUNTY, EXCERPT OF COASTAL AREAS
Source: Los Angeles County Draft General Plan Accessed December 26, 2013.[99]

6.4.2 Fire and Police Stations

According to the Pacific Institute's (2009) study on infrastructure at risk to sea level rise, they found no fire or police stations in the potential flood zone with 55 inches of sea level rise.[100]

6.4.3 Tsunami Inundation Zone

In addition to the flood risk from storms, the City has documented areas at risk of flooding from tsunamis. The occurrence, including the frequency and magnitude, of tsunamis are not directly affected by climate change. However, as sea level rises, so too will the baseline and the maximum run up of waves and surge generated by a tsunami. Figure 25 shows a map of the *current* tsunami inundation zone, which closely follows Hermosa Ave, again demonstrating the higher risk of the low-lying area that is to the west of this main artery. It also shows how the tsunami inundation zone compares to the flood zone with 55 inches of sea-level rise (inundation at present sea-level overlaps in key areas but goes even beyond the flood map with 55 inches of sea-level rise).

Key structures in the city already at risk of inundation during a tsunami include:

- Downtown District, 800-1500 Hermosa Avenue
- City Lifeguard, 1201 The Strand
- One Pump Station, 3500 The Strand

Even with this significant tsunami inundation risk at present sea level, a recent study by the U.S. Geological Survey[101] found Hermosa Beach to be in a *relatively* low-risk situation: only a small percentage of property and overall population is located in the current tsunami inundation zone; fewer than 5% of the population in this area is under 5 years of age; but nearly 25% are 65 years or older; 40% are renter households, less than 5% are female-headed with children and no spouse present, about 15% of employees are located in the inundation zone; there is also only a very small number of community-support businesses, dependent-care facilities and public venues located in the tsunami inundation zone. While this may be true in a quantitative sense, the downtown area, Pier, and Strand are key magnets for the public and for visitors: they constitute the very heart of Hermosa Beach.

FIGURE 25. TSUNAMI INUNDATION ZONE IN THE CITY OF HERMOSA BEACH AND 100 YEAR FLOOD MAP WITH 55 INCHES OF SEA-LEVEL-RISE.

Source: City of Hermosa Beach (tsunami inundation zone and city boundary maps); Pacific Institute (sea-level rise flood map)

This USGS assessment also did not account for sea-level rise and how the tsunami inundation zone may expand over time. Such new tsunami inundation modeling was beyond the scope of this study, so it is not possible to display the modified inundation zone with a 55 inch-higher sea level, and to determine with any specificity what additional sites might be at risk in a future tsunami inundation zone. However, to keep disaster preparedness planning current, future tsunami mapping and planning should take sea-level rise into account as the potentially affected population, infrastructure and economic activity will expand significantly beyond the 100-year flood zone with 55 inches of sea-level rise.

6.5 Infrastructure Vulnerabilities in Hermosa Beach: Summary

Streets, residences, the Strand and the Pier – all west of Hermosa Ave. – are the built infrastructure at greatest risk of flooding as sea level rises. Under the high-end sea-level rise scenario used here, an estimated 202 buildings, including 143 residences, are within the projected floodplain. The replacement value of this property and contents (in 2000 $) is an estimated $35 million. Several streets could flood and even five of the planned drainpipes (as noted in the City's GIS database) could be in the future flood risk area.

Without adequate incorporation of sea-level rise into infrastructure design, maintenance and planned upgrades over time, these structures could all be impaired in future floods. In addition, street flooding (from direct inundation and further inland from growing drainage problems) could impair emergency vehicles from accessing areas west of Hermosa Ave. in time of need. On the other hand, adequate proactive planning and adaptive management can enable the city's ability to maintain proper functioning of infrastructure, uphold first responders' response capacity in emergencies, and help the community recover more quickly after a disaster, should one occur.

The beach, arguably the city's most important asset – a form of "natural" (or at least quasi-natural) infrastructure, is also at risk to erosion as sea level rises. In its current width, it provides the city not only with its most important economic asset, but also with a natural and critical first-order protection from storm surge. For both reasons, the maintenance of the beach will be critical to the city's preparedness for any near-term storm and flooding events, and for longer-term adaptation to climate change.

7. Synthesis

The analyses conducted in this study aimed at assessing the social and infrastructure vulnerabilities that Hermosa Beach faces as a result of sea-level rise and associated flooding and erosion risks. These are summarized below before turning to the range of options available to adaptively manage them over time.

7.1 Sea-Level Rise Projections for Hermosa Beach

Over the past century, sea level has risen by approximately 7 inches along the California coast, which is consistent with the observed global average. While an oceanographic oscillation of currents (Pacific Decadal Oscillation) in the Pacific Ocean has suppressed sea level from rising along the West Coast of the United States since the 1980s, scientists currently see this phase coming to an end, and expect that sea-level rise will resume at a pace consistent with the global average in coming years and decades. Such decadal, as well as shorter term natural variations will continue in the future, while the global baseline will increase.

Based on the best available science, the Ocean Protection Council and Coastal Commission recommend using the following sea-level rise projections along Southern California's coast for the coming decades:

- 2-12 inches by 2030
- 5 inches - 2 feet (24 inches) by 2050
- 16 inches - 5.5 feet (66 inches) by 2100

To account for the uncertainty reflected in these ranges, the Coastal Commission advises communities to use scenario planning, with one of the scenarios being the high-end scenario (particularly needed for specific project permitting). Because the low-end (or an alternative mid-range) sea-level rise scenario was not available at the time of this study, only a high-end scenario was used here. Similarly, the 66-inch (high-end) sea-level rise scenario suggested for use by the Coastal Commission, combined with the 100-year design flood, has not yet been mapped (expected in 2015 or 2016). Thus, this study uses the best available data for a

55 inch sea-level rise plus 100-year flooding scenario to determine the extent of potential future flooding for Hermosa Beach.[102]

Experience and best available science shows that strong El Niños can temporarily (for several winter months) elevate regional sea level. While this is not explicitly included in the flood modeling presented here, prudent planning would add a safety buffer because this occasional *extra* sea-level rise (as much as 12 inches during some of the strongest El Niño's in recent decades) could worsen winter storms and related storm surges.[103] Differently put, long before the average baseline is 55 inches higher than the current sea level, a temporary sea level of 55 inches could be reached during a strong El Niño winter, with all the attendant storm-, flooding- and erosion problems all too familiar to Californians already.

The exposed area in Hermosa Beach from the 100-year flood with 55 inches of sea-level rise (Figure 26) extends inland from the Strand to Hermosa Avenue, particularly in central and southern portions of the city. Compared to other areas in LA County, Hermosa Beach appears to face a smaller relative risk than some other coastal communities. However, the potentially affected areas of the city are of high economic and cultural value, include substantial residential and commercial areas, and contain critical infrastructure on which city residents, the local economy and emergency responders depend.

FIGURE 26. EXTENT OF THE 100-YEAR FLOOD WITH 55 INCHES OF SEA-LEVEL RISE (RED) IN HERMOSA BEACH (BUILDING FOOTPRINTS OF CITY IS SHOWN IN WHITE). INSET SHOWS THE EXTENT OF THE SAME FLOOD FOR COASTAL AREAS OF LOS ANGELES COUNTY.

7.2 Economic and Social Vulnerability

In the absence of adaptation measures implemented in a timely fashion that will help avert threats to the population as well as minimize damage to residences and important infrastructure, climate change could jeopardize the stability and strength of Hermosa Beach's local economy and the welfare of its residents. The city and its beach economy and culture attract a large visitor population throughout the year, particularly in the summer. Retail businesses, employment and associated services depend on this regular flow of visitors, which could be diminished if adequate measures to adapt to sea-level rise are not taken.

The greatest resource in this regard is the beach, along with the Pier, the Strand and the related business activity and supporting infrastructure. While a quantitative economic impact assessment on the city was beyond the scope of this study, the discussion of potential impacts of sea-level rise, namely beach erosion and flooding, makes clear that this essential resource and related iconic infrastructure are at risk. The city's economy also relies heavily on property taxes, which places a great premium on taking appropriate adaptive measures to prepare for and adjust to sea-level rise and growing flood risks, while maintaining the defining feature of the city: its beach.

In terms of social vulnerability of residents, some segments of the population are more vulnerable to flooding hazards than others. The most important factor in social vulnerability include income/poverty, age, race, gender (female heads of household), housing type and home ownership, pre-existing health conditions such as physical or mental disabilities, and the presence of homeless and transient populations. Even where the percentage of people in poverty (as defined by federal standards) is low, the amount of discretionary funding available to residents is an important factor. For example, paying a high proportion of one's gross income for housing can limit people's ability to adequately prepare for flooding or take household-level adaptive measures.

Thus, it is helpful to take all of these factors into account in assessing people's sensitivity to the hazard and in their ability to prepare for, respond to, recover from flood events and adapt to sea-level rise.

Together with the exposure to the flood hazard, an integrated perspective of social vulnerability emerges for Hermosa Beach. Within the projected 100-year flood zone with 55 inches of sea-level rise, several areas within city bounds emerge as areas of special concern: most of the highest socially vulnerable areas are along the beachfront, which are also in areas expected to be at greatest risk of flooding as sea level rises. Overall the demographic variables explaining why these areas within the projected floodplain (west of Hermosa Ave) score as highly vulnerable relate mainly to income, home and vehicle ownership, and females as head of households. Several special needs populations are not represented in the demographic maps of Hermosa as there are no spatially reference data for them, including the homeless, visitors and people with disabilities.

In addition to the population-specific characteristics that reflect social vulnerability, a well-prepared emergency response system, and forward looking adaptive planning can ensure that the most vulnerable are cared for during emergencies and in the course of adaptation planning. The ability to do so depends in large measure on functional infrastructure.

7.3 Infrastructure Vulnerability

When overlaying the 100-year flood zone with 55 inches of sea-level rise on a map of the city (showing the current degree of build-up), some important infrastructure emerges as exposed to the growing flood hazard. There are presently 202 buildings exposed to the flood risk, 143 of these are residential buildings; one is a parking lot; and 13 are government owned buildings. From the 1400 block to the 100 block of Hermosa Avenue all of the exposed buildings are located below 20 feet of elevation at ground level. In addition, the Pier and much of the Strand are at risk of flooding. Based on estimates of the value of buildings and their contents, this reflects a current exposure of $35 million in economic replacement value.[104] (Re)development and infill, and changes to the market value of coastal properties as flood risks increase will change this figure over time.

In addition to specific buildings, sea-level rise and higher storm surges will increase the risk of street flooding (and damage to city streets). While the recently upgraded stormwater drainage system is a significant help in reducing the risk of street flooding within the downtown Pier Avenue business district, it will need to be kept in good repair to provide this benefit in the future. Additional stress on the sewage system – already in need of rehabilitation – can be expected from flooding (structural impairment) and saltwater intrusion (corrosion). Rising groundwater table as a result of sea-level rise could also be problematic. Streets seaward of Hermosa Avenue are at risk of being impassable during a 100-year flood event with 55 inches of sea-level rise, impeding evacuation from and first responders' access to these parts of the city. Fortunately, no police or fire stations are located within the projected flood zone. The tsunami inundation zone can be expected to expand as a result of the projected sea-level rise (even if the occurrence of tsunamis themselves is not directly affected by climate change), but this could not be quantitatively assessed in this study.

7.4 Conclusions

In summary, the following observations can be made about Hermosa Beach's vulnerability to sea-level rise and related flood and erosion risks:

Climate Change Impacts and Exposure to Coastal Hazards

- The 100-year flood zone is projected to increase 300% under a scenario of 55 inches of sea level rise (from 0.034 square miles at present to 0.1 square miles with 55 inches of sea level rise). The projected flood zone encompasses more than 200 buildings, including 143 residences, and about 1000 residents (not accounting for any future infill development or population growth).
- The 100-year flood zone with 55 inches of sea-level rise extends inland from the Strand to Hermosa Avenue, particularly in central and southern portions of the city.
- Long before the average sea level is 55 inches higher than the 2000 baseline, a smaller global average sea-level rise combined with a strong El Niño can result in a similarly high, if temporary, sea level situation. During such El Niño winters, coastal storms can cause significant beach erosion and flood damage.
- The amount and rate of beach loss as a result of sea-level rise could not be assessed in this study. However, the well-established scientific understanding of physical beach dynamics makes clear that the beach will not remain stable as sea level increases. Absent continued beach replenishment in the littoral cell, the shoreline can be expected to retreat at an accelerated rate as sea level rises.

Social, Economic and Infrastructure Vulnerabilities

- The greatest exposure to flood risks in the coastal, especially central and southern, areas of the city coincides with the greatest social vulnerability in Hermosa Beach. This overlap of challenges should be carefully considered in emergency response planning and in longer-term adaptation planning.
- The typically high social vulnerability of homeless, transient, and disabled populations could not be displayed in a spatially referenced way due to data limitations. However, they do require particular attention in emergency situations.
- Similarly, infrastructure vulnerabilities particularly with regard to the city's sewage system (already in need of rehabilitation at present), city streets, and some iconic structures and associated business activity particularly in the central and southern parts of the city coincide with the greatest exposure to flooding in a future 100-year flood. They require particular attention both for disaster preparedness and long-term adaptation planning, as they are essential to the city's economic vitality and functionality.
- To the extent business and residential areas are at risk of inundation during a future major flood and cannot easily evacuate or be reached by emergency responders, the vulnerability of residents in the affected areas increases substantially. This is the case in neighborhoods seaward of Hermosa Avenue. These areas require special attention in disaster preparedness and long-term adaptation planning.
- The city's greatest economic and cultural asset is its beach. As sea level rises, this asset is at risk of increased beach erosion and – eventually, permanent submergence. Without continued beach replenishment, this cornerstone of the city's economy can be expected to decline over time and diminish in its effectiveness as a storm buffer, resulting in growing exposure of residential and business establishments along the Strand and in near-shore areas to future flooding.

How these challenges might be addressed will be discussed in Part B.

Part B: Coastal Adaptation Options

1. Introduction

As part of its General Plan Update, the City of Hermosa Beach wants to update its Coastal Land Use Plan (CLUP) and related policies, programs and procedures including a coastal zoning code to obtain a certified LCP. At the same time, the California Coastal Commission – which will review and decide over the adequacy of the LCP update – has put forward guidance on how communities should update their LCPs.[105] In particular, the Coastal Commission guidance (currently only available in draft form) recommends that communities not only address the standard components of an LCP, but within them explicitly assess how climate change and sea-level rise will affect a number of key assets and areas of concern, including public access to the coast, recreation and visitor-serving facilities, water quality, environmentally sensitive areas, existing and new development, including culturally important areas, scenic and visual resources, and the risks from coastal hazards and the needs for shoreline protection. It also recommends that LCPs explicitly include policies and programs that facilitate adaptation over time to the growing risks from climate change and sea-level rise.

A related input into the General Plan Update will develop specific language for the CLUP update and the related LCP Implementation plan, and shepherd the LCP through the public comment and Commission's review processes. This section of our study is not to replicate that work, but to provide important input into it, based on the vulnerability assessment conducted in Part A. It reviews the existing CLUP of 1981 (as amended) and relates the findings of our vulnerability assessment to the components of the CLUP that will require updating. It also offers concrete suggestions for possible adaptation options that the City of Hermosa Beach may wish to consider in deliberating its alternatives. The work conducted here does not constitute engineering or legal advice, nor an economic assessment of the costs of alternative adaptation pathways (all of which are beyond the scope of the requested study). Instead it offers – based on the best available science and experience with adaptation planning and implementation elsewhere – a menu of adaptation options that address identified vulnerabilities. In offering these options, we take into account the guiding principles put forward by the Coastal Commission and seek to be consistent with current (and forthcoming) guidance from the Governor's Office of Planning and Research (OPR) to local communities on how to prepare General Plans.

Section 2 below briefly reviews Hermosa Beach's existing Local Coastal Program, Section 3 identifies the key issue areas that need to be addressed in an LCP update and which sea-level rise related vulnerabilities could be identified in each. And Section 4 then offers adaptation strategies to address them all.

2. Brief Review of Hermosa Beach's Existing Coastal Land Use Plan

Hermosa Beach prepared and passed its first " Coastal Land Use Plan" in 1980-81 and has amended it at least four times in the intervening 33 years (in 1988, 1992, 1995 and 2004).[106] The existing LCP addresses the following key issues:

- Parking needs and public access to the beach
- Housing and the preservation of mixed neighborhoods
- Coastal recreational access and the preservation of the beach
- Coastal development and design, including the preservation of scenic resources, viewsheds, and community character
- Maintenance of different types of land uses (residential, commercial, recreational, industrial, and open space)

The existing CLUP does not have *separate* sections explicitly addressing ecologically sensitive habitat areas, coastal hazards, or shoreline protection, although relevant sections of the Coastal Act are recognized, and the existing sections include mention of related considerations and policies. For example, the section on "Coastal

Development and Design" states among its five goals and objectives that its remaining open space should be preserved, although Appendix G recognizes that there is no native habitat left in Hermosa Beach.[107]

In the same section on development and design, one policy explicitly calls out that "Although the LUP proposes no additional construction of structures seaward of the mean hide tide line, the City recognizes the need to maintain consistency with provisions required for shoreline structures in other jurisdictions. " The related program element to implement this policy states that:

"Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger of erosion, and when designed and constructed to minimize erosive impacts on adjacent unprotected property and minimize encroachment on to the beach and shall indicate all area seaward of the seawall for lateral access for the public."

The minimal treatment of issues related to coastal hazards, natural resources, and shoreline protection is not surprising, as the issues were not as pressing in the early 1980s, and climate change was not on Hermosa Beach's (or most other communities') radar then. Moreover, sand replenishment within the littoral cell in the intervening years has created and preserved a wide beach in front of the Strand (which itself serves as a minor seawall) and thus has reduced the need for – and thus any question or debate over – the type of shoreline protection of individual properties.

The growth in recreational beach use over time due to population growth and fundamental socio-economic changes, and the resulting concerns with maintaining beach access, traffic management, parking, and the preservation of the community character have been of bigger concern in the past. The desire to update the LCP with special emphasis on coastal adaptation, however, suggests, that the City recognizes the potential threats to its shorefront neighborhoods and key economic and cultural assets.

3. Key Vulnerabilities to be Addressed in the Local Coastal Program Update

In this section, we briefly summarize the issue areas that need to be addressed in an CLUP update and related the key vulnerabilities identified in Part A of this study to each.

3.1 Required Components in a Local Coastal Program Update

The Draft Coastal Commission's guidance on LCP updates discusses 11 issue areas that should be addressed – as applicable – as local governments revise their LCPs. **Error! Reference source not found.Error! Reference source not found.**Table 6 lists these issue areas in brief and notes which are of particular relevance to Hermosa Beach, given existing land uses.

TABLE 6: ISSUE AREAS TO ADDRESS IN HERMOSA BEACH'S LCP UPDATE

	Issue Area	Comments	Relevance to HB
1	Public Access	Issues to address include the implementation of the California Coastal Trail, expanding non-automotive transportation, preventing loss of public access, recreational beach valuation, and comprehensive beach management.	**Yes**
2	Recreation & Visitor-Serving Facilities	Issues to address include condominiums, hotels and timeshares; new overnight facilities; upgrades, and conversions; and short-term (or vacation) rentals	**Yes**
3	Water Quality	The draft guidance currently does not yet discuss	**Yes**

	Issue Area	Comments	Relevance to HB
	Protection	this issue area due to recent changes in water quality requirements. Under development.	
4	Environmentally Sensitive Habitats and Other Natural Resources	Issues to address include Definitions of Environmentally Sensitive Habitat Areas (ESHA) and wetlands; ESHA identification, use of resources, cumulative impacts, buffers, mitigation ratios, restoration and monitoring, beach grooming, tree trimming and removal, bird-safe buildings, night lighting, surface noise, wind energy impacts, and climate change and sea-level change impacts on ESHA and biodiversity.	**Yes**
5	Agricultural Resources	Issues to address include uses in agricultural areas, urban-rural limit lines and buffers, agricultural land conversion criteria, and affirmative agricultural easements.	No
6	Planning and Locating New Development and Archaeological/Cultural Resources	Issues to address include concentration of development, second units, rural land divisions and development, cultural resources consultation, and discovery and preservation of cultural resources.	**Yes**
7	Scenic and Visual Resources	Issues to address include protected view identification, special communities and community character, visual assessments, night lighting, telecommunications facilities, signs and billboards, and landscape screening.	**Yes**
8	Coastal Hazards	Issues to address include definitions, land divisions (zoning), siting development to avoid hazards/setbacks, redevelopment, reconstruction and setbacks in oceanfront and blufftop areas, sea-level rise, tsunami hazards, fire hazards, climate adaptation, and a multi-hazard approach.	**Yes**
9	Shoreline Erosion & Protective Devices	Issues to address include maps and inventories, definitions, avoidance of future shoreline armoring, sea-level rise, minimizing and mitigating impacts of armoring, and monitoring and maintenance.	**Yes**
10	Energy and Industrial Development	Issues to address include directional oil and gas drilling, decommissioning and abandonment of facilities, onshore components of offshore energy development, power plants, desalination, aquaculture, and emerging technologies to provide renewable energy.	No
11	Timberlands	Issues to address include timber harvest locations, compatible and supporting uses, and timber harvest reviews.	No

Source: California Coastal Commission (2013).[108]

Several of the issue areas listed have direct and obvious relevance to climate change – such as #3, #8 and #9 – vulnerable ecosystems, coastal hazards, and shoreline erosion and protection. However, as the vulnerability assessment in Part A illustrates, several other issues are affected by climate change. For example, public access to the beach/shore may be impacted if key access roads are impacted; recreational or visitor-serving facilities may be impacted by erosion and flooding; cultural assets may be at risk from flooding and erosion, as may be existing and new development. Thus, in Section 3.4 we discuss climate change vulnerabilities and possible adaptation options not only in those sections where attention to them is explicitly called for, but in all sections where impacts can be expected and where adaptive actions therefore should be taken to avoid or minimize these potential impacts.

Since Hermosa Beach has no agricultural areas, timberlands, or heavy industrial activities and energy development in the immediate coastal zone, these issue areas are not further discussed here.

3.2 Key Identified Vulnerabilities in Key LCP Update Areas

The discussion here occurred ahead of new surveys of beach use, visitor and traffic concerns of the city, , so is based on the assessed infrastructure and socio-economic vulnerabilities discussed in Part A, Sections 5.2-5.9 and 6.2-6.4.

As will become clear from the list of identified vulnerabilities in each of the key issue areas that must be addressed in an LCP update, some require specific adaptation measures, yet many others can be collectively addressed through one or more overarching measures. These measures will be discussed in Section 4.

3.2.1 Public Access

Identified vulnerabilities for public access to the coast include the following:

- **California Coastal Trail** (which, in Hermosa Beach, is the Strand) is at risk of flooding during a 100-year flood with 55 inches of sea-level rise (note, the Strand/CCT are vulnerable to flooding much sooner, given that they are the closest built structure along the ocean).[109]
- **Access roads**. During such storm events, many public walkways and streets providing vehicular access to the beach are impassable. While temporary, such floods can cause significant damage to roadways, drainage infrastructure through flooding, wave action and scour, thus potentially leaving longer-lasting damage and impacts on public access to the beach.
- **Parking**. Hermosa Beach already has challenges with meeting the parking demand for local residents, businesses and visitors, especially during the summer months. Storms and related flooding would temporarily diminish available on-street residential parking spaces, and the infrastructure vulnerability assessment identified parking lots to be within the projected floodzone (again, likely to be affected long before the sea level has reached 55 inches). While visitor parking needs may be reduced during coastal winter storms – because fewer visitors are in town, and fewer would want to go to the beach – there is a possibility of greater numbers of winter visitors as a result of climate change.

3.2.2 Recreation & Visitor-Serving Facilities

Identified vulnerabilities for recreation and visitor-serving facilities to the coast include the following:

- **The beach.** The most basic and most important risk to recreation in Hermosa is how accelerating sea-level rise could affect the beach itself. Increased coastal erosion, unless compensated for by continued beach replenishment, could shrink the width of the beach, thus not only diminishing the basis for Hermosa Beach's recreational economy and culture, but also the quasi-natural buffer that currently protects the city from severe coastal storms, thus potentially increasing the risk of more severe damage to the Strand, and public access roads and related infrastructure.
- **Built structures on the beach.** Any built structures on or adjacent to the beach (lifeguard stations, toilets, concession stands, playground equipment) could be impacted by coastal storms, flooding, and wave action, unless temporarily removed prior to the onset of a storm.

- **Visitor accommodations.** The 202 buildings in the projected floodzone for a 100-year flood with 55 inches of sea-level rise include 143 buildings identified as "residential," which may include private homes (both owned or rented) of residents, condominiums, timeshares, and vacation rentals. The area within the future floodzone, however, also includes hotels and other overnight facilities.

- **Commercial-recreational establishments.** Restaurants, bars, and other visitor-serving businesses are located in downtown and near the Pier, both of which are within the future floodzones.

3.2.3 Water Quality

While the Commission's draft guidance does not yet provide clear directives for assessing and addressing water quality issues, our vulnerability assessment did surface potential impacts of sea-level rise and related flooding that should be addressed in the CLUP update. Identified vulnerabilities to water quality include the following:

- **Stormwater overflows.** Higher sea levels combined with high runoff from intense rainfall events can produce stormwater drainage problems, back-ups, and possible overflows into the streets and onto the beach.

- **Corrosion**. Higher sea levels intruding into coastal groundwater and raising coastal groundwater levels could lead to greater saltwater corrosion of water-related infrastructure (sewage and drainage pipes). This will reduce the effective lifespan of water-related infrastructure and would require more frequent repairs, maintenance, and replacement to avoid unwanted seepage or water infrastructure failures.

- **Saltwater barrier.** Regionally important is the saltwater barrier as it protects regionally important groundwater resources. Any threat to the integrity of this barrier could lead to quasi-irreversible contamination of valuable water supplies (Hermosa Beach itself does not draw on local groundwater but on other sources for its water supplies. Climate change impacts on those source areas will need to be considered in a more comprehensive climate change impacts assessment for the city.)

3.2.4 Environmentally Sensitive Habitats and Other Natural Resources

Hermosa Beach does not have any native habitat left in shorefront areas. Thus, there are no specific Environmentally Sensitive Habitat Areas (ESHAs) left to protect.[110] However, two "natural" (though not "native") areas exist that are vulnerable to the impacts of sea-level rise and related flooding and erosion:

- **The beach.** The beach is a heavily used "natural" resource and not home to any endangered species, but provides winter foraging habitat for the Western snowy plover, which is designated by the U.S. Fish & Wildlife Service as a "threatened" species. The beach also requires ongoing maintenance (grooming, beach clean-up). Its current width is the result of active beach replenishment within the littoral cell (upstream, not directly along Hermosa Beach's length of shoreline); without it, the beach would be affected by significant coastal erosion, and would be considerably narrower. Sea-level rise and coastal storms (particularly during El Niños and/or lunar high tides) will increase the risk of coastal erosion and beach narrowing.

- **Nobel Park.** There is only one small park area (Nobel Park) between 14th and 15th Street along the shoreline that is in a quasi-natural state. It is fronted by the beach and otherwise unprotected by any hard structures. As long as the beach itself is maintained it is not at risk of being eroded away. However, it would be temporarily inundated by a severe flood. An onsite assessment of the plant species in the Park would be required to assess whether they could withstand temporary inundation and the longer-lasting increase in soil salinity.

3.2.5 Planning and Locating New Development and Archaeological/Cultural Resources

Identified vulnerabilities to Hermosa Beach's development (new and existing) and cultural resources include the following:

- **New and re-development.** Already in the early 1980s, it was recognized that Hermosa Beach was a "basically fully-developed community which is going through a recycling process."[111] With little room left for infill, new development is of lesser concern than re-development. The vulnerability assessment could not assess how many buildings or parcels within the potentially inundated floodzone may be currently or in the future considered for redevelopment. Over the remaining years and decades of the 21st century, however, redevelopment is highly likely, if for no other reason than replacement or upgrading of old building stock for newer structures and accommodating population growth and expected growth in visitors. Moreover, if floods occur and if they cause severe structural damage to existing buildings (particularly non-floodproof structures), rebuilding of damaged/destroyed structures can also be expected within the projected floodzone. This redevelopment may increase density and intensity of urban land use, and if the new/renewed buildings accommodate a larger population, then the population at risk of future flooding also increases.

- **Cultural resources.** There are some historic or potentially historic buildings at risk. This assessment identified the Pier and the Strand as the key historical/cultural resources of Hermosa Beach. Both are the immediate shorefront and thus most at risk from coastal storms, flooding, wave action and erosion, even long before sea level has risen 55 inches above current levels. (A separate assessment will identify other archeological, historical or Native American cultural resources.)

3.2.6 Scenic and Visual Resources

Identified vulnerabilities to the city's scenic and visual resources include the following:

- **The beach.** The beach – backed by the wide expanse of the Pacific Ocean – is the city's most important scenic resource. Existing policies on building height restrictions, signage, local natural elevations (dunes) from which observers can enjoy views to the beach and ocean, and beach-perpendicular roads and walkways leading to the beach and ocean help to maximize viewing opportunities. Climate change and sea-level rise are not expected to affect the viewing opportunities, but can be expected to affect the beach width through increased coastal erosion (unless beach replenishment is sustained into the indefinite future). Without such replenishment, the beach would be affected by significant coastal erosion, and would be considerably narrower. Sea-level rise and coastal storms (particularly during El Niños and/or lunar high tides) will increase the risk of coastal erosion and beach narrowing.

3.2.7 Coastal Hazards

Coastal hazards have been the central focus of the assessment conducted for this report. In summary, key coastal hazards include the following:

- **Sea-level rise**. Sea level has already risen on average 7 inches along the California coast of the 20th century. Over the course of the 21st century, it is expected to rise four to nine times as fast as last century. While uncertainties about the exact rate of rise persist, this assessment has followed Coastal Commission guidance and used the best available science to assess potential impacts of accelerating sea-level rise, combined with extreme flood events (such as the flood that has a 1% chance of occurring in any given year, the 100-year flood). While the 2012 NRC report recommends a 66 inch scenario, data that combine that scenario with flooding are not available at this time (expected in 2015 or 2016). Thus, the 2009 Pacific Institute 55 inch sea-level rise scenario combined with the 100-year flood event was used as the high-end scenario.[112] A lower sea-level rise scenario with the 100-year flood has not been modeled. Thus only the high-end scenario is used here. Qualifications to account for El Niño and the possibility of yet higher sea levels in the future are made on a qualitative basis.

- **Increased risk of flooding**. Currently, Hermosa Beach does have no area in an officially designated 100-year or 500-year flood (as mapped by FEMA or USGS), However, the City's hazard Mitigation Plan of 2005 recognizes that winter-time flooding is a chronic problem. For this assessment, the 100-year floodzone with 55 inches of sea-level rise was mapped and exposed infrastructure and populations identified.

- **Increased risk of coastal erosion**. The coastline of Hermosa Beach is considered highly vulnerable to shoreline change by the USGS, but over many decades, it has remained relatively stable, largely thanks to beach replenishment upstream of Hermosa Beach, and a "sediment trap" at Redondo Beach, which prevents or slows sediment from disappearing off into Redondo Canyon. The beach is considerably wider than it would be without this beach replenishment. In the future, rising sea level will increase beach erosion, though local shoreline retreat rates could not be ascertained as part of this assessment.

- **Expansion of the tsunami run-up/inundation zone**. Hermosa Beach has mapped its tsunami wave run-up/inundation zone, and USGS has assessed all structures and populations at risk in that zone.[113] These existing assessments and maps do <u>not</u> consider the potential future expansion of this zone due to sea-level rise. While such modeling and new mapping was beyond the scope of this study, the 100-year flood zone with 55 inches of sea-level rise was found to overlap in many areas with the map of the tsunami inundation zone at <u>current</u> sea level. If 55 inches of sea-level rise were added, the tsunami zone would expand considerably.

- **Saltwater intrusion**. Sea-level rise will push saltwater further into existing coastal freshwater aquifer lenses and may increase the corrosive effects on existing saltwater intrusion barriers. This problem for the saltwater barriers could not be further assessed in this assessment. However, corrosive effects on existing water-related sewage and drainage infrastructure can be expected to reduce the expected lifetime of this infrastructure.

3.2.8 Shoreline Erosion & Protective Devices

As mentioned above, shoreline erosion has been identified as a growing threat resulting from accelerating sea-level rise. Potential impacts of shoreline erosion include:

- **Narrowing of the beach** as the basis for the recreational economy and culture of Hermosa Beach, unless continually maintained by beach replenishment upstream in the littoral cell.

- **Loss of the quasi-natural buffer** against coastal storms, wave action, and flooding, resulting in greater scour and impact on shoreline property and built structures (residential, recreational and commercial). Given the currently human-made wide beach, the question of additional shoreline protection has not been a priority issue in Hermosa Beach. However, virtually the entire shoreline is fronted by the Strand – the bike- and walkway that marks the hardened boundary between the beach and residential/commercial development of the city proper. The Strand serves effectively as a low seawall along the full length of the city, set back from the shoreline and fronted by the beach. If beach erosion were to continue unabated as a result of accelerated sea-level rise, it would eventually lead to a situation where the water's edge would be at the base of the Strand seawall. Missing the beach buffer, the waves – particularly storm waves – would eventually undercut the seawall and damage the Strand.[114]

If beach loss were to continue unabated, the demand for hard shoreline protection (i.e., armoring) could grow in Hermosa Beach. The impacts of more shoreline armoring have not been specifically modeled for this assessment, but the Coastal Commission summarizes the known science on impacts of hardening as follows:

- Direct loss of sandy and rocky intertidal areas that often have been found to be a critical component of the marine ecosystem;
- Interruption of natural shoreline processes, that may contribute to erosion of the shoreline in many areas;
- Impedance of public access to and along the coastline as a result of the structure's physical occupation of the beach; and
- Degradation of scenic and visual resources."[115]

3.2.9 Summary

The implications of climate change-driven sea-level rise could be significant for Hermosa Beach and manifest in every component that needs to be addressed in an LCP update. The three overarching challenges the city faces are:

(1) **coastal erosion**, which threatens the basis of Hermosa's natural beauty and scenic value, its economic and cultural basis, and its no.1 storm buffer;

(2) **coastal flooding**, which threatens fully developed and densely populated areas currently used for commercial, recreational and residential purposes; and

(3) **elevated coastal groundwater table and saltwater intrusion,** which – through its corrosive effect - threatens primarily shallow and water-related infrastructure and the foundations of buildings.

These threats are not independent, but interrelated: erosion increases temporarily during storm events which can also bring flooding, and both flooding and erosion and scour can put additional strain on shoreline infrastructure; and as erosion diminishes the beach buffer, waves and coastal flood waters can reach further inland, causing greater damage there. It is important to reiterate that the dynamic, interactive effect of erosion/shoreline retreat and flooding was not captured in the Pacific Institute model of the future floodzone with 55 inches of sea-level rise. Research currently underway by the USGS is addressing this gap, reinforcing that those data should be used in future risk mapping by the City.

If the city addresses these interrelated issues systemically and through a combination of near-, mid-, and long-term strategies, monitors and reviews the changing risks and the effectiveness of responses periodically, and adjusts these strategies as needed (i.e., adaptively, as the Coastal Commission recommends), it can devise solutions to each of the issue areas that need to be addressed in the LCP.

While global sea-level rise may be perceived as proceeding gradually and slowly to the human eye[116], its more destructive effects become particularly visible during extreme events such as coastal storms. Almost imperceptibly, gradual sea-level rise raises the "on-ramp" for storms such that even relatively minor storm events in the future can have devastating impacts. A comprehensive adaptation strategy thus needs to include both mid- and long-term response options for the challenges that will become problematic over the long-term (but which may require longer lead times to realize), and additional attention in ongoing emergency planning to address the more near-term challenges (which may yield benefits long before sea level has risen by 55 inches). Both long-term adaptive strategies and enhancements of emergency planning are thus discussed below.

4. Adaptation Options for Hermosa Beach

4.1 Introduction

Communities in California and across the nation have chosen different pathways to develop climate change adaptation plans.[117] Some have developed self-standing climate action plans (including greenhouse gas mitigation and, more recently, adaptation strategies), others have chosen to integrate their climate-related activities into existing governance mechanisms, such as general plans, hazard mitigation and emergency preparedness plans, long-term development and capital investment plans, infrastructure development and maintenance plans, annual work plans, or – as the case may be – Local Coastal Programs.

Hermosa Beach has chosen this latter approach for coastal adaptation, without precluding the future possibility of developing a more comprehensive strategy for other climate change threats (including additional public health, safety, infrastructure, environmental and water supply issues than are assessed in the more narrowly focused Part A of this study).

Section 4.2 below lays out the guiding principles suggested by the Coastal Commission and the Governor's Office for Policy and Research, and in Section 4.3 we turn to the specific adaptation options aimed to address the vulnerabilities identified in each of the LCP areas of concern.

4.2 Guiding Principles

The Coastal Commission's (draft) guidance on updating LCPs is fundamentally guided by the principles and goals first expressed and codified by law in the California Coastal Act of 1974. Thus, protection of public access to the coast for all, preservation of the natural and cultural resources that make the California coast unique, avoidance or minimizing coastal hazards, fostering thriving coastal communities, and ensuring public safety are overriding principles.

With specific reference to climate change, sea-level rise and related coastal challenges, the Commission's guidance spells out several more specific principles that we will adhere to in Section 3.4:

- To minimize the risk of urban sprawl (and related increase in vehicle miles travelled and transportation-related greenhouse gas emissions), preference should be given to infill development.[118]
- Scenic resources (incl. beaches) should be protected as much as possible.[119]
- In the case of new development, (1) risks to life and property in areas of high geologic, flood, and fire hazard shall be minimized, and (2) stability and structural integrity must be assured, so that it neither creates nor contributes significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way requires the construction of protective devices in the future. Preference should be given to responses to coastal hazards that minimize negative impacts on coastal resources.[120] The Commission suggests this be achieved through mechanisms such as the following:
  - avoid locating new development in hazardous areas, wherever feasible;
  - require assurance of safety and stability for the life of a development (generally 75-100 years);
  - if a hazard cannot be avoided entirely, maximize avoidance through safer design of new development such as elevation above the base flood elevation;
  - development that is so hazardous that it constitutes a significant risk to the public should not be allowed;
- LCP Updates should be used as opportunities to comprehensively address the development and protection of coastal lands, waters and resources; [121]
- Armoring should be minimized and shoreline areas and sand supplies should be protected and restored, taking into account projected sea-level rise;[122]

- Where shoreline protection is needed and allowed, the adverse impacts of allowed protection should be minimized, and alternative forms of shoreline protection that do not involve armoring should be facilitated; [123]

In addition to the guidance from the Coastal Commission, the 2013 State of California Hazard Mitigation Plan notes the following:

Climate change has also been recognized by the Governor's Office of Planning and Research (OPR) as a factor to be considered in preparation of local general plans. OPR is in the process of updating the 2003 General Plan Guidelines, which provide guidance to cities and counties in the preparation of their local general plans. *The next update will reflect legislative requirements enacted since 2003 and provide new guidance on addressing climate change, adaptation, and related issues*. The current General Plan Guidelines require a safety element as one of seven mandatory elements in the general plan. The primary aim of the safety element is to reduce the potential risk of death, injuries, property damage, and economic and social dislocation resulting from fires, floods, earthquakes, landslides, and other hazards. Local agencies are encouraged by California law to adopt Local Hazard Mitigation Plans (LHMPs) as part of their general plan safety elements. The LHMP must be consistent with the goals and objectives of both the local general plan and the [State Hazard Mitigation Plan]. As such, the general plan and LHMP provide a local vehicle for implementation of the SHMP, including provisions dealing with climate change. (CalOES, 2013, Sect. 4, p.100, emphasis added)[124]

While it is impossible to foresee the climate change adaptation-related specifics in the forthcoming OPR guidance for preparing General Plan Updates, being consistent – in fundamental philosophy – with the existing guidance is imperative. Thus a further guiding principle or goal considered here is "to reduce the potential risk of death, injuries, property damage, and economic and social dislocation resulting from fires, floods, earthquakes, landslides, and other hazards." The fact that Hermosa Beach already considers climate change in its General Plan Update can be considered a helpful step in meeting future OPR guidance.

4.3 Adaptation Strategies

4.3.1 Ongoing Overarching Regional Strategies

Several overarching strategies can help Hermosa Beach leverage its own resources and capacities and ensure that its own efforts are effectively linked and integrated with those of neighboring cities facing similar challenges.

Strategy 1: Continue Participating in the Regional Partnership in Climate Change Assessment and Adaptation Planning

Substrategy 1.1 Participate in LARC. Having recognized the importance of climate change and the limited effectiveness of any one city (no matter its size) trying to meet the challenges of climate change alone, City staff of Hermosa Beach already participate in ongoing regional assessment and planning efforts. For example, the City of Los Angeles, working with the LA Regional Collaborative for Climate Action and Sustainability (LARC)[125] and the University of Southern California's Sea Grant Program, conducted an in-depth vulnerability assessment to support the development of its adaptation strategies. Over the next few years this effort will expand to include the entire the Los Angeles region. Hermosa has the opportunity to take advantage of this collaborative by participating actively in all stages of the process. Early partnering in the regional process will help Hermosa ensure that its local plans are consistent with the regional goals and that its own local needs are met through the combined efforts, resources and regional strategies that will be developed. Key benefits involve leverage in attracting funding for research (such as the updated sea-level rise and flooding data) and – in the future – funding for the implementation of adaptation strategies, as well as for monitoring of key indicators (such as sea-level rise, advance of the saltwater frontier, changing beach width etc.). Through the LARC, Hermosa Beach will also be able to benefit from the experience of other regional adaptation planning collaboratives (e.g., in San Diego, the San Francisco Bay) that have formed across California.

Substrategy 1.2 Update Scientific Basis for Coastal Adaptation Planning. As repeatedly indicated throughout this report, there are efforts underway at present to improve on the sea-level rise and flooding scenarios, using the National Research Council scenarios and more dynamic modeling to project the future floodzone. In the absence of better information, this assessment replied on older available information. The new projections will become available over the course of this General Plan Update or shortly thereafter. The City should use that forthcoming information to follow Coastal Commission guidance to use "the best available science." In the future, new scientific insights will improve on this basis, and the City should remain vigilant as to when state-level guidance in this regard changes. In a continually changing environment, as we now live in, this periodic updating of the scientific basis is prudent practice.

Strategy 2: Pursue a Regional Approach to Sediment Management and Adaptive Shoreline Protection

Substrategy 2.1. Participate in Regional Sediment Management Planning. This regional coordination and participation is particularly important when it comes to sediment management. Historically, Hermosa Beach has benefited from beach replenishment upstream in the littoral cell which created a far wider beach than would otherwise naturally exist, and which counteracted beach erosion, thus creating an effective storm buffer and, of course, the city's economic and cultural basis. Active participation in regional sediment management will allow Hermosa Beach to voice its needs, allow for coordination with its coastal neighbors, and help identify creative financial mechanisms to maintain the city's most fundamental and important "resource."

Substrategy 2.2. Develop a Long-term Adaptive Shoreline Management Policy. In light of the overriding importance of the beach for Hermosa, and the Coastal Commission's strong encouragement to avoid shoreline armoring, beach replenishment is the most promising option for adaptation to sea-level rise in the near- to mid-term.[126] It would maintain the wide beach, which is a sought-after recreational destination, and thus continue to serve the important economic function it has served historically; it would also continue to serve as an effective storm buffer and thus protect the Strand and inland areas from the brunt of storm impacts. If the City (together with regional, state and federal partners) maintains and elevates the beach in place, this could also considerably lessen the risk of coastal flooding and thus the risk of infrastructure damage (note, however, that the risk from intense runoff and flooding from inland areas would <u>not</u> be reduced this way).

As sea-level rises significantly higher, beach nourishment would need to be conducted more frequently, and may involve larger sediment volumes to elevate the beach to keep up with the higher baseline. Eventually this may also require an elevation of the Strand to maintain the sightline to the beach and ocean, and any related adjustments to drainage and storm runoff infrastructure to ensure that low-lying storm drain outfalls continue to be able to perform their functions. Clearly, the prospect of this level of beach replenishment and related structural changes is expensive, though a comprehensive cost assessment was beyond this study.

Alternative responses include the "no beach replenishment" option, resulting in the gradual narrowing and eventual loss of the beach to erosion and permanent inundation of the beach area, followed by structural damage to the Strand and shoreline residential and commercial development. This option would likely result in calls for shoreline armoring from local residents and businesses through larger seawalls or revetments (on option not favored by the Commission). A second fundamentally different alternative is the "managed retreat" alternative whereby neither beach replenishment nor hard shoreline protection are employed, and instead, flood and erosion-threatened structures would be relocated when that threat become immanent in years hence, either before they are damaged or by simply not rebuilding them after they are damaged. The shoreline would be allowed to progress landward over time and natural shoreline processes would not be artificially altered. Given the soft substrate on which Hermosa Beach is built, this would maintain a natural shoreline with a natural beach, albeit one that slowly moves inland.

Substrategy 2.3 Conduct a Cost-Effectiveness Assessment of Shoreline Adaptation Alternatives. A full economic assessment of these adaptation alternatives would help determine (a) how long the beach replenishment option is fiscally feasible and cost-effective for the city, taking into account the costs of beach replenishment, the growing beach sand volumes over time, and the cost of related infrastructure adjustments, as well as the fiscal benefits of the beach as an economic asset and as a storm buffer; (b) how soon the need for shoreline hardening might arise, what damages and losses may be incurred both from periodic storm/flooding damage and from the permanent loss of the beach; and (c) what the loss and damages may be over time from the loss and removal of shorefront property, the change in the property tax base, the cost of relocation of buildings, and the benefits of a natural, albeit landward-moving shoreline and beach.

None of these options will be cost-neutral or low-cost; rather, they all may incur significant and growing costs over time, in monetary terms, in socio-cultural terms (e.g., the public's loss of the culturally significant beach) and in political terms (e.g., difficult trade-offs, unpopular options for some, but greater benefits for others). Assessing these costs, however, should not be put off. It is uncertain, given fiscal constraints at all levels of government and growing challenges from climate change everywhere, to what extent current cost-share ratios among local, state, and federal partners for shoreline protection will be retained in the future. Thus, some choices may need to be made sooner rather than later. A robust cost-effectiveness assessment should make assumptions about cost-share ratios explicit, and explore alternative ratios (e.g., no federal or state assistance or greater-than-present state and federal assistance)

Substrategy 2.4. Develop Creative Local and Regional Financing Mechanisms for the Preferred Shoreline Adaptation Strategy. Through continued regional engagement in sediment management planning, the City cannot only harmonize its preferred shoreline management approach with that of neighboring jurisdictions, but also work with regional partners on creative ways to jointly fund the preferred adaptation shoreline strategy.

4.3.2 Ongoing Overarching Local Strategies

In addition to coordinating with regional adaptation efforts, there are many things that Hermosa beach can do locally. These are listed here.

Strategy 3: Educate the Public about Flooding Risks and Promote Household Disaster Preparedness

Substrategy 3.1. Develop Flood Risk Educational Materials and Distribute them Widely and Repeatedly. With the 100-year flood zone projected to increase 300% under the 55-inch sea-level rise scenario, areas previously not affected by flooding will become flood prone. Neither residents nor visitors, homeowners, renters, developers or insurers may currently be aware of these growing risks. Structural development may have occurred without flood proofing considerations, as neither building codes nor insurance may have required such enhancements. Older building stock in particular may not be able to withstand the onslaught of moving water, leaving particularly ground floors of buildings vulnerable to flood damage. A first overarching strategy to overcome these shortcomings is to begin educating the public about these risks. Infrequent and passive web-based communication is generally considered inadequate. Best practices in how to communicate flood risks and inspire household-level disaster preparedness are available from FEMA and from NOAA's Coastal Services Center.

Substrategy 3.2. Survey Household-level Preparedness and Develop Programs to Fill Disaster Preparedness Gaps. To identify specific ways in which various actors in the city may not be adequately prepared for flood risks, and thus to be able to tailor risk communication effectively, the City should consider conducting a survey to better understand the population's level of risk awareness and disaster preparedness. Such a survey should be able to distinguish different groups within the population such as homeowners, renters, schools, businesses, and different populations identified as particularly socially vulnerable (see Part A). Tailored community-based, social marketing approaches to increase disaster preparedness will help reduce the social vulnerability of different segments of the population.

Substrategy 3.3. Require Flood Risk Disclosure and Active Acknowledgment of Flood Risk in Property Purchases/Turn-overs. Risk disclosure at appropriate times in real estate transactions are critically important to raise awareness of current and future flood risks, particularly in combination with City policies that establish flood-cognizant building codes (see Strategy 6) for new/re-development. It is generally recognized that risk disclosure at the point of the final sales agreement is too late, given the time and money invested already in acquiring or redeveloping a property. Thus, risk disclosure should be required early in the process. Risk disclosure in real estate transactions is particularly important as a component of general awareness raising efforts because buildings have expected lifetimes of 75-100 years (far longer than the average duration of a mortgage (30 years). Over this time span, flood risks will be significantly higher in Hermosa Beach.

Strategy 4: Educate the Public about Climate Change Risks and Adaptation Alternatives

Substrategy 4.1. Communicate climate change risks and what the City is doing to address them. Research on effective climate change communication shows that merely communicating the science of climate change is inadequate and often counter-productive to improving public understanding of the challenges ahead.[127] A sense of powerlessness and overwhelm can prevent meaningful engagement of the public with the topic. The politicization of the topic has also served as a turn-off for many. A comprehensive, scientifically informed approach to climate risk communication should affirm what is well established knowledge through extensive scientific research (including what remains uncertain), why climate change matters locally, and what different actors (from the individual to the City, to the State of California, to the US and the global community of nations) are doing and can do to help address the challenges. This involves both fundamental responses to climate change: mitigation/emissions reductions and adaptation/preparedness. The City is in a good position in that it is taking the science seriously, and is taking steps in both areas, and as such affirms the scientific consensus and helps people feel cared for. From this basis, the City can ask its residents and visitors to take part in addressing climate change within their spheres of influence.

Substrategy 4.2. Provide frequent updates to the population to keep climate change messaging fresh, and to signal the importance of the issue. In a communication environment in which everyone is overwhelmed with information, it is important to "keep climate change on the radar screen" through relatively frequent, short, and interesting communication. Social media can be very helpful in this matter, however, climate change communication is not sufficiently served through one-way communication (see Strategy 5).

Strategy 5: Meaningfully Engage the Public in Adaptation Planning

Individuals have strong emotional responses to climate change once they accept its reality, and need face-to-face dialogue to fully grasp the issue, grapple with its urgency and scope, and to support each other in taking meaningful action. Meaningful engagement thus must make space for such direct communication and dialogue. Individuals also need to see how their actions meaningfully contribute to what others within the community and beyond are doing to address climate change, both at its root causes and in its effects. The City can help community members track those action and see the ways they reinforce and support each other in community meetings. As the social vulnerability assessment illustrated, there are numerous questions about particularly vulnerable populations that statistical analysis and publicly available data cannot answer. Experience elsewhere illustrated how the lived experience of community members could significantly help in filling these data gaps and in identifying practicable adaptation options.[128] In this way, the interested public becomes part of the solution.

Strategy 6: Update Development and Redevelopment Policies

Substrategy 6.1 Update Definitions. To the extent the City does not already define the economic lifespan of structural development, it should do so in accordance with the Coastal Commission's recommendation: the economic lifespan of a development should be defined to be at least 75 or 100 years unless otherwise specified and restricted for specific development proposals), and redevelopment, reconstruction or remodel.

Substrategy 6.2. Update Elevation Requirements of Infill and Redevelopment. According to the California Coastal Act, new development (and re-development) should be directed to reduce risks to life and property and avoid substantial changes to natural landforms. Coastal Act section 30253 provides, in part, that new development shall do all of the following:

> (a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.
>
> (b) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.

While new development is of limited concern in Hermosa Beach given its high degree of development already, <u>re</u>development of existing lots in the course of normal replacement cycles or – if future floods or other hazardous events (such as fire, earthquakes or tsunamis) damage or destroy houses – rebuilding of such damaged structures is an important consideration for the City.

In order to adhere to Coastal Commission guidance and fulfill the Coastal Act requirement, infill or rebuilding and redevelopment within the projected 100-year flood zone with 55-inches of sea-level rise (or future updated sea-level rise projections) should be elevated above the expected base flood elevation expected with such a 100-year flood. The City should define thresholds as to when the new redevelopment/remodel policy applies.

Substrategy 6.3. Update Building Height Restrictions to Account for Elevation Requirements on New/Redevelopment Above Base Flood Level. A policy as suggested in Substrategy 6.1 to elevate new structures above the base flood elevation will impact the City's height restrictions on buildings and they need to be adjusted accordingly. Important considerations here relate to maintenance of the community character and protection of important viewsheds.

Substrategy 6.4. Update Parking Requirements Associated with Infill and Redevelopment. If structures to be built in the future are required to be above base flood elevation, an opportunity may arise (welcome in a city with limited parking space at present) whereby the parking needs associated with any new building may be met onsite, i.e. *below* the first livable floor. This would require an adjustment in parking related policies.

Strategy 7. Reduce Flood Vulnerability of Existing Structures

Substrategy 7.1. Issue Guidance to Homeowners and Renters on How They Can Protect Floodprone Ground Floor Installations. Where possible, homeowners and renters may be able to elevate appliances, heating and cooling equipment, and other valuable items to a higher floor. Informational and practical assistance should be provided to the population in floodprone areas, and – given turnover in building occupancy – such educational and practical assistance should be offered on a regular basis (e.g., once a year).

Substrategy 7.2. Floodproof Public Buildings. Both to serve as a model to the community and to ensure that key public buildings remain functional in flooding events, survey how public buildings are currently not flood proof, and remedy any identified weaknesses. Prioritize buildings closest to the coast and those affected in non-coastal wintertime flooding, and over time extend inland toward other buildings in the projected floodzone.

Substrategy 7.3. Develop Incentive Programs for Businesses to Floodproof their Establishments. Given the importance of functional businesses during and after disaster events, i.e. the ability of a community to recover quickly, the business sector requires special attention. Incentives to floodproof businesses can include informational and practical assistance, low-interest loans, and other means.

Strategy 8. Reduce Flood Vulnerability of Existing Infrastructure

Substrategy 8.1. Continue Stormwater Runoff Improvements. The city already has taken proactive steps to manage its runoff, which have the co-benefit of also supporting adaptation to climate change. Particularly, its urban runoff project with support from the U.S. EPA and funds from the American Recovery Act help filter stormwater runoff through a system built along the Strand.[129] Given the rising challenges with absorbing and diverting stormwater runoff as the sea level rises, these efforts should be continued, and the system should be kept in good repair over time to minimize potential problems with street flooding and drainage backups during storm events.[130]

Substrategy 8.2. Increase Surface Infiltration Throughout the City. Hermosa Beach can experience intense rainfall events, which already regularly cause major street and basement flooding problems and backups of drainage with vegetation debris. At present, the City's surface is substantially covered by impermeable surfaces. To reduce this problem and thus help reduce the pressure on the stormwater runoff system during (coastal) storm events, a policy requiring the creation of permeable surfaces wherever possible could help reverse this trend. It should apply to all new/redevelopment and to any landscape repairs and alterations (e.g., repair and replacement of concrete walkways, private parking spaces, street resurfacing and parking lot repavement).

Substrategy 8.3 Integrate Sea-Level Rise into the Repair and Replacement of Aging Infrastructure. The corrosive effect of saltwater from surface coastal flooding, from below-surface saltwater intrusion, as well as the scouring effect of moving flood waters can place additional strain on water- and transportation-related infrastructure. The City is already considering rehabilitating its sewers and drainage infrastructure, and should take sea-level rise into account at this time as necessary (i.e. in all areas that may be affected by flood waters over the expected lifetime of the newly placed infrastructure), and in the future when infrastructure is repaired or replaced under significantly higher sea level conditions.

Strategy 9: Consider Synergies and Trade-offs Between Climate Mitigation and Adaptation Policies, and between Climate and Non-Climate Policies.

Substrategy 9.1. Require City Staff to Routinely Assess Implications of Local Government Action for Greenhouse Gas Emissions and Climate Change Risks. To integrate climate change thinking into the day-to-day business of local government, establishing an overarching administrative policy that all applicable decisions have to consider the implications for climate change is a critical first step. "Applicable decisions" are those that pertain (1) to ongoing resource and energy consumption (i.e. direct or indirect greenhouse gas decisions) by all City government employees, (2) to long-term investments that commit the City and/or its residents to fossil-fuel based energy consumption, and (3) to any other decisions with long-term implications (i.e., the impacts of the decision will be felt for 20 or more years), e.g., building and infrastructure, (re)zoning, and major capital investment decisions.

Substrategy 9.2. Minimize Future Carbon Burden and Future Vulnerability to Climate Change Impacts Whenever Possible. Once the implications for greenhouse gas emissions and for the vulnerability to emerging and future climate change risks are assessed, City staff should develop option alternatives for those "applicable decisions" that minimize the carbon burden on the planet and that reduce or minimize vulnerability to these climate change risks. Many opportunities exist where options to minimize greenhouse gas emissions simultaneously maintain maximum flexibility to prepare for and adapt to climate change risks in the future.[131] For example, according to the South Bay Cities Plug-In Electric Vehicle Deployment Plan, the region plans to build publicly accessible plug-in stations throughout the region.[132] If Hermosa Beach participates in this effort and installs any additional charging stations within city bounds, potential sites should take precaution to avoid flooding risks or be built in a flood-proof manner.

4.3.3 Specific Improvements in Disaster Preparedness and Recovery Planning

The suggested policies and changes here are consistent with guidance and recommendations from the California Coastal Commission and those contained within the 2013 State Hazard Mitigation Plan. Specific additional guidance and practical advice can be obtained from the Office of Emergency Planning.[133]

Strategy 10. Update Tsunami Emergency Response Planning

Substrategy 10.1. Require Future Tsunami Inundation Mapping to Include the Best Available Science on Sea-Level Rise. As this assessment revealed, Hermosa Beach's current tsunami wave run-up/inundation map is almost identical to the 100-year floodzone with 55 inches of sea-level rise. This is helpful in so far as tsunami emergency planning may serve as a template or guidance for coastal flood emergency planning (similar except for the extremely short lead time in a tsunami). However, the current tsunami map and thus emergency planning does not take into account the possibility of higher future sea levels. This should be remedied in the next round of tsunami mapping and periodically thereafter to stay current. In addition, the greater risk of liquefaction should be assessed as sea level rises and groundwater elevations increase.

Substrategy 10.2. Ensure that Tsunami Emergency Response Considers Social Vulnerability Before, During and After the Event. As the social vulnerability assessment conducted in this study revealed different segments of the population have different needs before, during and after an emergency event. These considerations should inform tsunami emergency planning as much as all disaster preparedness.

Strategy 11. Improve Emergency Response Planning

Legal requirements for land use planning related to flood risk reduction have changed in recent years. Additional informational and practical assistance is available from the Department of Water Resources Planning[134] and from the Office of Emergency Planning.[135] The following recommendations do not replace that guidance and should be viewed as additional and complementary strategies.

Substrategy 11.1 Review and Improve Evacuation, Emergency Response and Recovery Plans by Considering Identified Vulnerabilities. The Social and infrastructure vulnerability assessment conducted here should motivate a review of the existing evacuation, emergency, and recovery plans, particularly for the entire area west of Hermosa Avenue. Where gaps are identified, these plans should be updated. In particular recovery plans are important opportunities to proactively build in adaptive measures that help reduce the community's vulnerability to future events.

Substrategy 11.2. Assess the Costs and Benefits of Joining the National Flood Insurance Program. The City currently does not participate in the National Flood Insurance Program (NFIP). This limits its access to certain federal hazard mitigation funds, which could help implement some of the strategies listed here, and which limits the opportunity for private homeowners and business owners to obtain affordable flood insurance that would help them cope in the case of a flooding disaster.[136]

While flood insurance rates are increasing, lack of property owners' self-insurance places a great financial burden on the entire community, state and nation when catastrophe strikes. As flood risks increase Hermosa Beach may consider participating in the program to buffer against the worst-case scenario. Moreover, participating in the NFIP's Community Rating System (CRS), whereby communities take community-wide flood protection measures and thereby bring down the insurance premiums for everyone, is an attractive option, especially in combination with the range of strategies listed here (especially, Strategies 2, 3, 4, 6, 7, 8, 9, and 10, all of which would gain Hermosa Beach premium-lowering bonus points in the CRS). The benefits of participating in the NFIP are further discussed in the State's Hazard Mitigation Plan.[137]

4.4 Summary of Adaptation Options and Conclusion

Many of the adaptation and disaster preparedness strategies listed here cut across any single area of concern that needs to be addressed in an LCP Update. Others are specifically geared toward just one. Which of the strategies proposed here addresses each of the vulnerabilities identified in Part A of this study (and summarized by LCP issue area in Section 3 of Part B) is summarized in Table 7 below. This overview suggests that the City has a considerable range of choices to reduce its vulnerabilities.

The strategies, however, should not be considered merely a menu from which to pick and chose at random. While all adhere to the Coastal Commission's guidance and principles, some overarching strategies seem indispensible in that they serve to address many key vulnerabilities at once, and others address key issues through specific actions. Not implementing them would leave key vulnerabilities unattended.

Given that Hermosa Beach is already built out, key policies are not about protecting natural areas or restricting shorefront development. Instead, of foremost importance is the maintenance of the beach which is the economic and cultural center of the city and the most important storm and coastal flood buffer the City has. In addition, dealing with growing flood risks and saltwater intrusion will further stave off far more profound (transformative) adaptation in future decades. In short, Hermosa Beach can implement many measures that will allow it to adapt *in place* while continuing to enjoy the many benefits of being an oceanfront community.

Table 7: Summary of Coastal Adaptation Strategies for Hermosa Beach

	Relevant LCP Areas of Concern For Hermosa Beach	Public Access	Recreation Facilities	Water Quality	ESHA & Nat. Res.	New/Redevelopment	Scenic & Visual Res.	Coastal Hazards	Erosion & Protection
	Adaptive Strategies Addressing LCP Areas of Concern	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**9**
Ongoing Overarching Regional Strategies	Strategy 1: Continue Participating in the Regional Partnership in Climate Change Assessment and Adaptation Planning								
	Strategy 1.1 Participate in LARC.							**X**	
	Strategy 1.2 Update Scientific Basis for Coastal Adaptation Planning.							**X**	
	Strategy 2: Pursue a Regional Approach to Sediment Management and Adaptive Shoreline Protection								
	Substrategy 2.1. Participate in Regional Sediment Management Planning.		**X**		**X**		**X**	**X**	**X**
	Substrategy 2.2. Develop a Long-term Adaptive Shoreline Management Policy.		**X**		**X**		**X**	**X**	**X**
	Substrategy 2.3 Conduct a Cost-Effectiveness Assessment of Shoreline Adaptation Alternatives.		**X**		**X**		**X**	**X**	**X**
	Substrategy 2.4. Develop Creative Local and Regional Financing Mechanisms for the Preferred Shoreline Adaptation Strategy.		**X**		**X**		**X**	**X**	**X**
Ongoing Overarching Local Strategies	Strategy 3: Educate the Public about Flooding Risks and Promote Household Disaster Preparedness								
	Substrategy 3.1. Develop Flood Risk Educational Materials and Distribute them Widely and Repeatedly							**X**	
	Substrategy 3.2. Survey Household-level Preparedness and Develop Programs to Fill Disaster Preparedness Gaps							**X**	
	Substrategy 3.3. Require Flood Risk Disclosure and Active Acknowledgment of Flood Risk in Property Purchases/Turn-overs					**X**		**X**	
	Strategy 4: Educate the Public about Climate Change Risks and Adaptation Alternatives								
	Strategy 4.1. Communicate climate change risks and what the City is doing to address them.							**X**	
	Strategy 4.2. Provide frequent updates to the population to keep climate change messaging fresh, and to signal the importance of the issue.							**X**	
	Strategy 5: Meaningfully Engage the Public in Adaptation Planning							**X**	
	Strategy 6: Update Development and Redevelopment Policies								
	Substrategy 6.1 Update Definitions.					**X**		**X**	

	Relevant LCP Areas of Concern For Hermosa Beach	Public Access	Recreation Facilities	Water Quality	ESHA & Nat. Res.	New/Redevelopment	Scenic & Visual Res.	Coastal Hazards	Erosion & Protection
	Adaptive Strategies Addressing LCP Areas of Concern	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**9**
	Substrategy 6.2. Update Elevation Requirements of Infill and Redevelopment.					**X**		**X**	
	Substrategy 6.3. Update Building Height Restrictions to Account for Elevation Requirements on New/Redevelopment Above Base Flood Level.					**X**	**X**	**X**	
	Substrategy 6.4. Update Parking Requirements Associated with Infill and Redevelopment.	**X**				**X**		**X**	
	Strategy 7: Reduce Flood Vulnerability of Existing Structures								
	Substrategy 7.1. Issue Guidance to Homeowners and Renters on How They Can Protect Floodprone Ground Floor Installations.							**X**	
	Substrategy 7.2. Floodproof Public Buildings.							**X**	
	Substrategy 7.3. Develop Incentive Programs for Businesses to Floodproof their Establishments.							**X**	
	Strategy 8: Reduce Flood Vulnerability of Existing Infrastructure								
	Substrategy 8.1. Continue Stormwater Runoff Improvements.			**X**				**X**	
	Substrategy 8.2. Increase Surface infiltration Throughout the City.			**X**				**X**	
	Substrategy 8.3 Integrate Sea-Level Rise into the Repair and Replacement of Aging Infrastructure.			**X**				**X**	
	Strategy 9: Consider Synergies and Trade-offs Between Climate Mitigation and Adaptation Policies, and between Climate and Non-Climate Policies.								
	Substrategy 9.1. Require City Staff to Routinely Assess Implications of Local Government Action for Greenhouse Gas Emissions and Climate Change Risks.							**X**	
	Substrategy 9.2. Minimize Future Carbon Burden and Future Vulnerability to Climate Change Impacts Whenever Possible.							**X**	**X**
Specific Improvements in Disaster	Strategy 10: Update Tsunami Emergency Response Planning								
	Substrategy 10.1. Require Future Tsunami Inundation Mapping to Include the Best Available Science on Sea-Level Rise.							**X**	
	Substrategy 10.2. Ensure that Tsunami Emergency Response Considers Social Vulnerability Before, During and After the Event.							**X**	
	Strategy 11. Improve Emergency Response Planning								

	Relevant LCP Areas of Concern For Hermosa Beach	Public Access	Recreation Facilities	Water Quality	ESHA & Nat. Res.	New/Redevelopment	Scenic & Visual Res.	Coastal Hazards	Erosion & Protection
	Adaptive Strategies Addressing LCP Areas of Concern	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**9**
	Strategy 11.1 Review and Improve Evacuation, Emergency Response and Recovery Plans by Considering Identified Vulnerabilities.							**X**	
	Strategy 11.2. Assess the Costs and Benefits of Joining the National Flood Insurance Program.							**X**	

Appendix 1: Description of Social Vulnerability Index Constructed for Hermosa Beach

Development of the Vulnerability Index

A set of 11 variables was used to calculate an integrated social vulnerable index for Hermosa Beach's risk of flooding. The variables were chosen primarily based on the Cutter et al. 2003 Social Vulnerability Index commonly used. However, because Hermosa Beach is a smaller area than this general index is calculated for, the method needed to be revised slightly. Therefore, we decided that integrating the indicators using principle components analysis was not appropriate due to the small sample size (16 block groups). Instead we summed the standardized values of the individual indicators. We chose the indicators from the Cutter et al. SoVI that displayed variation among block groups in Hermosa Beach, omitting those that showed very little or no variation across block groups. This omission was done only to reduce unnecessary "noise" in the analysis, therefore, it is important to note that the omission of indicators does not mean the variables are not important to understanding social vulnerability. It only means that they would not affect the quantitative differentiation between block groups. The ultimate goal of the index is to find where variation exists. Variables used to construct the index, with sources, are listed in Table 8.

TABLE 8: VARIABLES USED IN THE SOCIAL VULNERABILITY INDEX, TAILORED TO HERMOSA BEACH

Indicator	Metric used	Source (US Census table)	Database and year	Processing
Race	% non-white population	SE:T13. Race	ACS 2008-2012	All metrics standardized (z-scores), then summed, then mapped by standard deviation to create vulnerability index score
Age-dependent population	% population <5 yrs and 65 and older	SE:T7A. Age - Cumulative (Less)	ACS 2008-2012	
Female as head of household	% female head of family households	SE:T17. Households By Household Type	ACS 2008-2012	
Population (*this is subtracted from vulnerability scoring*)	% of households that earn >$200K	SE:T56. Household Income (In 2012 Inflation Adjusted Dollars)	ACS 2008-2012	
Population living at poverty level	% population that earn less than 75K (2013 definition for 300% of federal poverty level for hh of four people)	SE:T56A. Household Income (In 2012 Inflation Adjusted Dollars) - Cumulative (Less)	ACS 2008-2012	
Renter occupied housing units	% renter occupied units	SE:T94. Tenure	ACS 2008-2012	
Vacant housing	% unoccupied housing units		ACS 2008-2012	
Burden of overpayment of housing costs for renters		SE:T103. Gross Rent As A Percentage Of Household Income In 2012	ACS 2008-2012	
Price of rental unit	Gross median rent	SE:T104. Median Gross Rent	ACS 2008-2012	
Overpayment burden of housing costs for home owners with mortgage		SE:T110. Selected Monthly Owner Costs As A Percentage Of Household Income In 2012 For Housing units with a mortgage	ACS 2008-2012	
No access to vehicle	% of population that do not own a vehicle	ACS12_5yr:B25044. Tenure By Vehicles Available	ACS 2008-2012	

Interpreting the Vulnerability Index

Figure 27 displays the breakdown of how each Census Block Group scored overall (black dot) and individually across all variables. Patterns for those block groups scoring highest (meaning the most vulnerable) show a pattern of high proportion of the population as females as heads of family household and high proportion of households earning less than $75K per year. The block group scoring as most vulnerable is just east of the Strand, bordered on the south by Herdono St. This score is dominated by a high proportion of females as head of family households, high vacancy of housing units. The second highest block group is inland, not exposed to flooding according to the 100 year flood map with 55 inches of sea-level rise. The third highest block group (located along the Strand in the southern part of the city) was dominated by income related and other factors: relatively low proportion of households earning $200K, high proportion of households earning >$75K, and high renter-occupied units.

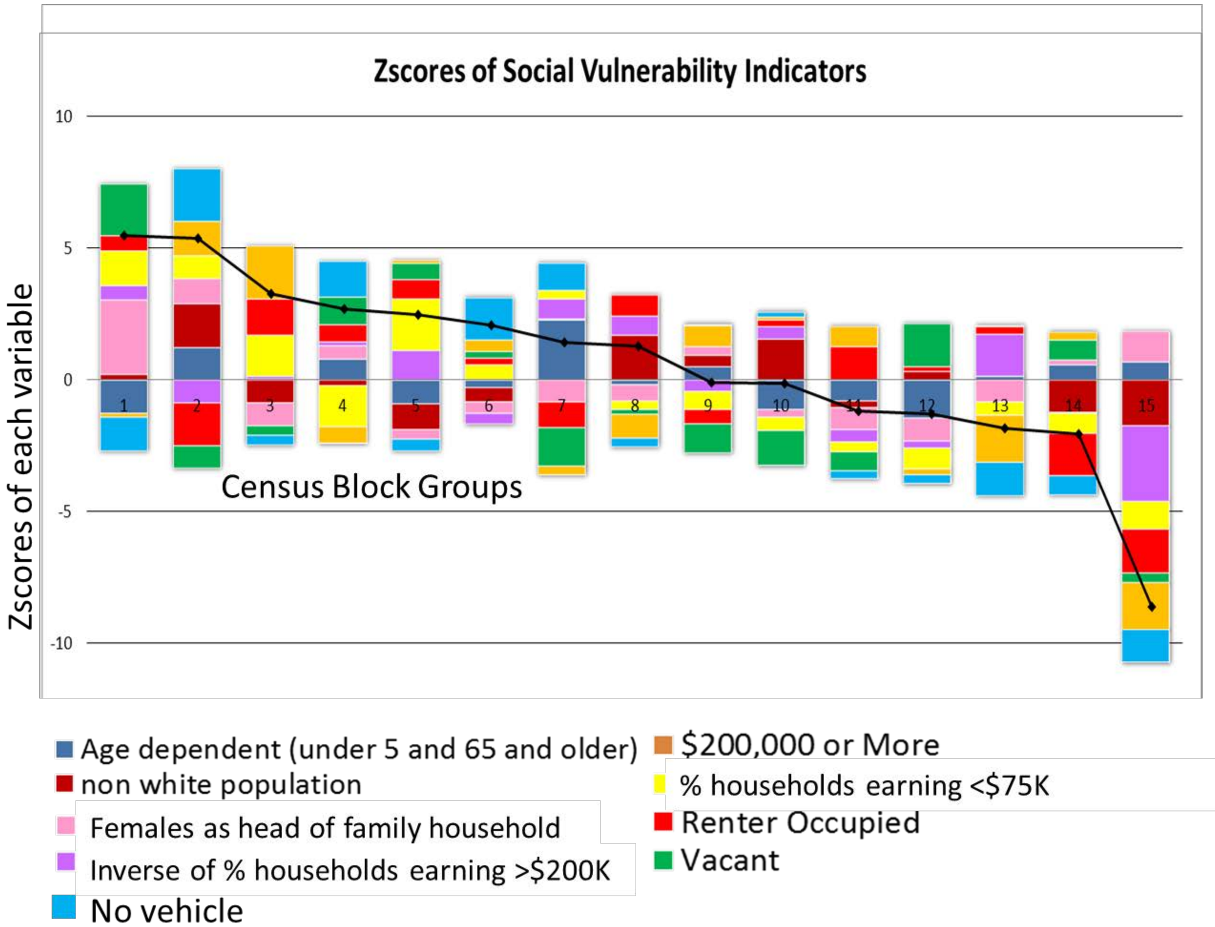


Figure 27: Bar Graph Showing Values of z-scores (standardized values) of each indicator used in the Social Vulnerability Index for Hermosa Beach. Sum of z-scores is indicated with a black dot (and line connecting between Census Block Groups)

Endnotes and References

[1] Photo by Dave Proffer (2010). Available from: http://commons.wikimedia.org/wiki/File:Land_Shark_over_Hermosa_Beach%3F_(4361868358).jpg.

[2] California Coastal Commission (2013). *California Coastal Commission Draft Sea-Level Rise Policy Guidance*. Public Review Draft of October 14, 2013. San Francisco, CA; Coastal Commission. Available at: http://www.coastal.ca.gov/climate/slr/guidance/CCC_Draft_SLR_Guidance_PR_10142013.pdf.

[3] California Ocean Protection Council (2011). Resolution of the California Ocean Protection Council on Sea-Level Rise. Available at: http://www.opc.ca.gov/2011/04/resolution-of-the-california-ocean-protection-council-on-sea-level-rise/. The most recent Update to the Guidance Document can be accessed here: http://www.opc.ca.gov/2013/04/update-to-the-sea-level-rise-guidance-document/

[4] California Natural Resources Agency (2009). *2009 California Climate Adaptation Strategy*. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF.

[5] According to the survey results of what motivates coastal managers and other professionals in California to begin adaptation to climate change, as reported in: Finzi Hart, J. A., P. M. Grifman, S. C. Moser, A. Abeles, M. R. Myers, S. C. Schlosser, J. A. Ekstrom. (2012). *Rising to the Challenge: Results of the 2011 Coastal California Adaptation Needs Assessment*. USCSG-TR-01-2012. Available at: http://www.usc.edu/org/seagrant/research/climateadaptsurvey/SurveyReport_FINAL_OnlinePDF.pdf.

[6] For example, Messner, S. Miranda, K. Green, C. Phillips, J. Dudley, D. Cayan, and E. Young (2008). *Climate Change Related Impacts in the San Diego Region by 2050*. *A Summary Prepared for the 2008 Climate Change Impacts Assessment*, Second Biennial Science Report to the California Climate Action Team. Available at: http://www.escholarship.org/uc/item/870746sr#page-2.

[7] Multihazard Mitigation Council (2005). Natural hazard mitigation saves: An independent study to assess the future savings from mitigation activities. Volume 2 - Study Documentation, National Institute of Building Sciences, Washington, D.C. Available at: http://www.nibs.org/resource/resmgr/MMC/hms_vol2_ch1-7.pdf?hhSearchTerms=Natural+and+hazard+and+mitigation.

[8] Foster, J., A. Lowe and S. Winkelman (2011). *The Value of Green Infrastructure for Urban Climate Adaptation*. Center for Clean Air Policy, Washington, DC.

[9] For a comprehensive compilation of relevant research supported by the State of California on different climate change aspects, see the California Climate Change portal at: http://www.climatechange.ca.gov/.

A discussion of sea-level rise impacts on coastal areas is also included in the *2013 State Hazard Mitigation Plan*, which explicitly acknowledges how various climate-related hazards are becoming more widespread and/or challenging due to climate change. See: Governor's Office of Emergency Services (CalOES, 2013). 2013 State of California Multi-Hazard Mitigation Plan. Mather, CA, Section 6.4.3, pp. 318-325.

[10] The California Natural Resources Agency in coordination with other state agencies is revising and updating the 2009 strategy document. The draft of this updated strategy, *Safeguarding California*, was released in late 2013, and is open for public comment until February 28, 2014. Available at: http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.

Note these definitions are also largely consistent with definitions used in the 2013 State Hazard Mitigation Plan. See: Governor's Office of Emergency Services (CalOES, 2013). *2013 State of California Multi-Hazard Mitigation Plan*. Mather, CA, Section 4, pp. 93-97).

[11] Romero Lankao, P. and J. L. Tribbia (2009). Assessing patterns of vulnerability, adaptive capacity and resilience across urban centers. Paper presented at the *Fifth Urban Research Symposium 2009*: p. 4.

[12] Romero Lankao, P. and J. L. Tribbia (2009). Assessing patterns of vulnerability, adaptive capacity and resilience across urban centers. Paper presented at the *Fifth Urban Research Symposium 2009*: p. 4.

[13] California Natural Resources Agency (2009). *2009 California Climate Adaptation Strategy*. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[14] This definition is consistent with the California Ocean Protection Council's Sea-level Rise Guidance document: "Adaptive capacity is the ability of a system to respond to climate change, to moderate potential damages, to take advantage of opportunities, and to cope with the consequences." See: Ocean Protection Council (2013). *Updated California SLR Guidance*. Available at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf, p. 4.

[15] Kasperson, J.X., R.E. Kasperson, and B.L. Turner II. (2009). Vulnerability of coupled human-ecological systems to global environmental change. In: *Human Footprints on the Global Environment: Threats to Sustainability*, eds. E.A. Rosa, A. Diekmann, T. Dietz, and C.C Jaeger, 231-294, Cambridge, MA: The MIT Press.

[16] National Research Council (2012). *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Washington, DC: The National Academies Press. Available at: http://www.nap.edu/openbook.php?record_id=13389&page=103

[17] Bromirski, P. D., A. J. Miller, R. E. Flick, and G. Auad (2011). Dynamical suppression of sea level rise along the Pacific coast of North America: Indications of imminent acceleration. *Journal of Geophysical Research* 116: C07005, 12 pp.

[18] National Research Council (2012). *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Washington, DC: The National Academies Press. Available at: http://www.nap.edu/openbook.php?record_id=13389&page=103

[19] National Research Council (2012). *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Washington, DC: The National Academies Press. Available at: http://www.nap.edu/openbook.php?record_id=13389&page=103

[20] Bromirski, P. D., D. R. Cayan, N. Graham, M. Tyree, and R. E. Flick (2012). *Coastal Flooding-Potential Projections: 2000–2100*. California Energy Commission. Publication number: CEC-500-2012-011.

[21] This also means that a storm such as the January 2010 storm which significantly affected areas across LA County (only a "10-year" storm at present, i.e. a storm with an annual probability of occurring of 10%) can be expected to occur at least annually well before the end of the century, and probably much sooner and far more frequently.

[22] Ocean Protection Council (2013). 'Update to the Sea-Level Rise Guidance Document' (webpage). Accessed December 2013. Available at: http://www.opc.ca.gov/2013/04/update-to-the-sea-level-rise-guidance-document/

[23] National Research Council (2012). *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Washington, DC: The National Academies Press. Available at: http://www.nap.edu/openbook.php?record_id=13389&page=103.

[24] The California Ocean Protection Council's Sea Level Rise Guidance advises that, "It is important to note that the NRC [National Research Council] report is based on numerical climate models developed for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report which do not account for rapid changes in the behavior of ice sheets and glaciers and *thus likely underestimate sea-level rise* (the new suite of climate models for the Fifth Assessment Report was not available when the NRC report was developed). The committee used the model results from the IPCC Fourth Assessment Report, together with a forward extrapolation of land ice that attempts to capture an ice dynamics component." (See: Ocean Protection Council. 2013. Updated California SLR Guidance. Available at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf, p.3; emphasis added).

[25] Joughin, I., B.E. Smith and B. Medley (2014). Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica. *Science* 344 (6185): 735-738;DOI: 10.1126/science.1249055.

Rignot, E., J. Mouginot, M. Morlighem, H. Seroussi and B. Scheuchl (2014). Widespread, rapid grounding line retreat of Pine 1 Island, Thwaites, Smith and Kohler glaciers, West 2 Antarctica from 1992 to 2011. *Geophysical Research Letters* 2014GL060140; DOI: 10.1002/2014GL060140.

[26] California Coastal Commission (2013). *California Coastal Commission Draft Sea-Level Rise Policy Guidance*. Public Review Draft of October 14, 2013. San Francisco, CA; Coastal Commission. Available at: http://www.coastal.ca.gov/climate/slr/guidance/CCC_Draft_SLR_Guidance_PR_10142013.pdf, pp.5, 23.

[27] Ocean Protection Council (2013). Updated California SLR Guidance. Available at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf, p.5.

[28] Cayan, D., M. Tyree, D. Pierce, T. Das (2012). *Climate Change and Sea Level Rise Scenarios for California Vulnerability and Adaptation Assessment*. Scripps Institution of Oceanography, prepared for the California Energy Commission. Publication number: CEC-500-2012-008.

[29] More detail on the methodology is available from: Heberger, Matthew, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore (2009). The Impacts of Sea-Level Rise on the California Coast. California Energy Commission's Public Interest Energy Research (PIER) Program Research Report, CEC-500-2009-024-F. http://dev.cakex.org/sites/default/files/CA%20Sea%20Level%20Rise%20Report.pdf

[30] Climatic information based on nearby Los Angeles averages. See: *Weatherbase: Historical Weather for Los Angeles, California, United States of America*. Available at: http://www.weatherbase.com/weather/weather.php3?s=159227&refer=.

[31] City of Hermosa Beach, *Hazard Mitigation Plan 2005*, p.148.

[32] Neighborhood Link.'90254 Zip Code Profile' (webpage). Access December 2013. Available at: http://www.neighborhoodlink.com/zip/90254

[33] City of Hermosa Beach elevation map, provided as a shapefile to Ekstrom from Sonali Tambe, GIS Analyst, City of Hermosa Beach, on 12/27/2013.

[34] Morino, D. (2011). Hermosa Beach Storm Water System Receives EPA Award. *Daily Breeze*, March 21, 2011. Accessed December 23, 2013 at: http://www.dailybreeze.com/general-news/20110321/hermosa-beach-storm-water-system-receives-epa-award.

[35] Turner, C.H., Ebert, E.E., and Given, R.R. (1969). Man-made reef ecology. *Fish Bulletin 146.*State of California, Department of Fish and Game. Available at: http://content.cdlib.org/view?docId=kt2x0n9933&brand=calisphere&doc.view=entire_text.

[36] GIS shapefiles from City of Hermosa Beach supplied by Sonali Tambe, GIS Analyst, City of Hermosa Beach

[37] Thieler, E.R. and E.S. Hammar-Klose (2000). *National Assessment of Coastal Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Pacific Coast*. USGS, Woods Hole, MA. Available at: http://pubs.usgs.gov/of/2000/of00-178/index.html.

[38] Sherman, D. and B. Pipkin (2005). The coast of southern California: Santa Monica to Dana Point. In: Griggs, G., K. Patsch and L. Savoy (eds.), *Living with the Changing California Coast*. University of California Press: Berkeley, LA, pp. 427-473.

[39] Thieler, E.R. and E.S. Hammar-Klose (2000). *National Assessment of Coastal Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Pacific Coast*. USGS, Woods Hole, MA. Available at: http://pubs.usgs.gov/of/2000/of00-178/index.html.

[40] Unnamed author (2002). Chapter 6: Effectiveness Beach Nourishment, in *California Beach Restoration Study*. Available at: http://www.dbw.ca.gov/PDF/Reports/BeachReport/Ch6_Effectiveness.pdf

[41] California Beach Restoration Study (2002).Table 6.3. It draws on Leidersdorf et al. (1994). "Human Intervention with the Beaches of Santa Monica Bay, California" *Shore & Beach,* 62(3): 29-38.

[42] See also Flick, R.E. (1993). The Myth and Reality of Southern California Beaches. Paper based on a presentation given at the California Shore and Beach Preservation Association Annual Meeting, Session on Special Coastal Issues, 17 November 1992, p.9. Accessed 12/30/13 at: http://cmbc.ucsd.edu/content/1/docs/Flick_3.pdf.

[43] Opportunistic replenishment is typically defined as follows: "Opportunistic beach nourishment projects are those that are undertaken when beach-quality sand becomes available from projects unrelated to beach nourishment. To date, the primary sources of this 'sand of opportunity' in California have been harbor construction and maintenance dredging. Opportunistic nourishment is driven by economics, in that it often proves more cost effective to place the excavated material on nearby beaches than to dispose of it inland or offshore." (California Beach Restoration Study (2002), Chapter 6, p.6-2, available at: http://www.dbw.ca.gov/PDF/Reports/BeachReport/Ch6_Effectiveness.pdf.

[44] This relative stability of the area south of Manhattan Beach is also described in Sherman, D. and B. Pipkin (2005). The coast of southern California: Santa Monica to Dana Point. In: Griggs, G., K. Patsch and L. Savoy (eds.), *Living with the Changing California Coast*. University of California Press: Berkeley, LA, see, especially, the discussion on pp. 433-447 and the map on p. 437.

[45] Photo from: http://geology.campus.ad.csulb.edu/people/bperry/AerialPhotosSoCal/CoastalCities.htm, Photo #25 Southern California. Original source: Image Science and Analysis Laboratory, NASA Johnson Space Center.

[46] City of Hermosa Beach.(2005). Hazard Mitigation Plan: p.151.

[47] City of Hermosa Beach. (2005) Hazard Mitigation Plan: p. 151.

[48] U.S. Census Bureau: State and County QuickFacts. Data derived from Population Estimates, American Community Survey, Census of Population and Housing, County Business Patterns, Economic Census, Survey of Business Owners, Building Permits, Census of Governments. Accessed 1/1/14, online: http://quickfacts.census.gov/qfd/states/06/0633364.html

[49] City of Hermosa Beach (website).Accessed January 3, 2014. Available at: http://www.hermosabch.org/index.aspx?page=5

[50] U.S. Census (2007).*QuickFacts: City of Hermosa Beach*. Available at: http://quickfacts.census.gov/qfd/states/06/0633364.html.

Annual sales are defined here as: "Sales includes payments from customers for services rendered, from the use of facilities and from merchandise sold." (See: http://quickfacts.census.gov/qfd/meta/long_AFN120207.htm)

[51] Southern California Council of Governments (SCAG) (2013). Profile of the City of Hermosa Beach. (May 2013), Section VI. Employment.

[52] Southern California Council of Governments (SCAG) (2013). Profile of the City of Hermosa Beach. (May 2013), chart on p.30.

[53] Southern California Council of Governments (SCAG) (2013). Profile of the City of Hermosa Beach.(May 2013), p.29.Available at: http://www.scag.ca.gov/Documents/HermosaBeach.pdf.

Above SCAG report contains figure with sources noted as California Employment Development Department 2007, InfoGroup, and SCAG.

[54]According to the Los Angeles County Fire Department, Lifeguard Division. Available at: http://www.hermosabch.org/index.aspx?page=5.

[55] The estimate of residents to flooding with sea-level rise is based on a proportional calculation (i.e. percentage) of residents per flooded block group after 55 inches of sea-level rise. This assumes equal population density throughout the block groups (the most robust assumption absent any other indication that population is not distributed evenly). The ACS 2008-2012 data were used for population data and the Pacific Institute's 100-year floodplain with 55 inches of sea-level rise was used for the spatial extent of projected flooding.

[56] Dunning, C.M. and Durden, S. (2013). *Social Vulnerability Analysis: A Comparison of Tools*. Institute for Water Resources White Paper. US Army Corps of Engineers (February 2013). Available at: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/Social_Vulnerability_Analysis_Tools.pdf.

[57] Census Bureau (2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/

[58] Census Bureau (2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/.

[59] City of Hermosa Beach (2013). Housing Element Technical Report (September 10, 2013), p.I-8. Available online: http://www.hermosabch.org/modules/showdocument.aspx?documentid=1305

[60] City of Hermosa Beach (2013). Housing Element Technical Report (September 10, 2013), p.I-8. Available online: http://www.hermosabch.org/modules/showdocument.aspx?documentid=1305.

[61] Census Bureau (2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/.

[62] Curtis, A., J.W. Mills, M. Leitner (2007). Katrina and Vulnerability: The Geography of Stress. *Journal of Health Care for the Poor and Underserved* 18: 315-300. Available at: http://cretscmhd.psych.ucla.edu/nola/Volunteer/EmpiricalStudies/Katrina%20and%20vulnerability%20-%20the%20geography%20of%20stress.pdf.

Morrow, B.H. (1999). Identifying and mapping community vulnerability. *Disasters* 23(1):1–18.

[63] Housing Element City of Hermosa Beach (2012), available at: http://www.hermosabch.org/modules/showdocument.aspx?documentid=757, p.II-18.

[64] Census Bureau (2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/.

[65] Census Bureau (2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/

[66] Census Bureau (2012). Selected Housing Characteristics (more information) 2008-2012 American Community Survey 5-Year Estimates, available at: http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.

[67] Census Bureau.(2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/

[68] Census Bureau.(2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/

[69] See: http://www.homelessshelterdirectory.org/cgi-bin/id/city.cgi?city=HermosaBeach&state=CA.

[70] Fortunately, the Runaway Youth Homeless Shelter is located about 5 blocks east of Hermosa Avenue and thus not directly in the 100-year floodplain after 55 inches of sea-level rise. See map at: http://www.homelessshelterdirectory.org/cgi-bin/id/shelter.cgi?shelter=11232.

[71] Housing Element City of Hermosa Beach (2012), available at: http://www.hermosabch.org/modules/showdocument.aspx?documentid=757, p.II-15.

[72] Thomallla, F., T. Downing, E. Spanger-Siegried et al. (2006). Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters* 30(1):39-48. Available online with subscription at: http://onlinelibrary.wiley.com/doi/10.1111/j.1467-9523.2006.00305.x/abstract

Perry , R.W. and A.H. Mushkatel (2008). *Minority Citizens in Disasters*. University of Georgia Press: Athens, Georgia.

[73] Ekstrom, J., and S. Moser. (2013). Sea-level rise impacts and flooding risks in the context of social vulnerability: an assessment for the City of Los Angeles. Prepared for the Mayor's Office, City of Los Angeles.

[74] Census Bureau (2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/

[75] City of Hermosa Beach (2005). Hazard Mitigation Plan, p.118.

[76] Note that the boundaries of Census-designated block groups have changed since the year 2000, so this map's block groups different from those shown in the maps constructed with ACS 2008-2012 data.

[77] Ekstrom, J. and S. Moser (2013). Sea-level rise impacts and flooding risks in the context of social vulnerability: an assessment for the City of Los Angeles. Prepared for the Mayor's Office, City of Los Angeles.

Social Vulnerability Index (SoVI) data were downloaded from the NOAA Coastal Services website, accessed 1/4/2014 (available at: http://www.csc.noaa.gov/digitalcoast/dataregistry/#/sovi). SoVI results for Los Angeles County were filtered out of the statewide dataset and drawn for the county. Thus, standard deviations were calculated and mapped (marked by different colors) based on the data for the County only.

[78] See webra.cas.sc.edu/hvri/docs/SoVIRecipe.pdf for more information on method for conducting the SoVI analysis.

[79] Those variables included in the SoVI method that did not display variation among Census Block Groups of Hermosa Beach were omitted from the analysis. Differently put, those characteristics are homogenous across the city and thus do not reveal any differences in social vulnerability. To combine the variables, we summed the standardized scores to generate a single 'vulnerability' score for each Census Block Group. See Appendix 1 for further discussion.

[80] For description of how this was calculated and the sources of the data, see Appendix 1.

[81] Census Bureau (2012). American Community Survey 2008-2012, released January 2014 at http://www.census.gov/acs/www/data_documentation/summary_file/

[82] According to the *Los Angeles Times*, January 18, 2010, downed power lines from heavy downpours caused 44,000 Southern California Edison customers to lose power. Available at: http://latimesblogs.latimes.com/lanow/2010/01/rains-worsen-this-afternoon-prompting-flooding-fears-power-outages-traffic-troubles.html

[83] City of Hermosa Beach, Hazard Mitigation Plan 2005, p.148.

[84] Bromirski, P. D., D. R. Cayan, N. Graham, M. Tyree, and R. E. Flick (2012). *Coastal Flooding-Potential Projections: 2000–2100*. California Energy Commission. Publication number: CEC-500-2012-011.

[85] Jha, Abhas K., Robin Bloch and Jessica Lamond (2012). *Cities and Flooding: A Guide to Integrated Flood Risk Management for the 21st Century* and *A Summary for Policy Makers*, Washington, DC: The World Bank.

CH2M HILL, Inc. (2009). *Confronting Climate Change: An Early Analysis of Water and Wastewater Adaptation Costs*. A report prepared for the National Association of Clean Water Agencies and the Association of Metropolitan Water Agencies, Washington, DC.

[86] Funds granted by the Clean Water Act State Revolving Fund Program. For more information about the grant program and the Hermosa Beach Strand Infiltration Trench see: http://www.epa.gov/region9/water/lid/ and http://hermosabeach.patch.com/groups/politics-and-elections/p/city-installs-new-filtration-system.

[87] City of Hermosa Beach, Housing Element (2013), p.68.

[88] City of Hermosa Beach, Housing Element (2013), p.68.

[89] Water Replenishment District of Southern California (WRD) (2007). Battling seawater intrusion in the Central & West Coast Basins.WRD Technical Bulletin, Vol. 13. Available at: http://www.wrd.org/engineering/seawater-intrusion-los-angeles.php, accessed 1/1/2014.

[90] According to Edwards and Evans (2002): "This problem is significant because much of the water used by the nearly 10 million residents of Los Angeles County comes from ground-water sources. Although not all coastal aquifers in the region are at risk, the existing resources are vital and must be protected to maintain adequate supplies of potable water." (See: Edwards, B. D., and K. R. Evans. 2002. Saltwater Intrusion in Los Angeles Area Coastal Aquifers – the Marine Connection. U.S. Geological Survey Fact Sheet 030-02. Available at: http://pubs.usgs.gov/fs/2002/fs030-02/. Accessed 6/10/2012.

[91] Most of the city's freshwater supply comes from the San Joaquin River Delta and the snowmelt from the Sierra Nevada (see: http://hermosabeach.patch.com/groups/editors-picks/p/study-climate-change-to-affect-water). Both of these sources of water will become less reliable with other climate change impacts to California (temperature change and changes in precipitation).

For information about source of water to Los Angeles region, see: Water Education Forum. 'Where does my water come from?' (webpage). Available at: http://www.water-ed.org/watersources/community.asp?rid=9&cid=562.

For information about the projected reduction in snowpack, see: Moser, S., Franco, G. Pittiglio, S. Chou, W. and Cayan, D. (2009). The Future Is Now: An Update on Climate Change Science Impacts and Response Options for California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2008-071. Available at:
http://www.energy.ca.gov/2008publications/CEC-500-2008-077/CEC-500-2008-077.PDF

[92] For more information about groundwater intrusion of saltwater, refer to the California State Resources Control Board, available at::http://www.waterboards.ca.gov/gama/docs/coc_salinity.pdf.

[93] Based on the "November 2013 Zoning shapefile" map provided by the City of Hermosa Beach, November 2013, to Raimi and Associates for the purposes of work related to the General Plan Update.

[94] The estimate cost of replacing property was calculated here based on the sum of building structural values and the building contents values, as estimated by the HAZUS database. See below for methodology used for calculating this from the HAZUS database.

[95] FEMA (2014). HAZUS Database and Software. Downloaded data on 1/2/2014 by Juliano Calil; processing and analysis by J. Ekstrom for Hermosa Beach Census Block Groups. Available at: http://www.fema.gov/hazus

The HAZUS database and software was developed by FEMA to estimate potential losses from hazards. "Hazus is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters" (http://www.fema.gov/hazus).

The map in Figure 21 were constructed using the sum of building structural values and the building contents values, as estimated by the HAZUS database. Building Structural Exposure Values were extracted from HAZUS out-of-the-box data, which are stored in the table 'hzExposureOccupT' from the geodatabase 'bndrygbs.mdb'.

Metadata: "This data set provides the building valuation for each HAZUS specific occupancy classifications developed from the 2000 U.S. Census and Dun& Bradstreet. All data was developed at the census block level (for the United States in the fifty states, the District of Columbia, and the territories), and then aggregated at census tract level. ABSG developed this data set from the 2000 version of TIGER/Line files and first quarter of 2002 data from D&B. This dataset was developed by applying RS Means replacement values for typical building floor areas and construction for each specific occupancy."

Building Contents Exposure Values were extracted from HAZUS out-of-the-box data, which are stored in the table 'hzExposureContentOccupT" from the geodatabase 'bndrygbs.mdb'.

Metadata: "This data set provides the content valuation for each HAZUS specific occupancy classifications. All data was developed at the census block level (for the United States in the fifty states, the District of Columbia, and the territories), and then aggregated at census tract level. ABSG developed this data set from the 2000 version of TIGER/Line files and first quarter of 2002 data from D&B. The dataset was generated through the application of proportions of contents to building value over the total building value for each specific occupancy."

[96] Pacific Institute (2009). GIS data downloads from: http://www.pacinst.org/reports/sea_level_rise/data/, downloaded October 2013.

[97] City of Hermosa Beach, Hazard Mitigation Plan (2005), Table 4-3, p.125.

[98] Photo in public domain. Source: http://commons.wikimedia.org/wiki/File:Hermosa_Beach.jpg.

[99] Map from the L.A. County DRAFT General Plan (accessed 2012). Available at: http://planning.lacounty.gov/assets/upl/project/gp_2035_2012-FIG_9-7_la_co_disaster_routes.pdf

[100] Herberger, M. Cooley, H., Herrera, P., Gleick, P. and E. Moore (2009). The Impacts of Sea-Level Rise on the California Coast. A Report Prepared for the California Climate Change Center. CEC-500-2009-024-F. Available at: http://dev.cakex.org/sites/default/files/CA%20Sea%20Level%20Rise%20Report.pdf

[101] Wood, N., Ratliff, J., and Peters, J. (2013). Community exposure to tsunami hazards in California: U.S. Geological Survey Scientific Investigations Report 2012–5222, 49 p. (Available at http://pubs.usgs.gov/sir/2012/5222/.)

[102] The flood modeling was conducted by the Pacific Institute with funding from the California Energy Commission, as part of the California's Second Climate Change Assessment (2009). See: http://www.climatechange.ca.gov/.

[103] Caldwell, M.C., Griggs, G. Ewing, L. Moser, S. C. et al. (2012). Coastal Areas and Resources, in: *Assessment of Climate Change in the Southwest United States: a Technical Report Prepared for the U.S. National Climate Assessment.* A report by the Southwest Climate Alliance [G. Garfin, A. Jardine, R. Merideth, M. Black, and J. Overpeck (eds.)], pp.168-196. Tucson, AZ: Southwest Climate Alliance.

[104] FEMA (2014). HAZUS Database and Software. Downloaded data on 1/2/2014 by Juliano Calil; processed by J. Ekstrom for Hermosa Beach Census Block Groups. Available at: http://www.fema.gov/hazus.

[105]California Coastal Commission (2013).*California Coastal Commission Draft Sea-Level Rise Policy Guidance*. Public Review Draft of October 14, 2013. San Francisco, CA; Coastal Commission. Available at: http://www.coastal.ca.gov/climate/slr/guidance/CCC_Draft_SLR_Guidance_PR_10142013.pdf, pp.5, 23.

[106] City of Hermosa Beach (1981, as amended). Local Coastal Plan (including related Appendices). Available at: http://www.hermosabch.org/index.aspx?page=501.

[107] City of Hermosa Beach (1981, as amended). Local Coastal Plan, Appendix G, p. G-10. Available at: http://www.hermosabch.org/index.aspx?page=501.

[108] California Coastal Commission (2013). Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[109] See the description of the California Coastal Trail, Section 12 at: http://www.californiacoastaltrail.info/hikers/hikers_main.php?DisplayAction=DisplaySection&CountyId=18&SectionId=61.

[110] Section 30107.5 of the California Coastal Act defines environmentally sensitive area as follows:

> *"Environmentally sensitive area" means any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.*

[111] City of Hermosa Beach (1981, as amended). Local Coastal Plan, Appendix G, p. G-11. Available at: http://www.hermosabch.org/index.aspx?page=501.

[112] Heberger, Matthew, Heather Cooley, Pablo Herrera, Peter H. Gleick, and Eli Moore (2009). The Impacts of Sea-Level Rise on the California Coast. California Energy Commission's Public Interest Energy Research (PIER) Program Research Report, CEC-500-2009-024-F. http://dev.cakex.org/sites/default/files/CA%20Sea%20Level%20Rise%20Report.pdf

[113] Wood, N., Ratliff, J., and Peters, J. (2013). Community exposure to tsunami hazards in California: U.S. Geological Survey Scientific Investigations Report 2012–5222, 49 p. (Available at http://pubs.usgs.gov/sir/2012/5222/.)

[114] This statement is based entirely on a general scientific understanding of the physical dynamics of progressive shoreline retreat of soft substrate coasts in the face of a rising sea. A technical engineering study would be required to assess how fast the shoreline in front of Hermosa Beach could retreat from its current position under different sea-level rise scenarios without further sediment additions. Such an analysis was beyond the scope of this assessment.

[115] California Coastal Commission (2013), Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Section 9, p.1. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[116] This does not consider the short-term changes due to tidal, seasonal and interannual variability which raise and lower the sea level more rapidly but only temporarily.

[117] Bierbaum, R., J. B. Smith, A. Lee, M. Blair, L. Carter, F. S. C. III, P. Fleming, S. Ruffo, M. Stults, S. McNeeley, E. Wasley & L. Verduzco (2012). A comprehensive review of climate adaptation in the United States: More than before, but less than needed. *Mitig Adapt Strateg Glob Change,* 18**,** 361-406.

Moser, S. C. & A. Abeles (2012). Public Engagement and Communication on Adaptation: A Brief Analysis of Adaptation Plans. White Paper prepared for ecoAmerica, 38 pp. Santa Cruz, CA: Susanne Moser Research & Consulting.

[118] California Coastal Commission (2013), Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Section 6, pp. 3-4. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[119] California Coastal Commission (2013), Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Section 7, p. 1. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[120] California Coastal Commission (2013), Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Section 8, p. 1. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[121] California Coastal Commission (2013), Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Section 9, p.1. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[122] California Coastal Commission (2013), Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Section 9, p.1. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[123] California Coastal Commission (2013), Local Coastal Program (LCP) Update Guide, Part I: Updating LCP Land Use Plan (LUP) Policies. Section 9, pp.1-2. Available at: http://www.coastal.ca.gov/climate/SLRguidance.html.

[124] Governor's Office of Emergency Services (CalOES, 2013). 2013 State of California Multi-Hazard Mitigation Plan. Mather, CA. Available at: http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp.

[125] For further information, see: http://www.laregionalcollaborative.com/.

[126] Finzi Hart, J., Grifman, P. Moser, S., Abeles, A., Myers, M., Schlosser, S. and Ekstrom, J. (2012). *Rising to the Challenge: Results of the 2011 Coastal California Adaptation Needs Assessment*. USCSG-TR-01-2012. Available at: http://www.usc.edu/org/seagrant/research/climateadaptsurvey/SurveyReport_FINAL_OnlinePDF.pdf

[127] Most of the publications (and other related ones) listed here are available at www.susannemoser.com:

Moser, Susanne C. (2014). Communicating climate change adaptation: The art and science of public engagement when climate change comes home. *Wiley Interdisciplinary Reviews–Climate Change*,

Moser, S. C. (2013). Navigating the political and emotional terrain of adaptation: Community engagement when climate change comes home. In *Successful Adaptation to Climate Change: linking Science and Policy in a Rapidly Changing World,* eds. S. C. Moser & M. T. Boykoff, 289-305. London: Routledge.

Moser, S. C. (2012). Climate Change in Paradise: Engaging the Community in Successfully Preparing for Monterey's Future. Highlights from Focus Groups Held in April and June 2012. Monterey, CA: Stanford, Center for Ocean Solutions.

Moser, S. C. & L. Dilling. (2011). Communicating Climate Change: Closing the Science-Action Gap. In *Oxford Handbook of Climate Change and Society,* eds. R. Norgaard, D. Schlosberg & J. Dryzek. Oxford: Oxford University Press.

Wolf, J. & S. C. Moser (2011) Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change,* 2**,** 547-569.

Moser, S. C. & L. Dilling. (2007). Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change. Cambridge, UK: Cambridge University Press.

Moser, S. C. & L. Dilling (2004) Making climate hot: Communicating the urgency and challenge of global climate change. *Environment,* 46**,** 32-46.

[128] See the experience with just such an engagement process described in: Moser, S. C. & J. A. Ekstrom (2011). Taking ownership of climate change: Participatory adaptation planning in two local case studies from California. *Journal of Environmental Studies and Sciences,* 1**,** 63-74.

[129] HermosaBeachPatch (2010). City Installs New Filtration System. Available at: http://hermosabeach.patch.com/groups/politics-and-elections/p/city-installs-new-filtration-system, accessed 12/27/13.

[130] See Climate Ready Scope of Work to evaluate long-term feasibility of such systems in consideration of increased sea level elevation.

[131] Liverman, Diana and Susanne C. Moser (Convening Lead Authors) et al. (2012). Climate choices for the Southwest, in: *Assessment of Climate Change in the Southwest United States: a Technical Report Prepared for the U.S. National Climate Assessment.* A report by the Southwest Climate Alliance [Gregg Garfin, Angela Jardine, Robert Merideth, Mary Black, and Jonathan Overpeck (eds.)], pp.405-435. Tucson, AZ: Southwest Climate Alliance.

[132] Southern California Council of Governments (SCAG) (2013). South Bay Cities Plug-In Electric Vehicle Deployment Plan. Available at: http://innovation.luskin.ucla.edu/sites/default/files/South%20Bay%20Plan.pdf

[133] Governor's Office of Emergency Services (CalOES, 2013). 2013 State of California Multi-Hazard Mitigation Plan. Mather, CA. Available at: http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp.

[134] Implementing California Flood Legislation into Local Land Use Planning: A Handbook for Local Communities Available at: www.water.ca.gov/LocalFloodRiskPlanning/

[135] Governor's Office of Emergency Services (CalOES, 2013). 2013 State of California Multi-Hazard Mitigation Plan. Mather, CA. Available at: http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp.

The Multi-Hazard Mitigation Plan also offers a long list of adaptation planning resources for use by local communities. This list can be found on pp. 102-105 of the plan.

[136] Open-market flood insurance is almost impossible to obtain and is far more expensive than policies from the National Flood Insurance Program (NFIP) even though that program is currently in the process of being reformed to better reflect the growing flood expenditures incurred across the nation.

[137] Governor's Office of Emergency Services (CalOES, 2013). 2013 State of California Multi-Hazard Mitigation Plan. Mather, CA, SECTION 5.3 - pp. 220-222. Available at: http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp.