

AB 691 Sea-Level Rise Assessment
City of Santa Cruz Tide and Submerged Lands 1969 Grant
Santa Cruz Municipal Wharf

(Revised & Resubmitted July 17, 2018; ADA Compliant Submitted July 8, 2019)



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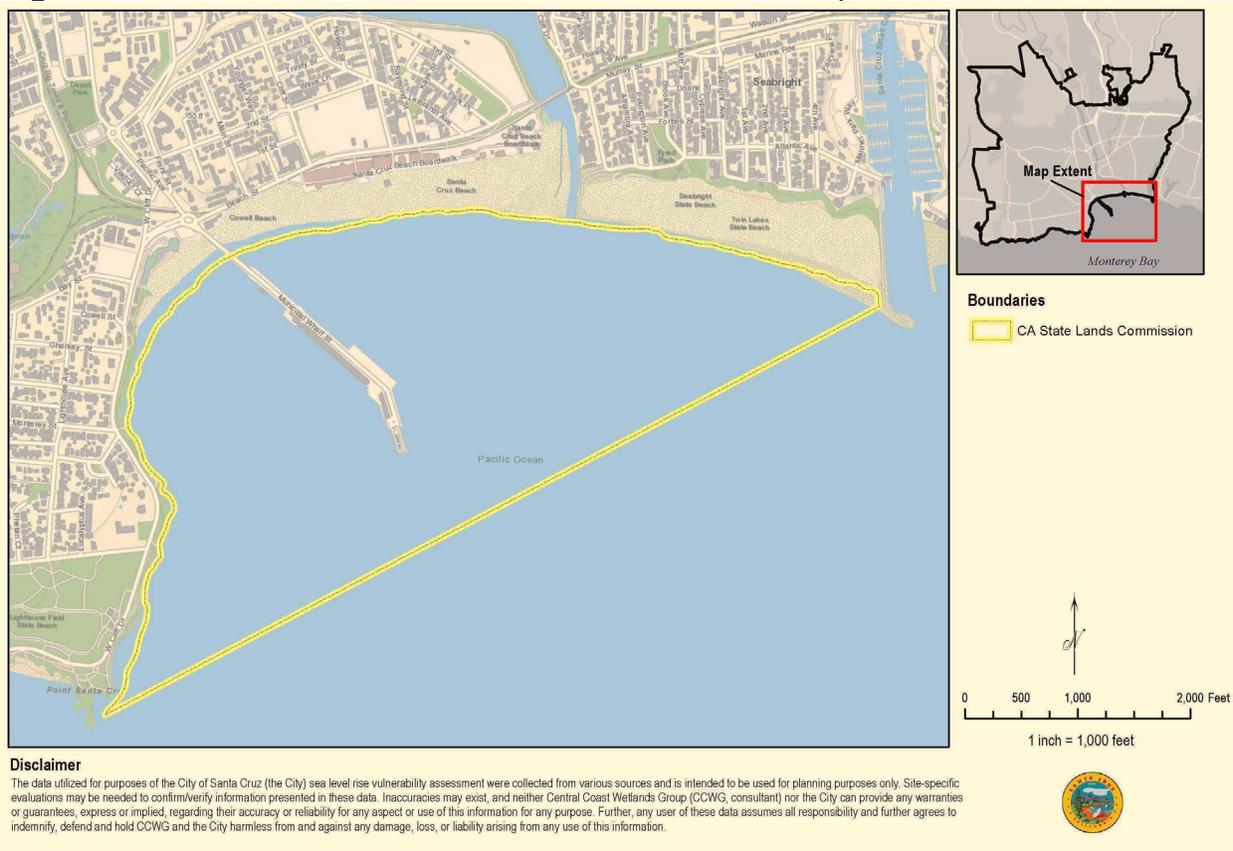
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State Grant Tide and Submerged Lands Description

In 1969 the State of California granted the City of Santa Cruz the Submerged and Tide lands on the landward side of a line connecting Lighthouse Point on the west to the tip of the Santa Cruz Harbor Jetty on the east. The only physical structure in the grant submerged and tide lands area (State Grant Area) is the Santa Cruz Municipal Wharf; there are no other structures or improvements within this area. The total area of the State Grant Area is approximately 411 acres of which 26 acres are beaches (tide lands) and 385 acres are seabed (submerged) areas. Figure 1 depicts the boundaries of this area.

Figure 1: California State Lands Commission Boundary



1. Assessment of Impacts of Sea Level Rise (SLR)

The scientific community has reached a strong consensus that the climate is changing, and new scientific evidence has highlighted the potential for extreme sea-level rise (SLR) as a result of a changing climate. Climate change impacts include threats not only to our infrastructure but to our health, safety and to the economic vitality of our community. Climate scientists agree that there are only three approaches to addressing the impacts of climate change: retreat, resist or ignore. There are different costs associated with each of these paths. Thus, incorporating climate resilience planning into all that we do as a city allows us to address some of these difficult decisions in advance and take advantage of potential opportunities to protect our residents, infrastructure and economic well-being. This document is intended to identify and characterize the impacts of SLR in the State Grant Area, and to provide resources, information, and strategies for adaptation.

Surrounded by a greenbelt of open space areas and the Pacific Ocean, Santa Cruz is a compact, vibrant beach community that preserves the diversity and quality of its natural and built environments, creates a satisfying quality of life for its residents and attracts visitors from around the world. Its unique geography, from exposed Pacific Ocean cliffs to sheltered Monterey Bay beaches and a coastal river running through its downtown and tourist-serving areas, is a part of its appeal, yet these features also increase its vulnerability to the impacts of SLR. Every aspect of the city — its economic prosperity, social and cultural diversity, scenic beauty and historical character — is threatened by potential impacts of SLR.

In 2011, FEMA grant funding was used to contract Dr. Gary Griggs, Director of the Institute of Marine Sciences, and Dr. Brent Haddad, Professor of Environmental Studies and Director of the UCSC Center for Integrated Water Research, to co-author the first Climate Adaptation Vulnerability Study. That study, [*City of Santa Cruz Climate Change Vulnerability Assessment*](#)¹, identified SLR as a significant climate change impact for which the community should prepare. According to the document:

“Sea level rise is probably the process that has generated some of the most obvious and visible effects in Santa Cruz historically and that will continue to produce some of the most significant impacts on the city in the decades ahead. A continuing rise in sea level will produce a range of hazards or impacts including inundation of low-lying areas, erosion of coastal cliffs, and intrusion into the lower San Lorenzo River

¹ Griggs, Gary and Haddad, Brent. [*City of Santa Cruz Climate Change Vulnerability Assessment*](#). 11 January 2011.

accompanied by lateral infiltration of water beneath the downtown area.²”

The 2011 study was referenced and included as an appendix in the City’s first Climate Adaptation Plan, adopted in 2012. In 2017, during the City’s update to the Climate Adaptation Plan (currently in draft format), the Central Coast Wetlands Group (CCWG) was contracted to conduct the City’s first SLR Vulnerability Analysis. CCWG’s three key objectives were intended to further City planning for the likely impacts associated with SLR by:

1. Identifying critical coastal infrastructure (municipal, residential and commercial) vulnerable to SLR and estimating when those risks may occur;
2. Identifying specific hazards (coastal flooding, SLR, erosion) that pose risks to various infrastructure and the value of potential infrastructure and property loss; and
3. Defining appropriate strategies for these risks.

The SLR Vulnerability Analysis is integrated into and included in the [City of Santa Cruz Draft Climate Adaptation Plan Update 2017-2022](#) (CAP Update)³ that is currently being prepared for finalization and adoption in September, 2018. Minimizing the impacts of future SLR is part of the City’s Climate Adaptation Goals as well as the General Plan Goals related to climate adaptation. Although the projected magnitude of total damage has not been quantified for any of the planning horizons (current, 2030, 2060 and 2100), this document does identify and put a value to the current (2018) property and infrastructure exposed to climate hazards. A summary of the overall projected impacts is included below for reference and is not specific to the State Grant Area boundary.

2030 Planning Horizon (or 4 inches of SLR). For the 2030 planning horizon, according to the CAP Update, cumulative risks of coastal climate change on City of Santa Cruz public and private infrastructure are projected to be significant. In sum, the City projects that:

- Most of West Cliff and East Cliff are protected by sea walls and rip rap, mitigating much of predicted erosion hazards.
- New sea walls may need to be constructed for portions of West Cliff and East Cliff where no structures currently exist, if maintaining the same level of service (auto, bike and pedestrian) along the coast is a priority.

² Griggs, Gary and Haddad, Brent. [City of Santa Cruz Climate Change Vulnerability Assessment](#). 11 January 2011.

³ City of Santa Cruz. [Draft Climate Adaptation Plan Update](#). 2017-2022.

- Storm flooding is predicted in the socially vulnerable Beach Flats area due to waves overtopping the coastal infrastructure on Beach Road, but impacts are assumed to be managed by current storm water pumps along the San Lorenzo River levee.
- Acreage and tidal duration of availability of City beaches is projected to decrease.

2060 Planning Horizon (or 28 inches of SLR). For the 2060 Planning Horizon it was assumed that coastal armoring and water control structures will no longer function as designed without upgrades or replacement. Under this assumption, many buildings are projected to be vulnerable to climate hazards and erosion if maintenance and management of existing protective structures is not maintained. More buildings would be vulnerable if existing levees and storm pump infrastructure also failed to function. Furthermore, roadways as well as water, wastewater and storm drain pipes are projected to become vulnerable as well. Finally, several coastal access locations are projected to be at risk.

2100 Planning Horizon (or 68-inches of SLR). While 2100 is a distant time horizon, as noted in [Rising Seas in California, an update on sea-level rise science](#)⁴ it is increasingly important to plan for long range sea level rise (SLR); “consideration of high and even extreme sea levels in decisions with implications past 2050 is needed to safeguard the people and resources of coastal California”(Griggs et al., 2017). For the 2100 Planning Horizon (or 68-inches of sea-level rise), there will be an even greater impact on buildings, roadways, water, wastewater and storm drain pipes, and larger portions of all other land uses. Furthermore, more coastal access locations are projected to be lost, and sensitive habitat will be at greater risk.

The SLR vulnerability assessment confirms that coastal erosion along West Cliff and East Cliff will be a continuing challenge for the City of Santa Cruz. Much of the most vulnerable coastal infrastructure is owned and operated by the City. Establishing sound coastal adaptation and protection policies early will likely best enable the long-term implementation of these policies and ensure long term sustainability for the community. The economic exposure of current residential, commercial and municipal buildings and infrastructure are contained in Section 3a (replacement or repair costs of resources and facilities that could be impacted by SLR) below.

While sea levels are modeled to reach specific levels in the following three time horizons evaluated (2030, 2060 and 2100), these time horizons serve to create an envelope of impacts and will be used as general guidelines for

⁴ Griggs et al. [Rising Seas in California, an update on sea-level rise science](#). California Ocean Science Trust, April 2017.

planning purposes. As SLR rates continue to increase and models become more robust, SLR will be periodically monitored, and observed and projected changes will be incorporated into future updates to the City of Santa Cruz Climate Adaptation Plan.

a. Inventory of vulnerable natural and built “manmade” resources and facilities

The only manmade facility in the State Grant Area is the Santa Cruz Municipal Wharf. The Santa Cruz Wharf was constructed in 1914, and is 2,750 ft. long (its original length). The Wharf structure is of timber construction, with 183 bents (rows) of vertical timber piles, supported by 4,450 piles. There is one coastal access point and 19 businesses currently operating in the Wharf’s various buildings. A complete description of this facility is contained the [Santa Cruz Wharf Engineering Report, 2014](#).⁵

In terms of natural resources, aside from the submerged seabed, there are two natural features that are partially included in the State Grant Area: beaches and bluff/cliff topography. The State Lands Commission boundary follows the mean tide line along the beach and thus the majority of the unsubmerged Seabright, Main and Cowell Beaches are excluded from the State Grant Area. Similarly, the State Lands Commission boundary extends to and follows a portion of West Cliff Drive’s adjacent cliffline, including some seawalls. These features are exposed and vulnerable to the combined impacts of sea level rise, including: rising tide, coastal storm flooding, and erosion. Further information on these resources and facilities is detailed in the following sections of this report.

b. Consider impacts of storms and extreme events

Flooding and extreme storms are predicted to occur more frequently and with greater intensity as a result of climate change and can combine synergistically with SLR, which in turn will exacerbate coastal storm events, cliff erosion and flooding. According to the [City of Santa Cruz Local Hazard Mitigation Plan Five Year Update 2017-2022](#) (LHMP)⁶, flooding along the coast of Santa Cruz may occur with the simultaneous occurrence of large waves and storm swells during the winter. Storm centers from the southwest produce the type of storm pattern most commonly responsible for the majority of serious coastline flooding. The strong winds combined with high tides that create storm surges are also accompanied by heavy rains. When storms occur simultaneously with high tides, and rising sea levels, flood conditions are exacerbated. This combination has the potential for structural

⁵ Moffatt & Nichol. [Santa Cruz Wharf Engineering Report](#). Prepared for the City of Santa Cruz. 8 October 2014.

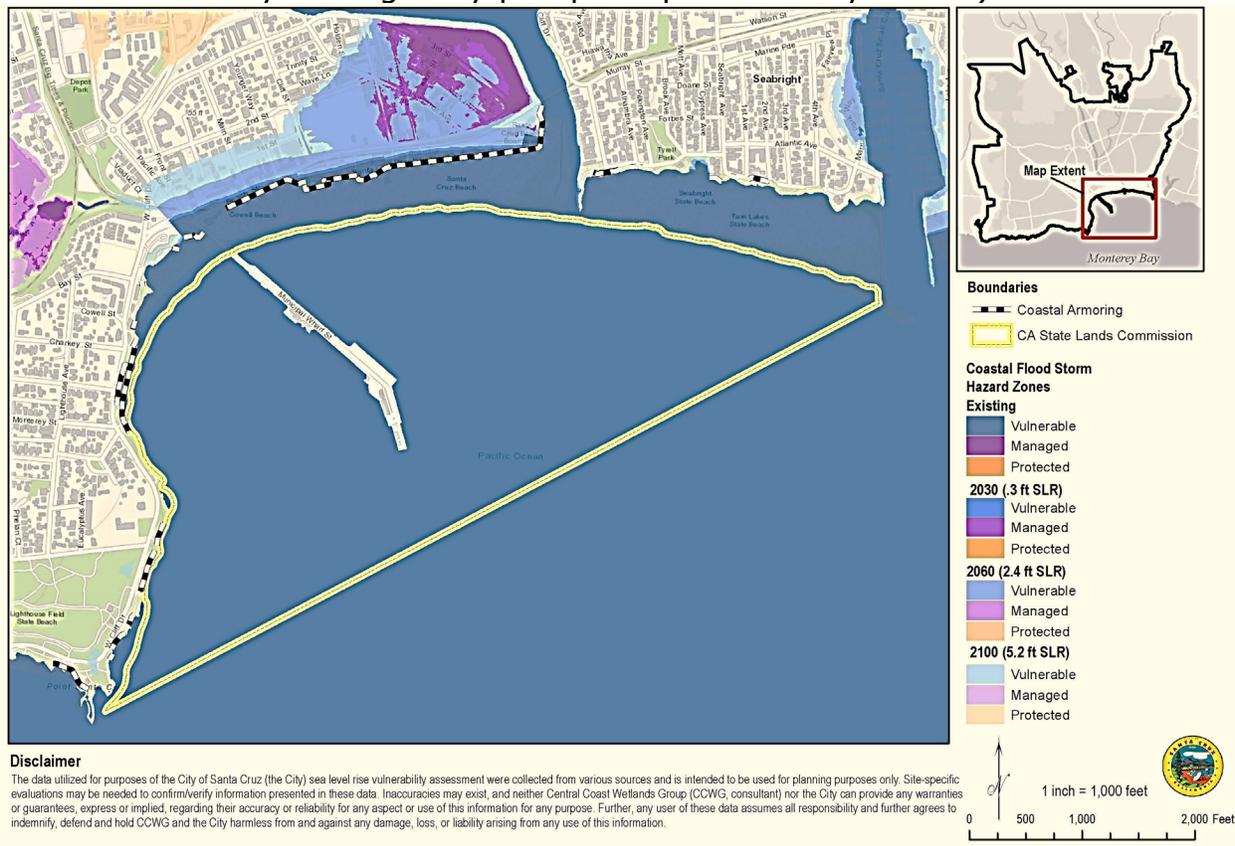
⁶ City of Santa Cruz. [Local Hazard Mitigation Plan Five Year Update 2017-2022](#). 2017.

and financial losses in the State Grant Area, particularly with respect to the Municipal Wharf. Additionally, according to the CAP Update:

“An increase in the intensity and amount of rainfall over short time periods can concentrate runoff and lead to more frequent or larger flood flows. Extreme coastal storms can create storm surge that increases tidal elevations and coastal flooding. Intense storms are also associated with high winds, and lead to soil saturation that exacerbates flooding, erosion, and tree fall.”

Figure 2 depicts the coastal storm flood hazard zones (i.e., 100 year storm) for the 2010 baseline year as well as for the 2030, 2060 and 2100 planning horizons. It is important to note that the impact of river storm flows was not analyzed in the City’s SLR assessment, thus impacts are likely underestimated; however, analyzing, integrating, and mapping climate-influenced hydrology is currently underway.

Figure 2: Coastal Storm Flood Hazard Zones (hazard zones include areas that are currently managed by pumps or protected by levees)



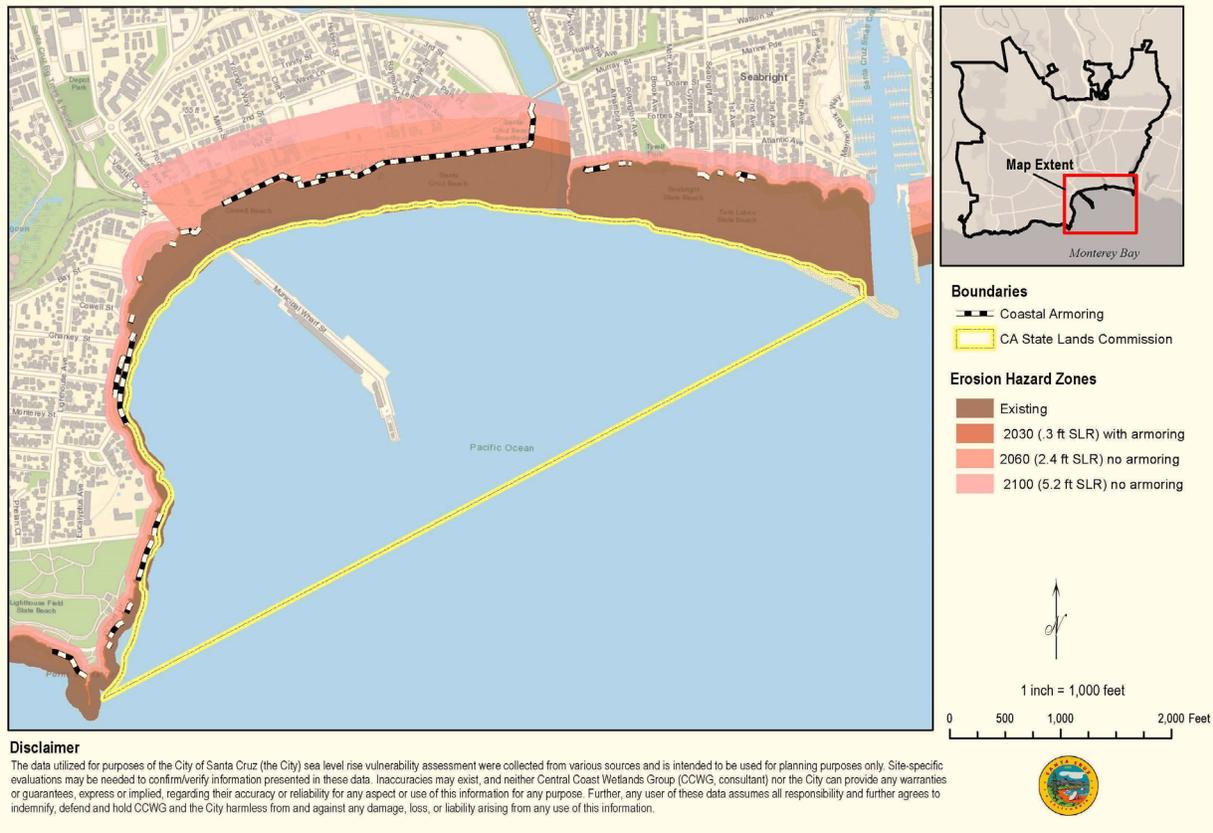
For the baseline year of 2010, along the entire coast (i.e., not exclusive to the State Grant Area), it is estimated that several existing buildings as well as existing roadways, power, sanitary sewer, storm pipes and water mains are vulnerable to the combined hazards of SLR, storms and extreme events.

Additionally, existing wetlands, habitat, coastal trails, access points and beaches are vulnerable to the combined effects of SLR. Projected impacts over the three future time horizons include the following:

2030 Planning Horizon (or 4 inches of SLR). For the 2030 Planning Horizon, storm flooding is predicted in the socially vulnerable Beach Flats area—adjacent to the Grant Area—due to waves overtopping the coastal infrastructure on Beach Street, thereby causing water to flow down Beach Street into low lying areas. This will cause a short term flood condition. However, impacts are assumed to be managed by current storm water pumps along the San Lorenzo River levee (see Figure 2).

2060 Planning Horizon (or 28 inches of SLR). For the 2060 Planning Horizon, the CAP Update assumed that coastal armoring and water control structures will no longer function as designed without upgrades or replacement. Additionally, unprotected portions of West Cliff (located adjacent to the State Grant Area) are projected to be vulnerable to increased coastal erosion due to rising tides and coastal storms, threatening the road and subterranean utilities. Coastal erosion includes both cliff/bluff erosion and beach erosion, and is a result of both winter wave attack as well as a slowly rising sea level. In the past, the impacts of coastal erosion have been significant. Any increase in coastal storm frequency or severity will increase coastal cliff retreat rates. This will in turn endanger coastal properties and infrastructure. The impacts that storms, extreme events, climate change and erosion may have on our cliffs/bluffs and our local beach frontage range from issues at the Santa Cruz Harbor, loss of beach and cliff frontage at the mouth of the San Lorenzo River, as well as the loss of roadway and bicycle paths along West Cliff Drive. Figure 3 depicts the projected erosion hazard zones in the State Grant Area.

Figure 3: Erosion Hazard Zones



Furthermore, for the 2060 planning horizon, all of Cowell/Main Beach is projected to be vulnerable to the combined effects of storms, extreme events and SLR (see Figure 2). Projected vulnerabilities from rising tides (exacerbated by coastal storms) to areas of Lower Ocean, parking lots in Beach Flats, and greenspace of Neary Lagoon are assumed to be managed by current storm water pump infrastructure. As illustrated in Figure 3, houses along West Cliff between Woodrow and Lighthouse Field are vulnerable to coastal erosion, and the first block inland of Beach Street is vulnerable to erosion and storm flooding.

2100 Planning Horizon (or 68-inches of SLR). For the 2100 planning horizon, coastal erosion along West Cliff and East Cliff (as depicted in Figure 3 and not constrained to the State Grant Area) is projected to be an ongoing challenge for the City of Santa Cruz. According to the CAP Update, much of the most vulnerable coastal infrastructure is owned and operated by the City. It is important to note that while the study projects impacts to assets over the 2030, 2060 and 2100 time horizons, the City acknowledges that the current composition and distribution of assets is not necessarily representative of future conditions.

When considering the impacts of storms and extreme events on the Santa Cruz Municipal Wharf, the 2014 Santa Cruz Wharf Engineering Report contains a complete analysis of the potential impacts on the structure. It also includes a section on Monterey Bay tidal action, discussing how more extreme storm events will increase the impact of the normal tidal actions. Specific reference to these events is discussed in sections 10-3 & 4 of the Wharf Engineering Report. Sections 3 and 4 of this assessment contain recommendations from the Wharf Engineering Report to prepare the Wharf for extreme storm events. As for the coastal bluffs adjacent to the State Grant Area, the Engineering Report finds:

“Near the Wharf, just south of the Cowell’s Beach, the West Cliff Drive consists primarily of sea cliffs that front a flat marine terrace. Because most of this portion has been armored with riprap (visible from Google Earth®), it is not considered to be threatened immediately. However, a continuous rising sea level with severe storms might potentially cause cliff erosion and consequently retreat, especially where the riprap is not functionally intact during the events.”

c. Consider changing shorelines

Shoreline changes as a result of SLR will significantly impact the beaches at the foot of the Santa Cruz Municipal Wharf where it meets Cowell and Main Beaches, which are flat and wide, and where the portion below mean sea level is within the State Grants Area. The beaches are essentially continuous from Cowell/Main Beach to the Harbor jetty and are highly vulnerable to rising tide in addition to coastal storms and erosion (as noted in the previous section). The beaches are also backed in many locations by seawalls, preventing the migration of beaches with shorelines.

Shorelines are expected to recede due coastal erosion, and will be further impacted by SLR, which may effect assets in the State Grant Area. All of Main Beach is projected to be vulnerable to the combined effects of SLR, with over half of Main Beach projected to be reduced by rising tides alone by 2060. Figure 4 depicts rising tide hazard zones (previously called tidal inundation zones), and Figure 5 depicts projected shorelines for the 2010 baseline year as well as for the 2030, 2060 and 2100 planning horizons.

Figure 4: Rising Tides Hazard Zones

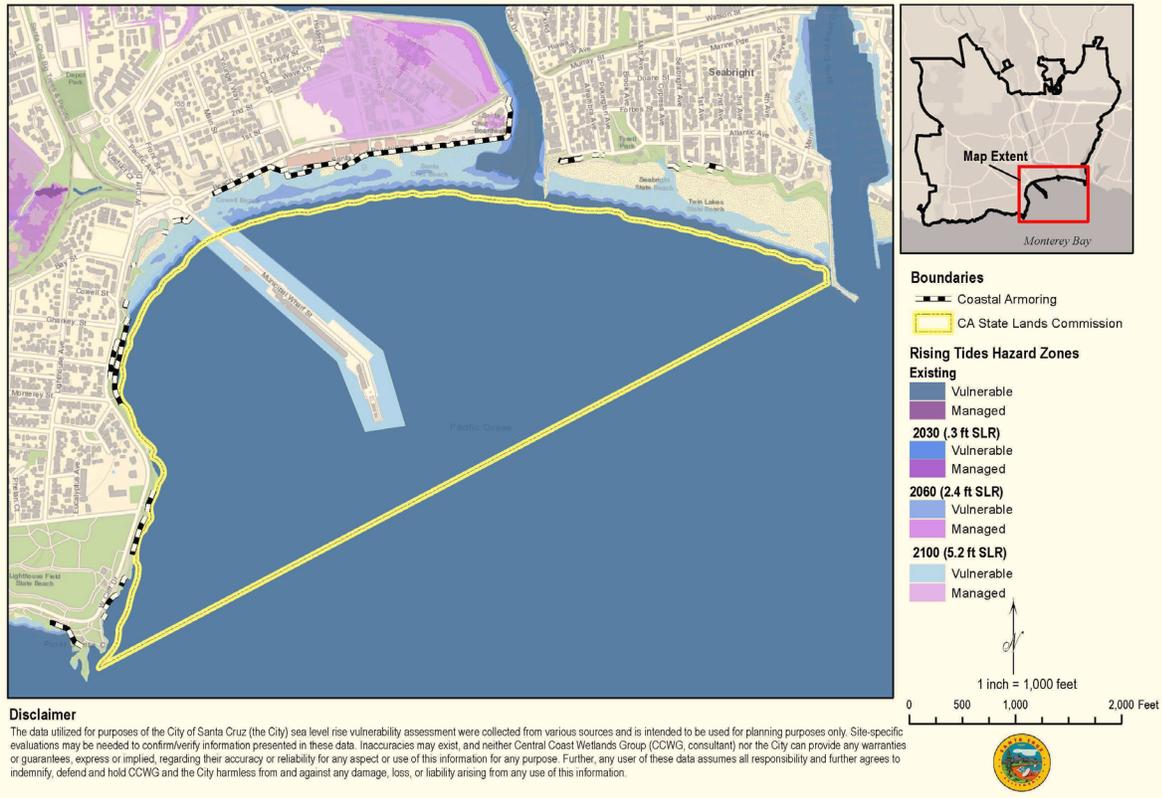
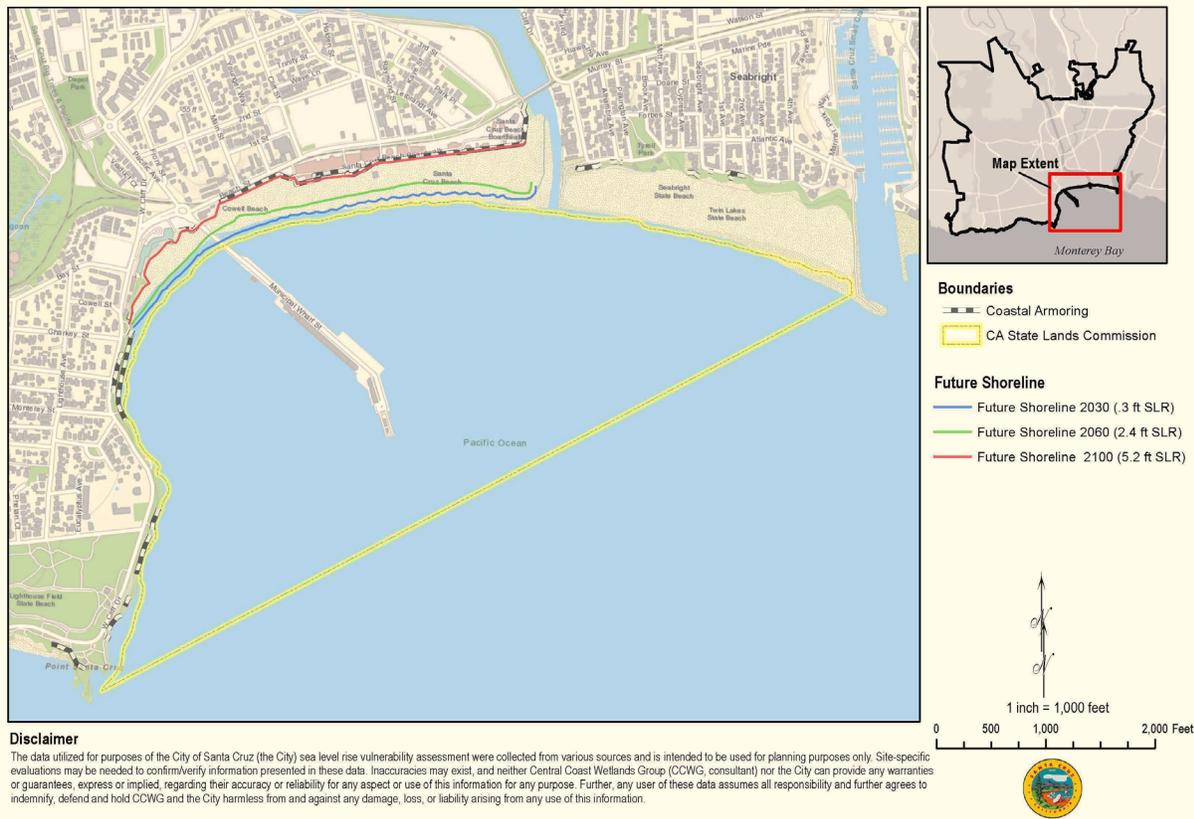


Figure 5: Projected Future Shorelines



d. Consider trends in relative local sea level

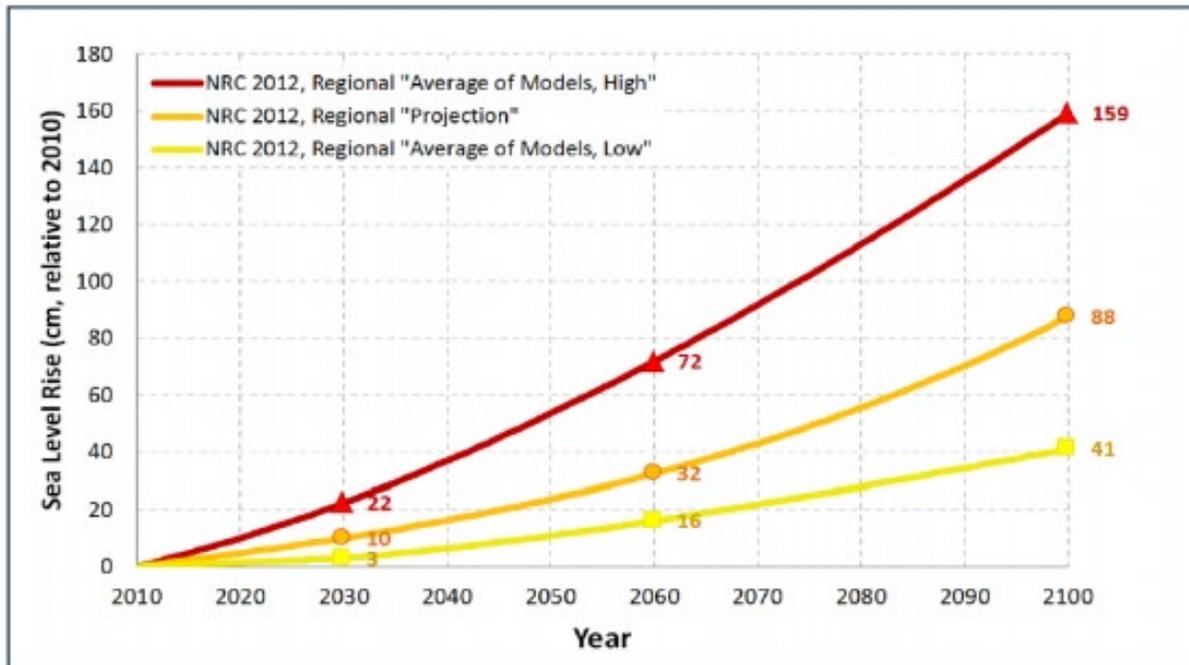
According to the CAP Update, SLR projections are typically presented in ranges due to several sources of uncertainty such as the magnitude of future emissions and loss of sea ice among other sources. The [California Coastal Commission Guidance Document](#)⁷ recommends evaluation of SLR impacts using a “scenario-based analysis.” This method seeks to understand how SLR and other drivers interact to threaten health, safety, and resources of coastal communities. Briefly, “the best available science (the 2012 NRC report) is used to identify a range of sea level rise scenarios including high, low, and intermediate projections.” Regional factors such as El Niño and extreme storm events that affect ocean levels, precipitation, and storm surge are then added to the model (see Figure 6). For clarity, the SLR analysis focuses the hazard analysis on a subset of those scenarios, recommended by local and state experts (see Table 1). Resulting sea levels are overlaid on geographic data including coastal elevation, infrastructure, and population information to produce hazard zones⁸.

The coastal climate vulnerability maps used for the CAP Update identify hazard zones for each climate scenario for the three planning horizons (2030, 2060, and 2100) under three different regional emissions scenarios (High, Medium and Low).

⁷ California Coastal Commission. [California Coastal Commission Sea Level Rise Policy Guidance: Interpretative Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits](#). 12 August 2015.
2015.

⁸ SLR hazard zones were originally prepared by ESA through funding by the California Coastal Conservancy.

Figure 6: Sea Level Rise Scenarios For Each Time Horizon (Figure Source: CAP Update)



The Coastal Commission recommends all communities evaluate the impacts of the highest water level conditions that are projected to occur in the planning area. Local governments may also consider including higher scenarios (such as a 6.6 ft. [2m] scenario) where severe impacts to Coastal Act resources and development could occur from SLR. In addition to evaluating the worst-case scenario, planners need to understand the minimum amount of SLR that may cause impacts for their community, and how these impacts may change over time.

The City's SLR hazard evaluation is intended to provide a predictive chronology of future risks to benefit local coastal planning and foster discussions with state regulatory and funding agencies. Estimates of the extent of assets at risk of various climate hazards were made using best available regional data. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and build an understanding of the overall risk posed by potential future SLR.

Table 1: Sea Level Rise Scenarios Selected for Analysis

Time Horizon	SLR Scenario	Notes
2030	med (10 cm or 4 in)	Erosion projection: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm)
2060	high (72 cm or 28 in)	Erosion projection: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm) Future erosion scenario: Increased storminess (doubling of El Niño storm impacts in a decade)
2100	high (159 cm or 63 in)	Erosion projection: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm) Future erosion scenario: Increased storminess (doubling of El Niño storm impacts in a decade)

The OPC’s [State of California Sea-Level Rise Guidance Document](#) (Guidance Document)⁹, initially released in 2010 and first updated in 2013, also provides guidance to state agencies for incorporating SLR projections into planning, permitting, investment, and other decisions. The 2013 Guidance Document was referenced in the City’s Sea Level Rise Vulnerability Assessment. The [2018 Update](#)¹⁰ to the Guidance Document was released after the completion of the City’s Sea Level Rise Vulnerability Assessment and thus was not integrated into the CAP Update. The 2018 Update reflects advances in SLR science and addresses the needs of state agencies *and* local governments as they incorporate SLR into their planning, permitting, and investment decisions. One of the major changes made to the 2018 Update is providing probabilistic SLR projections versus the scenario-based SLR projections of the 2013 OPC Guidance Document. According to the 2018 Update:

“the 2013 OPC Guidance was based on scenario-based sea-level rise projections from the 2012 National Research Council report, which produced a set of three scenarios (low, central, and high), with greater weight given to the central scenario; these scenario-based projections were partially but not fully tied to specific emissions scenarios presented in the Intergovernmental Panel on Climate Change’s Fourth

⁹ State of California Ocean Protection Council. [State of California Sea-Level Rise Guidance Document](#). March 2013 Update.

¹⁰ State of California Ocean Protection Council. [State of California Sea-Level Rise Guidance Document](#). 2018 Update.

Assessment Report and do not include a likelihood of occurrence. Subsequently, in 2013, the IPCC Fifth Assessment Report adopted a probabilistic approach and produced estimates of the likely range of global sea-level rise under different emission scenarios, where 'likely' covers the central 66% of the probability distribution (i.e., the sea levels that fall within the range created by the value that is 17% likely to occur and the value that is 83% likely to occur). The IPCC Fifth Assessment Report did not estimate sea-level rise outside these central 66% probability ranges or produce local projections for California. This updated Guidance [2018 Update] thus incorporates probabilistic sea-level rise projections, which associate a likelihood of occurrence (or probability) with sea-level rise heights and rates, and are directly tied to a range of emissions scenarios... [However] the probabilistic projections may underestimate the likelihood of extreme sea-level rise (resulting from loss of the West Antarctic ice sheet), particularly under high emissions scenarios. Therefore, the 2018 update to the Guidance also includes an extreme scenario called the H++ scenario¹¹. The probability of this scenario is currently unknown, but its consideration is important, particularly for highstakes, long-term decisions."

Table 2 compares SLR projections (used for the CAP Update and this assessment) from the original OPC Guidance Document (as noted above), and the 2018 Guidance Document Update. Moreover, Table 2 distinguishes the differences between the scenario-based SLR projections of the California Coastal Commission guidance document and the probabilistic SLR projections of the 2018 Guidance Document Update.

¹¹ The H++ extreme high SLR projections recommended for scenario analysis by the California 4th Climate Assessment were not evaluated in the coastal climate change analysis as CCWG's modeling and data sets utilized predate the H++ scenario development. The extreme H++ scenario has an unknown probability but could lead to SLR exceeding 10 feet in California by the end of the century

Table 2: Comparison of OPC 2013 Guidance Document and 2018 Update’s Projected SLR projections (in inches)¹²

Time Horizon	OPC 2013	2018 Update Probabilistic SLR Projections			
	SLR Scenario-based projections	Emissions Scenario	Likely Range* (66% probability SLR is between...)	1-In-200 Chance** (0.5% Probability SLR meets or exceeds...)	H++ Scenario***
2030	Med (4 in)	high	3.6 – 6in	9.6in	12in
2060	High (28 in)	low	6 – 14.4in	27.6in	45.6in
2060	High (28 in)	high	8.4 – 16.8in	31.2in	45.6in
2100	High (63 in)	low	10.8 – 27.6in	66in	121.2in
2100	High (63 in)	high	18 – 39.6in	82.8in	121.2in

Notes:*Low risk aversion projection**Medium-high risk aversion projection***Extreme risk aversion projection

e. Consider impacts to the public trust resources and values, including but not limited to public access, commerce, recreation, coastal habitats and navigability

The two main public trust resources to be impacted by SLR in the State Grant Area are the beaches (Seabright, Cowells and Main Beaches) and the Santa Cruz Municipal Wharf. With regard to the Santa Cruz Municipal Wharf, the Wharf Engineering Report states the following:

¹² According to the 2018 Update of the OPC SLR Guidance Document, probabilistic projections for SLR are shown in Table 2, along with the H++ scenario (depicted in the far right column), as first presented in the Rising Seas Report (Griggs *et al.* 2017). The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents Representative Concentration Pathways (RCPs) of 8.5; low emissions represents RCP 2.6.

“Because of its location and deck elevation (+23 ft., MLLW) Santa Cruz Wharf should continue to function well into the future, as it has for the past 100 years with continued maintenance and strengthening. With a sea level rise of 3.5 ft.”

The Wharf Engineering Report also includes recommendations for strengthening the Wharf to withstand the impacts of projected increased storm action. These recommendations are discussed in Section 3 of this assessment.

The impacts on Cowell and Main Beach will be most noticeable when the SLR reaches one foot; the following excerpt from the Wharf Engineering Report discusses this impact:

“...a foot of sea level rise would cover much of the Main Beach and consequently lead to beach erosion.”

Additionally, while not in the State Grant Area, SLR over this century will directly impact the Santa Cruz Beach Boardwalk which is adjacent to the State Grant Area. These impacts will not be included in this assessment since they are on private property, but are noted for information purposes. The City participates in ongoing discussions with the Boardwalk on sea level rise resilience.

Public Access. The projected rise in sea level will have a major impact on public access and recreation since at least a million visitors use these beaches annually, most in the summer months and to a lesser extent in the winter months. Several options are being discussed to mitigate this impact on an interim basis. A rise of two feet in sea level will start to have impacts on the sea wall to the rear of these two beaches. Figure 7 depicts the impact of SLR on access points at Cowell/Main and Seabright beaches. Four access points within or adjacent to the State Grant Area are exposed and vulnerable to sea level rise.

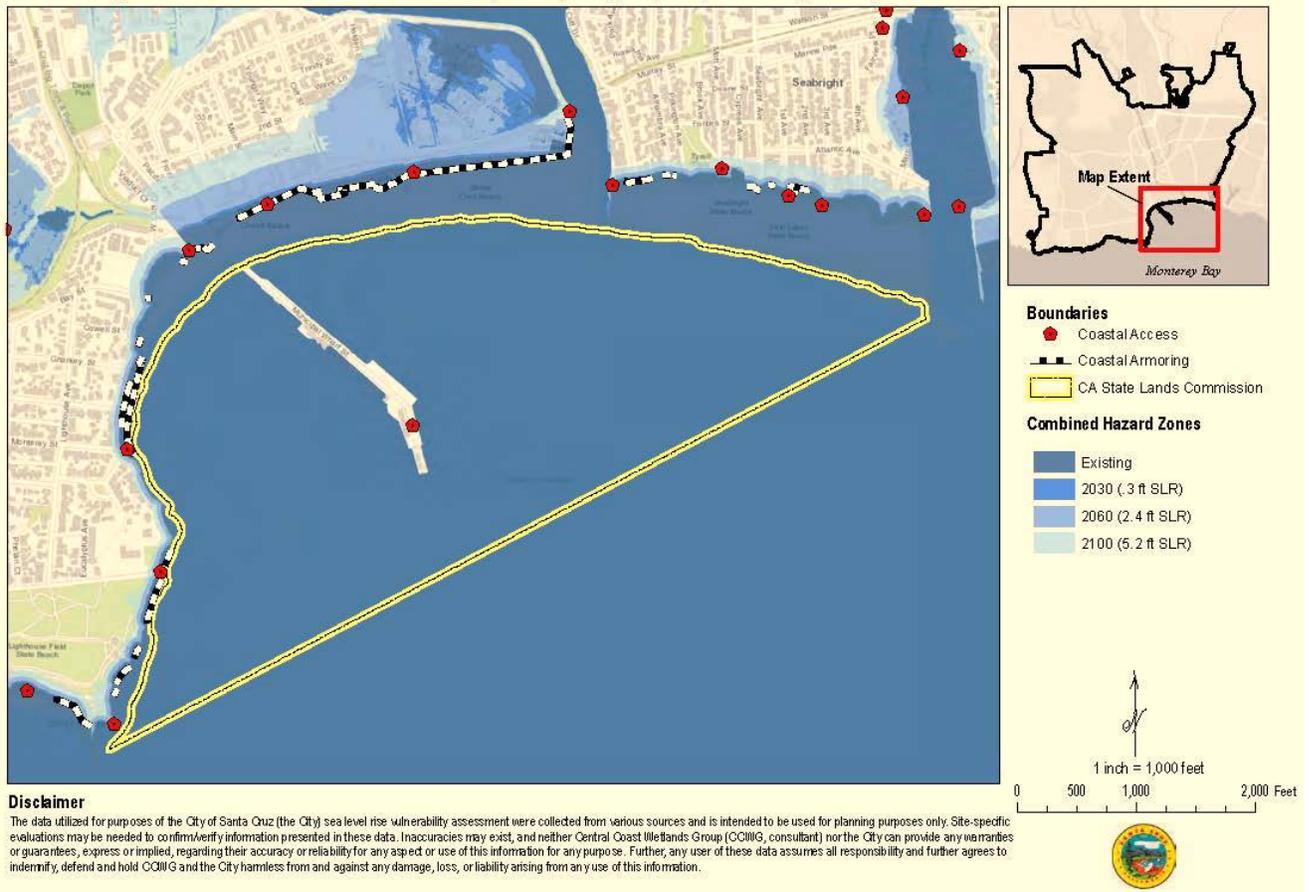


Figure 7: Coastal Access Points and Combined Coastal Climate Change Hazard Zones (hazard zones include areas that are currently managed by pumps or protected by levees)

Commerce. Climate change impacts from SLR will have a major impact on tourism in particular. Specifically, near shore lodging and transient occupancy taxes, as well as economic revenue from recreational and retail activities will be reduced. Although commerce was not assessed in the CAP Update, it is a high priority (called out as a strategy) to complete a more robust cost/benefit analysis evaluating business as usual development with various adaptation strategy pathways. The economic value of the loss of future tourism at the Wharf and Beaches is assessed in Section 3.

Recreation. Beaches within the State Grant Area are used for a variety of recreational activities such as beach volleyball, sunbathing, picnicking, running/walking, swimming and surfing. Surfing is embedded in Santa Cruz culture, and two prominent surf spots—Steamer Lane and Cowells Beach—are located within the State Grant Area as depicted on Figure 8. Steamer Lane is one of Santa Cruz’s most famous surf breaks, and hosts several surf contests throughout the year which attract surfers and tourists from all over

the world. According the article *Using local knowledge to project sea level rise impacts on wave resources in California*¹³ by Dr. Dan Reineman:

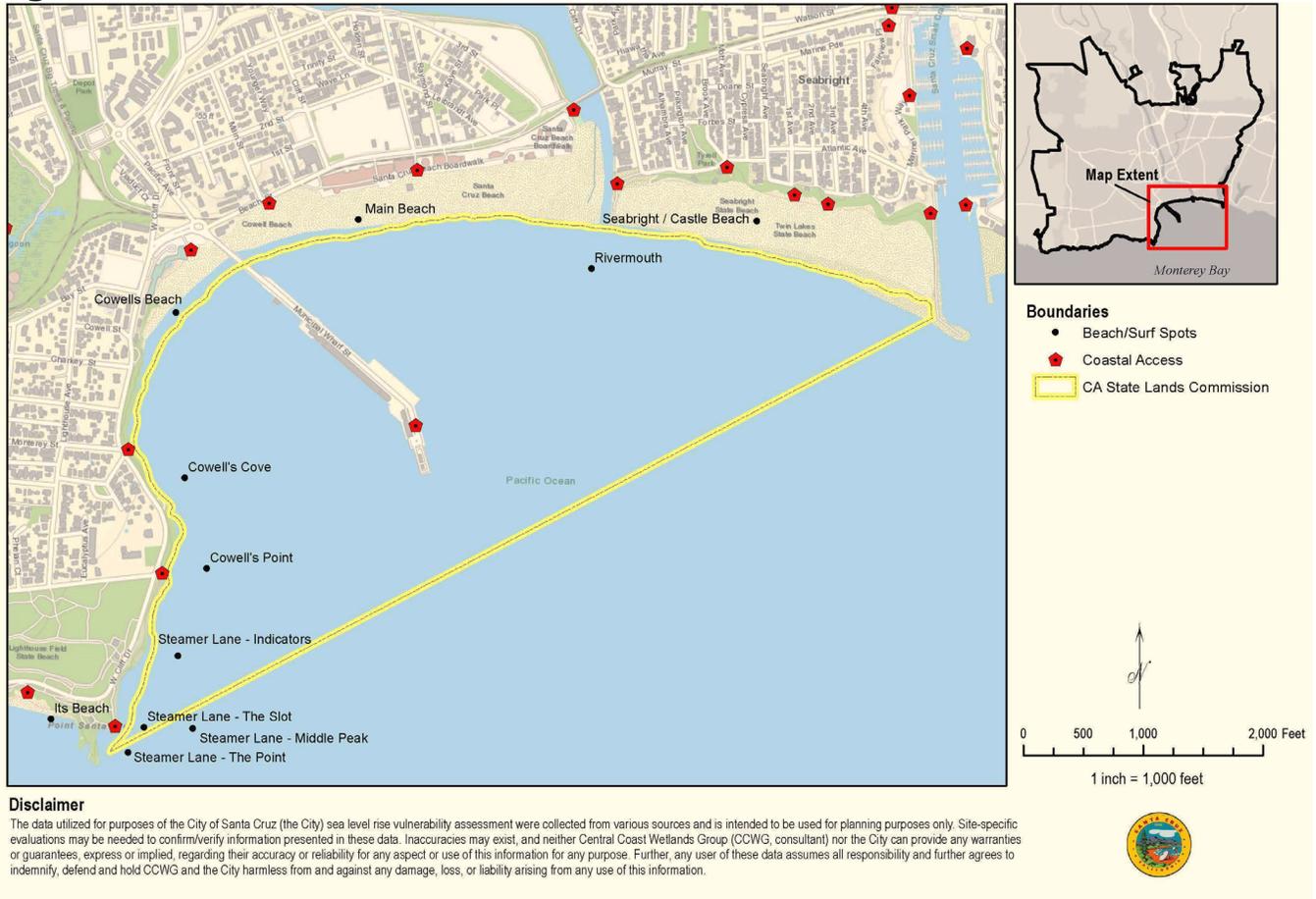
“Sea level rise will have significant impacts on many coastal resources. Waves are an important resource in California, where they support the recreation of 1.1 million surfers who inject millions of dollars into local economies. The impacts of sea level rise on wave resource quality, however, are unknown... Breaking waves are a key element of California's intertidal ecosystems, are central to the viewshed and experiences of many tens of millions of people who live on and visit the California coastline each year, and enable surfing—one of the most iconic, as well as culturally and recreationally significant, activities in coastal California... more than one-third [of California surf spots] are vulnerable to impacts from sea level rise... [however] surf-spot vulnerability is clearly not distributed evenly along the coast. San Francisco, Santa Cruz, Ventura, and San Diego counties in particular each have very high proportions of vulnerable surf-spots.”

Furthmore, according to another report by the same author titled *Projected Sea Level Rise Impacts for Santa Cruz, CA*¹⁴, Steamer Lane and Cowells will be drowned at 0.4 and 0.66 meters of SLR, respectively, which are projected to occur between the 2030 and 2060 time horizons. These two breaks currently experience their best conditions at the lower end of the present day tide range. SLR will increase the water depth over these breaks such that as the lower levels of present day tide range are sequentially drowned; the best conditions will only occur during future lower and lower tides. This will continue until such time as the tide is never low enough (*i.e.*, the water is no longer ever shallow enough) during any part of the tide range and the surf break effectively “drowns.” To reach this conclusion, the report assembled and analyzed data from interviews and secondary sources, then presented results on projected impacts of SLR on wave resources in the City of Santa Cruz.

¹³ Reineman, Dan et al. *Using local knowledge to project sea level rise impacts on wave resources in California*. Ocean & Coastal Management Journal. January 2017.

¹⁴ Report Prepared by Dr. Dan Reineman, Environmental Science & Resource Management, California State University Channel Islands..

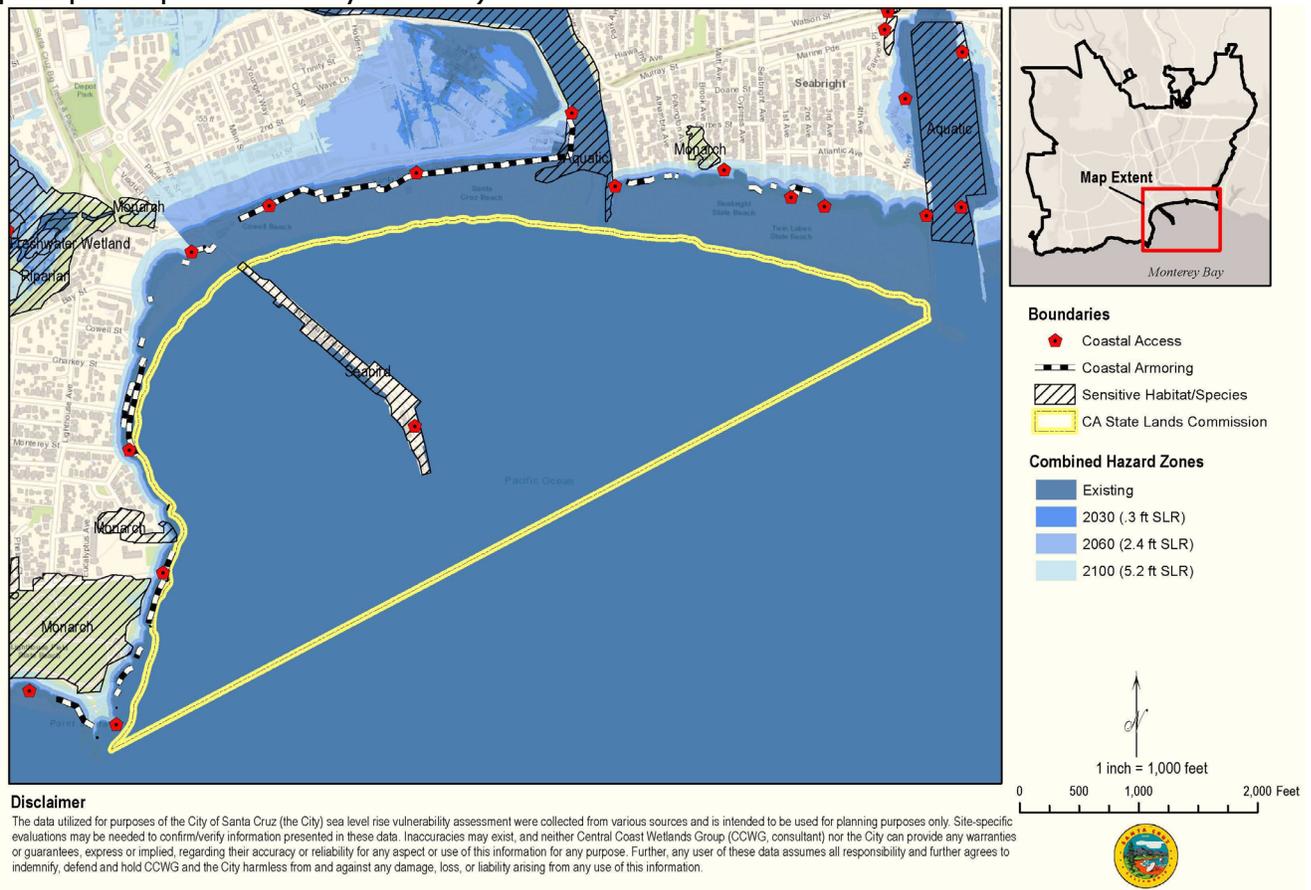
Figure 8: Coastal Access/Beach and Surf Breaks



It is possible that the location of Cowells Beach surf break will migrate shoreward at a rate commensurate with rising sea levels since it overlies a sandy bottom; however, this likelihood decreases as rates of SLR increase. It further decreases as human interventions detrimentally impact natural coastal processes (e.g., shoreline stabilization prevents upland migration of beach environment and reduces sediment replenishment in the nearshore). In the case of Steamer Lane—which overlies hard rock reef—the potential for break migration is very low. As such, Steamer Lane faces a high risk of extinction due to SLR.

Coastal Habitat. Habitat that exist within or near the State Grant Area includes shorebird habitat at the Wharf, aquatic habitat within the State Grant Area, as well as monarch butterflies, nesting birds, and seals who find habitat on the coastal bluffs adjacent to the State Grant Area.

Figure 9: Sensitive Habitat/Species and Combined Coastal Climate Change Hazard Zones (hazard zones include areas that are currently managed by pumps or protected by levees)



According to the CAP Update, flooding and erosion from SLR could cause coastal habitats to be converted from one type of habitat to another, and generally reduces the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. As depicted in Figure 9, sensitive habitat/species (mainly avian species) are located on the Wharf and within the State Grant Area. Between 2011 and 2014 a study was conducted to document the abundance and behaviors of birds located near the Wharf relative to a wind turbine¹⁵. According to the report, *Monitoring the Impacts of a Vertical Axis Wind Turbine on Avifauna at the Santa Cruz Wharf: Final Report*¹⁶, the most

¹⁵ Notably, this wind turbine is the only offshore wind turbine permitted by the Coastal Commission off the coast of California. A three year monitoring study and resulting report were a condition of the Coastal Commission development permit. The findings of the report supported the Coastal Commission’s discontinuation of the monitoring condition going forward.

¹⁶ Wise-West, Tiffany and Rinkert, Alex. *Monitoring the Impacts of a Vertical Axis Wind Turbine on Avifauna at the Santa Cruz Wharf: Final Report*. UC ...

parsimonious set of primary factors that theoretically could impact bird ecology in the Wharf's unique marine setting include: *season, water depth, and weather*. When considering water depth, as it relates to this assessment, the study found that "the presence of bird species at the Wharf could be explained by their prey distribution which may vary with water depth. With increased water depth, we expect increased availability of food sources... It is expected that as water depth increases so does food availability" (Wise-West et al., 2014). According to the study:

"From February 2012 to February 2014, a total of 61 bird species were detected on 60 on-site avian surveys. Only 24 of those species were detected with any regularity ($\geq 5\%$ of the time) at any plot in their appropriate season of occupancy at the Wharf... This demonstrates the small composition of species that are regularly present at this site, and how diversity at the Wharf is significantly influenced by passage migrants and other local transient species."

Furthermore, the study found "over the course of the on-site surveys, four species were confirmed to be breeding on the Wharf. Because of these species' regular presence and interaction with the Wharf during an important stage in their life cycle, they are assessed to be species potentially at risk from anthropogenic effects of Wharf operations." These four species include the following: Pelagic Cormorant (*Phalacrocorax pelagicus*), Western Gull, Pigeon Guillemot (*Cepphus columba*), and Rock Pigeon (a non-native, introduced species that is present year-round in high abundance).

Cormorants were observed roosting underneath the Wharf, Pigeons were perching underneath the Wharf near nest sites, and Rock Pigeons preferred to nest underneath the Wharf. With the advent of SLR, it is likely that this area of the Wharf will be impacted, potentially displacing the birds that roost, perch, and nest under the Wharf. However, no California state or federally listed endangered or threatened bird species were detected during on-site surveys. Although three species listed as California Bird Species of Special Concern were detected once each: Brant (*Branta bernicla*), Black Swift (*Cypseloides niger*), and Vaux's Swift (*Chaetura vauxi*).

A complete review of these impacts is beyond the scope of the CAP Update as well as this assessment and will be addressed in the upcoming West Cliff Drive Shoreline Adaptation and Management Plan development. However, sensitive habitat is projected to be minimally impacted within or adjacent to the State Grant Area. Since the bluffs are in some places 35 feet in elevation above the sea level, it is assumed the birds and seals will adapt and find new habitat at a slightly higher elevation along these coastal bluffs. Moreover, as

... Santa Cruz. The Center for Sustainable Energy and Power Systems (CENSEPS). July 2014.

discussed in subsequent sections of this assessment, green or natural infrastructure solutions are being considered that have the benefit of providing protection from SLR and increasing habitat space and connectivity.

Navigability. Minimal impact to coastal navigability is anticipated within the State Grant Area since there are no docking or harbor facilities in the area boundary (with limited docking activity for small craft at the Wharf) and thus boating activities are limited to occasional recreational boats (e.g., stand up paddle boards, kayaks, non commercial fishing). With respect to the Wharf, as sea level rises toward the Wharf deck, boats operating in the area may have diminished capability to fully ascertain the location of the Wharf. However, SLR does not negatively impact the Wharf since the deck of the Wharf is well above the projected 100 year SLR. Navigability was not assessed in the CAP Update.

f. Prioritize vulnerabilities to be addressed

A number of adaptation strategies contained in the CAP Update were prioritized for consideration. Each strategy was evaluated across the FEMA STAPLEE evaluation criteria and ranked by internal and external stakeholder teams and City leadership. The strategies listed in Table 3 pertains to the two primary assets in the State Grant Area—the Wharf and Beaches—that are exposed and vulnerable to SLR as well as assets directly adjacent to the State Grant Area. Until the City develops and implements a monitoring, triggers and threshold program, these priority strategies are addressed as funding and resources allow. All strategies are aimed at bolstering preparedness and resiliency of municipal, private, and public stakeholders.

Table 3: Adaptation Strategies for the Wharf and Cowell/Main/Seabright Beach

Title	Timeline	Est. Cost	Status	Priority
A-1: Increase public awareness, education, and public outreach in areas with social vulnerabilities that coincide with hazard zones	2017-2030	Unknown	Ongoing but targeted outreach campaign planned for FY18; State technical assistance requested in FY18	Very High
A-2: Evaluate related decisions through a climate change impact lens	Ongoing	Unknown	CIP adaptation list, staff report, annual progress review proposed	Very High

Title	Timeline	Est. Cost	Status	Priority
			for approval in FY17	
A-3: Prepare for potential SLR throughout the City	Ongoing	Unknown	Unknown	Very High
A-4: Identify priority areas for managed retreat to retain public access and sufficient beach area for recreational use; plan to relocate roadways	2030-2060, 2060-2100	Unknown	Local Coastal Plan update in progress; Cost benefit analysis of business as usual vs. adaptation strategies pending funding	Very High
A-5: Adopt policies to evaluate limiting municipal capital improvements that would be at risk	2017-2030; Ongoing	Unknown	CIP adaptation list, staff report adaptation statement template proposed for approval in FY17	Very High
A-6: Prioritize coastal protection structures for upgrade and replacement	2017-2060; Ongoing	Unknown	West Cliff Management Plan begins in April 2019; Cost benefit analysis of business as usual vs. adaptation strategies pending funding	Very High
A-11: Monitor all pumping station sites	2010-2020	Up to \$50k/year	Pending	Very High
A-14: Protect downtown, beach area, and surrounding neighborhoods from San Lorenzo River flooding	Ongoing project	Unknown	Ongoing	Very High
A-15: Protect adjacent neighborhoods and commercial areas from	Ongoing	Unknown	Habitat restoration plan in progress with	Very High

Title	Timeline	Est. Cost	Status	Priority
Branciforte Creek and other stream flooding			PW, consultant and agencies.	
A-19: Protect coastline related water infrastructure	Ongoing	Unknown	Unknown	Very High
A-20: Improve resiliency to flooding along the Coast	2030–2060; ongoing	Unknown	Ongoing	Very High
A-21: Reduce impacts of creek and/or river flooding to water system infrastructure	Ongoing	Unknown	Unknown; fluvial analysis of San Lorenzo river flooding pending funding	Very High
A-25: Protect visitor serving venues and natural resources	Ongoing with annual status reviews	Unknown	Unknown	Very High

Title	Timeline	Est. Cost	Status	Priority
B-2: Investigate beach nourishment	2017–2060; ongoing	Unknown	Beach nourishment from San Lorenzo River designed and pending suitable funding.	High
B-5: Promote and preserve economic base and tourism industry in the face of a changing climate	Ongoing	Unknown	Outreach to Downtown Association via the Downtown Commission	High
B-6: Require setbacks adjacent to cliffs	2017–2030	Unknown	Planning Department is working with the Coastal Commission on the Local Coastal Plan Update, which will provide guidance on how to implement this strategy.	High
B-7: Protect natural shoreline	2017–2030	Unknown	Will be a consideration of West Cliff Management Plan pending identification of suitable funding	High
B-8: Mitigate development in flood plains	2017–2030	Unknown	City maintains flood plan and floodway regulations in developed flood areas. There are few undeveloped flood areas to develop.	High

Title	Timeline	Est. Cost	Status	Priority
B-9: Disseminate flood hazard information and encourage participation in Federal Flood Insurance Program	2017–2030	Unknown	Unknown	High
C-6: Protect and preserve tree canopy and other native coastal vegetation	Ongoing with status reviews	Unknown	FY17 CAL FIRE grant provides for development of a GIS-based urban tree inventory and planting of 500 trees in addition to the 300 trees planted annually in the City.	Important

Santa Cruz Municipal Wharf. The Wharf Engineering Report recommends methods for increasing the resiliency of the wharf structure to reduce potential damage and to enhance public safety in extreme weather conditions related to climate change and rising sea levels. Specifically, to quote the Wharf Engineering Report: “The elevation of Wharf deck (23 ft. MLLW) is sufficient to keep the Wharf deck above all but the infrequent, highest waves which can be up to 20 feet in height. As sea level rises, waves will be closer to the Wharf deck more frequently. Additional piles to widen the Wharf will increase the Wharf’s ability to withstand these waves and other lateral forces.” The Wharf Engineering Report contains the following recommendations:

“Because of its location and deck elevation (+23 ft., MLLW) Santa Cruz Wharf should continue to function well into the future, as it has for the past 100 years with continued maintenance and strengthening. With a sea level rise of 3.5 feet, the deck of the Santa Cruz Wharf would be approximately at the same present elevation of the Capitola Wharf.”

The Wharf Engineering Report also identifies the immediate maintenance and structural improvements needed to prepare the Wharf for the projected SLR and climate change. Some of the recommendations for the needed structural improvements and strengthening of the Wharf include the following:

- Add piles in Master Plan features to increase Wharf lateral stability
- Install side plate connections at unsupported cap splice

- Replace deteriorated stringers, decking, and caps
- Install bolts at stringers laps to provide longitudinal continuity
- Test existing Wharf timbers to obtain actual allowable stress values if higher load capacity is sought
- Perform design level seismic analysis for additions to the Wharf

Cowell and Main Beach. Given the relatively flat topography, the most immediate impacts of SLR will be experienced along the City’s beaches resulting in narrower beaches with less recreation potential and reduced habitat. While the options are limited on how to address and mitigate sea level rise impacts on Cowell/Main Beach, the City is currently developing a plan to utilize sediment removed from the San Lorenzo River Flood Control Project to more frequently replenish the sand at these beaches. The preliminary engineering plans and CEQA Initial Study are now being prepared for the initial beach sand replacement project. If this effort is successful, it can be used in future years as a short term method to mitigate the beach erosion caused by sea level rise.

g. Consider impacts and recommendations described in the current version of the Ocean Protection Council’s (OPC) Sea-Level Rise Guidance Document

Section 1d discusses SLR probabilistic based scenarios as compared to previous OPC guidance. Other recommendations from the Guidance Document suggest that adaptation strategies should prioritize use of natural or green infrastructure solutions. Because of the bluff topography along West Cliff and the presence and orientation of current seawalls, there is limited opportunity for natural solutions along West Cliff Drive. CalTrans recently funded a West Cliff Drive Shoreline Adaptation and Management Plan, slated to commence in the spring 2019, where the City will evaluate other natural infrastructure solutions (e.g., living sea walls for the bluffs adjacent to West Cliff Drive, which in some places is adjacent to the State Grant Area).

There is greater opportunity for natural solutions at the low lying beach locations and, in fact, dune revegetation is already in progress at Seabright State Beach (Seabright). In the CAP Update, the City identified consideration of natural infrastructure solutions in order to protect low-lying areas that are fronted by these beaches. The City is currently exploring the concepts of vegetated dunes constructed from San Lorenzo River sedimentation and transient wetland systems to provide improved habitat and water quality at the San Lorenzo Rivermouth.

In addition to the solutions described above, the following recommendations are provided in the CAP Update for the Cowell/Main Beach area:

“Small to medium scale beach nourishment has been found to be a cost effective, although temporary, adaptation measure when material is available. Strategic placement of river sediment at a site north of Santa Cruz could artificially increase local littoral sand abundance, which would be passively distributed down coast, benefitting subtidal areas along West Cliff as well as Cowell and Main beaches.”

As for Seabright, there is the possibility of further beach stabilization and dune building as adaptation strategies. There is an existing dune at Seabright that is in the process of being restored by Groundswell Coastal Ecology, known as the Seabright Beach Coastal Enhancement Project, which began in 2013. The project started at the entrance cove to Seabright and now extends from the San Lorenzo River Mouth to the West Harbor Jetty, making it the largest coastal restoration project in the City of Santa Cruz. The project increases coastal resiliency by using green infrastructure to build coastal dunes that protect the shorelines, and provides important wildlife habitat. As of now, over one-half mile of coastal dune, sand, and bluff habitat have been restored at Seabright.

According to the Ocean Protection Council’s SLR Guidance Document, adaptation planning and strategies should also prioritize social equity, environmental justice and the needs of vulnerable communities. As such, in addition to its focus on climate-induced hazards, the CAP Update also takes environmental justice and social equity into account by identifying those who may be most impacted by these hazards through an innovative social vulnerability scoring feature. Although no socially vulnerable census block groups that coincide with the coastal climate hazard zones are contained within the State Grant Area, we include the following description of the process to determine social vulnerability in order to demonstrate the City’s focus on environmental justice and social equity. According to the CAP Update:

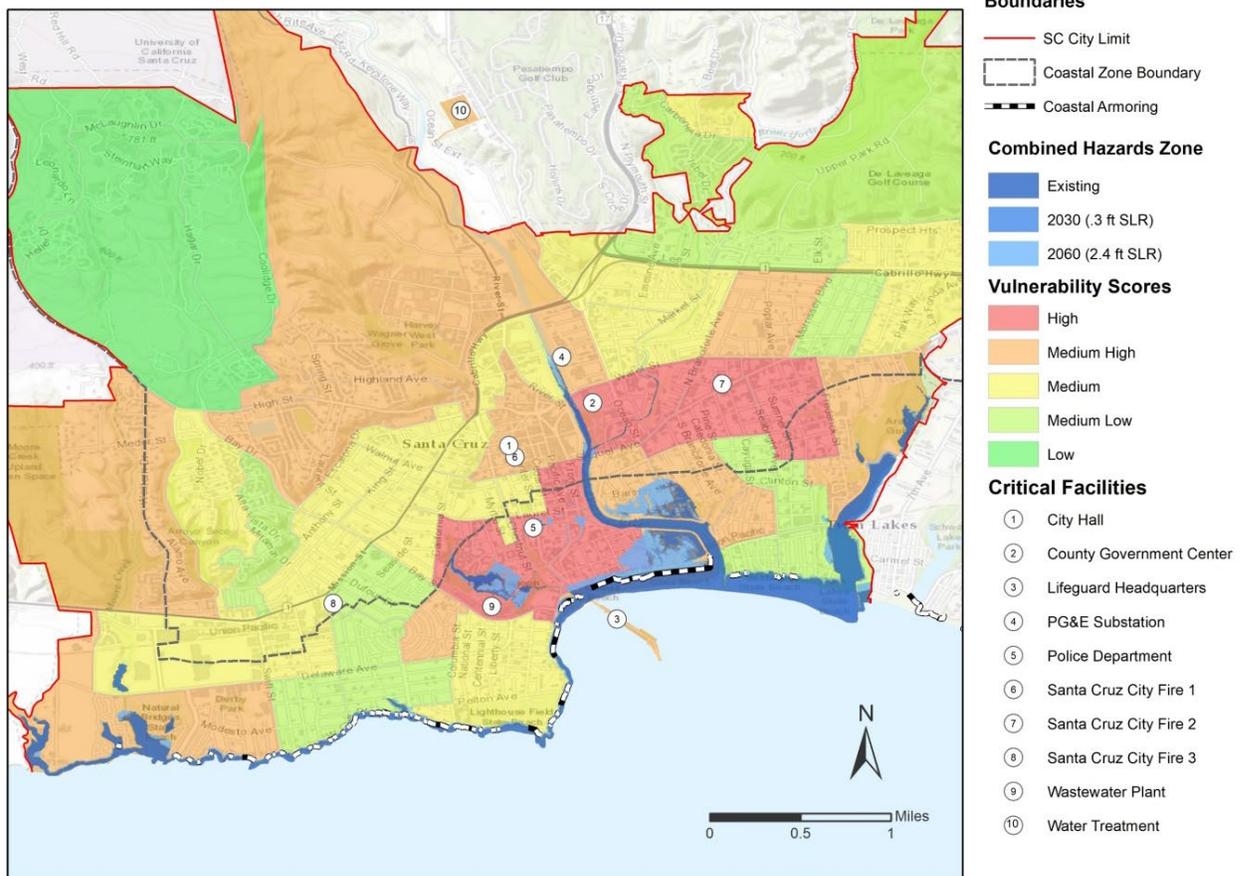
“The objective of the Social Vulnerability to Climate Change Hazards Assessment was to evaluate the geographic scale and drivers of social vulnerability. Taking place at the city block group level, several local indicators were compiled to form a social vulnerability score for each block group. The indicators of social vulnerability include (1) an income below the median income (based on HUD home income limits), (2) elderly (>65 years of age), (3) language limitations, (4) disability, and (5) crime incidence (violent and property crimes). The

methodology used to determine social vulnerability scores for each city block group is contained in Appendix E of the CAP Update.¹⁷

Figure 10 displays the results of the social vulnerability scoring. As depicted in the Figure 10, several of the communities adjacent to the State Grant Area (Beach Hill, Downtown/South of Laurel and Lower Ocean) have medium-high to high social vulnerability scores relative to other census block groups.

¹⁷ Appendix E of the CAP Update also contains maps of the individual social vulnerability indicator scores.

Figure 10: Social Vulnerability to Climate Hazards by Census Block Group



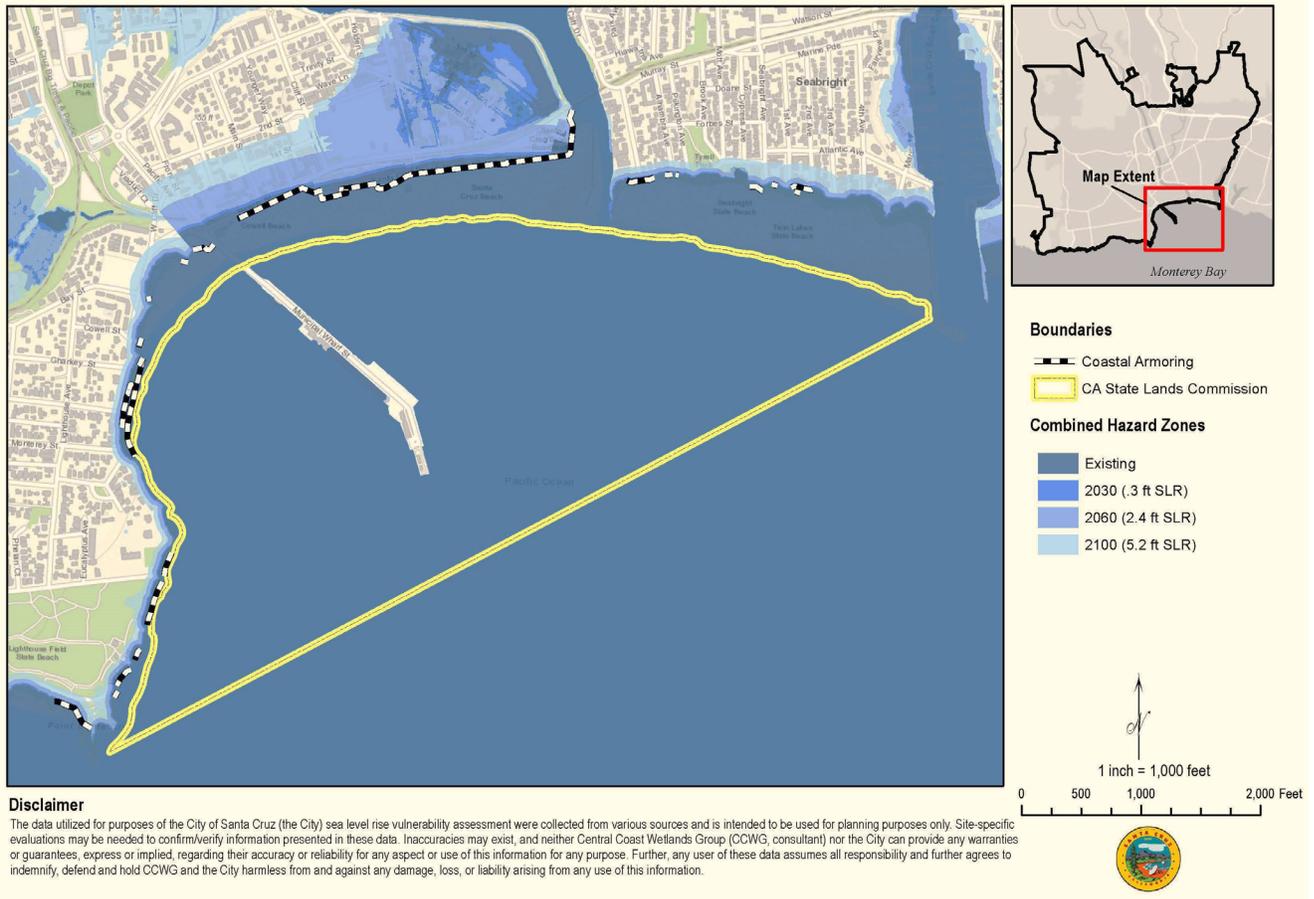
This method of hazard characterization improves policy and investment decision-making, allowing the City of Santa Cruz to ensure equitable resilience building across all sectors of the community. The social vulnerability scoring feature of the CAP Update assists in engaging vulnerable populations with education and assistance in climate awareness and adaptation planning.

In addition to the targeting of socially vulnerable populations through the social vulnerability scoring feature, public outreach was, and will continue to be, conducted in order to address environmental justice and social equity. Public input during the development of the CAP Update included public information events, a community survey on the 2011 CAP, and activities documenting residents' experience with and preparedness for climate change related impacts. In Appendix I of the CAP Update, there is a detailed description of the full project outreach along with the results of a public survey where nearly 400 residents responded. This input assisted in shaping the CAP Update's strategies.

2. Maps of 2030, 2060 and 2100 Impacts

Figure 11 depicts the combined impacts of coastal climate change hazards (rising tide, 100-year coastal storm flooding and erosion) projected in the years 2010 (baseline year), 2030, 2060 and 2100 on the beaches and coastal bluffs in or adjacent to the State Grant Area. While building footprints, roadways, greenspace, and river area is shown, above and below ground utilities and associated infrastructure are not included for clarity.

Figure 11: Combined Coastal Climate Change Hazards in the State Grant Area (hazard zones include areas that are currently managed by pumps or protected by levees)



Section 1 contains a detailed description and maps of the separate SLR related climate hazards (e.g., rising tides, coastal storm flooding, and erosion) as well as the cumulative risks and impacts of SLR and coastal climate change projected for the current, 2030, 2060 and 2100 planning horizons. Table 4 describes the specific assets within and adjacent to the State Grant Area that are projected to be vulnerable to the cumulative risks of coastal climate change and SLR.

Table 4: Specific Assets Projected to be Vulnerable to SLR in or adjacent to the State Grant Area

Asset/Area	Type	Coastal Hazard Impact	Impact Threshold
West Cliff Drive	Road – Isolated Sections	Erosion	2030
West Cliff Drive	Pocket Beaches	Rising Tides	2060
West Cliff Drive	Homes – Areas without armor	Erosion	2060
Lighthouse Field State Park	Bike and walking path	Erosion	2030
Lighthouse Field State Park	Lighthouse	Erosion	2060
Wharf Entrance	Road	Erosion	2030
Cowell/Main Beach	Beach	Erosion Rising Tides	2030 2060
Beach Street	Road and Visitor Serving	Erosion	2060
Beach Street	Visitor Serving	Coastal Storm Flooding	2030
East Cliff Drive	Road	Erosion	2030
East Cliff Drive	Homes – Area without armor	Erosion	2060

3. Estimate of financial costs of sea-level rise

a. Replacement or repair costs of resources and facilities that could be impacted by sea-level rise and climate change processes

Santa Cruz Municipal Wharf. The Wharf Engineering Report contains a detailed cost estimate for the various recommended improvements. The estimated cost of the improvements needed for strengthening the Wharf in preparation for SLR is \$1,750,000 to \$2,600,000. The recommendation for the addition of new Wharf lateral mass is estimated in the Wharf Master Plan at \$14.3 to \$17.3 million. The lateral mass addition would involve the addition of an Eastern Promenade and Western Public Access Extensions, which would also improve pedestrian access to the Wharf.

Cowell and Main Beach. The need for beach nourishment during sea level rise is one of the alternatives available to slow the inevitable beach erosion and inundation. This adaption strategy is now in engineering design and involves the transportation of San Lorenzo River sediment to a beach nourishment site through a slurry pipe. The current estimated cost for this project is approximately 5 million. However, the permitting and other

regulatory constraints on this approach make the timing hard to predict unless there is some regulatory priority given by the State for beach nourishment projects. In addition, the State Water Quality Board needs to adjust its fee schedule for beach nourishment projects related to sea-level rise.

Depending on the outcome of public outreach, adaptation alternative feasibility analyses and Local Coastal Program policies adopted, a second improvement at Cowell and Main Beach could be the eventual increase in height of the sea wall which runs along the back of these beaches. Presently, the wall is two feet in height, and a potential four foot height increase (for a total of 6 feet in height) would cost approximately \$500,000 to \$1,000,000 depending on the amount of foundation work needed to support the new wall height.

No assessment of operational or permitting costs for protecting these two assets has been evaluated.

Seabright Beach. As noted in Section 1, there is an existing sand dune at Seabright that is in the process of being restored by Groundswell Coastal Ecology, known as the Seabright Beach Coastal Enhancement Project, which began in 2013. The project includes dune building and coastal resiliency enhancements, and spans from Santa Cruz Harbor West Jetty northwest to the San Lorenzo Rivermouth. Since 2013, approximately \$377k has been invested in the project; however, the cost for maintenance, restoration, and vegetation for the dune is currently unknown. As such, a cost-benefit analysis must be undertaken by the City to evaluate dune building and other feasible green infrastructure, maintenance, restoration, and vegetation at Seabright.

b. Non-market values including recreation and ecosystem services of public trust resources that could be impacted by climate change and sea-level rise processes.

Three approaches were evaluated in order to ascertain the non-market value of recreation in the beach areas within the State Grants Area, creating a potential range of impact associated with SLR.

First Approach. The Ocean Economics Website, references a study entitled: [*Valuing Recreation and Amenities at San Diego County Beaches*](#)¹⁸. Based on the report, the average visitor to a San Diego County beach spent \$37/day visiting the beach. It is estimated that the City of Santa Cruz has between three to four million visitors each year who visit the Wharf, Downtown and

¹⁸ DANIEL K. LEW & DOUGLAS M. LARSON (2005) Valuing Recreation and Amenities at San Diego County Beaches, Coastal Management, 33:1, 71-86, DOI: [10.1080/08920750590883079](https://doi.org/10.1080/08920750590883079)

the Boardwalk and approximately one million of these visitors spend time at the City's beaches. Using the San Diego County statistics this would mean the loss of the City's beaches would be in the area of \$37 million dollars annually (one million visitors' at \$37 per person a day).

Second Approach. Another approach to measure the economic impact of the loss of the City's beaches it to utilize local statistics. The Santa Cruz Visitor's Council website states that the average visitor to Santa Cruz County spends \$151 per day. It is assumed that a day at the beach is free then this expenditure should be reduced by at least half to \$75 per person a day.

Utilizing this higher local figure, the "day at the beach" economic valuation ranges from \$37 to \$75 per person per day. Thus, a reasonable valuation would be the mid-point between these two figures which would establish a "day at the beach value" of \$56 per day or \$56 million annually spent by the one million Santa Cruz beach visitors.

Third Approach. This approach is based on a March 2016 study by the Nature Conservancy for the California State Coastal Concervancy, titled: [*Economic Impacts of Climate Adaptation Strategies for Southern Monterey Bay*](#)¹⁹ (Economic Impacts Report). Through strategies including coastal user counts and intercept surveys, the study found that beaches provide substantial non-market goods and services such as recreational value as well as significant ecological functions. According to the study, economists measure the non-market value of beach recreation by beach-goers' willingness to pay to recreate at a beach. The key findings of the study were that "40% of visitors were from Monterey County, and roughly half (51%) were on overnight trips. The typical party size was 3.5 and close to 80% of visitors arrived by car. Overnight visitors typically spent just under \$50 per person per day while day-trippers spent \$12 per person per day."

When extrapolated over a year-long period, the study estimated that yearly attendance for four different beaches in Southern Monterey Bay (Del Monte, Sand City, Marina and Moss Landing) ranged between 50,000 and 197,000 people; and the annual spending for beach-goers was between \$1,540,000 and \$6,060,000. This equates to roughly \$30.8 per person a day over the year-long period. Using the local beach goer estimate of 1,000,000 people annually as well as the Southern Monterey Bay statistics, we project that a loss of the City's beaches would result in a \$30.8 million dollar annual loss. Based on these three approaches, it is projected that between 2060 and

¹⁹ The Nature Conservancy. *SCC Climate Ready Grant #13-107 Economic Impacts of Climate Adaptation Strategies for Southern Monterey Bay*. March 2016.

2100, approximately \$30.8 to \$56 million is lost annually in the local economy due to SLR's impact on beaches.

This approach excludes other climate change impacts (e.g., ocean acidification on fishing resources and aquatic ecosystems). Those other non market values will be evaluated in a future cost benefit analysis. However, evaluating the ecological conditions of these beaches is a challenging task. Collecting and evaluating the necessary data to determine the ecological condition of beaches can be very time consuming and expensive. Furthermore, placing a dollar value on the ecological functions that beaches provide can be a challenge. However, a possible strategy to calculate a dollar value associated with the ecological condition of these beaches would be to implement a two-step approach similar to that of the Economic Impacts Report. First, a replacement cost analysis could be applied based on reported costs of nearby coastal restoration; and second, an ecological assessment could be conducted in order to determine an ecological score for each beach in the State Grant Area. The score would be based on present conditions, and then calculated for resulting future ecological conditions arising from any adaptation strategies.

Section 1 also contains a detailed description of the impacts of climate change and SLR on recreation and ecosystem services within the State Grant Area. Since it is unlikely the projected sea level rises would cause major closure of the Santa Cruz Wharf, it has not been included in this analysis.

c. Consider costs of 2030, 2060 & 2100 sea level rise projections with 100 year storm.

The financial cost associated with the loss of the two primary assets—Wharf and Beaches—within the State Grant Area boundary were summarized in Sections 3a and 3b. Current and future (2010, 2030, 2060 and 2100) costs associated with sea level rise (rising tide, erosion, 100-year coastal storm flooding and their combined impacts) are described for the City's entire coastal zone and are not constrained to the State Grant Area (as no other assets are within that area). It is important to emphasize that the economic impacts of sea level rise represents only the present day valuation of current (2016) property and infrastructure assets that are vulnerable. The valuation does not include inflated costs, changes in land use, or the value of power system infrastructure, ecosystem services, recreation and tourism, etc. Currently \$136 million in property and infrastructure are vulnerable to the combined hazards of coastal climate change within the City of Santa Cruz (Table 5). A significant number of properties are currently being protected from flooding and storm damage by a substantial set of structures including levees, storm drains, pump stations, and sea walls.

By 2030, the total value of vulnerable properties and infrastructure (not protected behind current structures) increases to \$148 million. By 2030, \$22 million (17% of the total value of vulnerable properties) in residential properties will be at risk. About \$44 million in commercial properties alone (34% of the total value of vulnerable properties) will be vulnerable to 2030 hazards. More than half of the total property value at risk in 2030 is public property and infrastructure totaling over \$64 million. This estimate does not include the Wastewater Treatment Plant.

The value of vulnerable property and infrastructure within the 2060 coastal climate hazard zone increases to over \$622 million assuming that existing coastal armoring is replaced and new structures are constructed to protect against the hazards of sea level rise. In a comparative scenario, the value of vulnerable property and infrastructure within the 2060 coastal climate hazard zone is just over \$1 billion if it assumed that existing coastal armoring is not replaced and new structures are not constructed to protect against the hazards of sea level rise. To note, in 2060, vulnerable property and infrastructure at risk is valued at over \$33 million and consists of public buildings, roads and utilities.

Table 5: Cumulative Exposed and Vulnerable Asset Valuation for Various Time Horizons (entire City coastline)

ASSET	VALUE PER UNIT	2010 WITH ARMOR	2030 WITH ARMOR	2060 WITH ARMOR	2060 NO ARMOR
Buildings and Structures					
Residential	\$960,000	\$22,080,000	\$26,880,000	\$204,480,000	\$437,760,000
Commercial	\$2,600,000	\$44,200,000	\$49,400,000	\$140,400,000	\$218,400,000
Public	\$4,000,000	\$40,000,000	\$40,000,000	\$88,000,000	\$108,000,000
Specific Municipal structures	\$0	\$24,288,000	\$24,288,000	\$140,653,100	\$140,653,100
<i>Valuation of vulnerable properties</i>		<i>\$130,568,000</i>	<i>\$140,568,000</i>	<i>\$573,533,100</i>	<i>\$904,813,100</i>
Parks²⁰					

²⁰ The value of vulnerable parks will be determined between the draft and final CAP Update adoption during the summer of 2018.

ASSET	VALUE PER UNIT	2010 WITH ARMOR	2030 WITH ARMOR	2060 WITH ARMOR	2060 NO ARMOR
Parklands	\$	\$	\$	\$	\$
Transportation					
Roads	\$500	\$1,193,500	\$1,548,000	\$13,790,000	\$33,969,500
Highway	\$4,000	\$0	\$0		\$28,000
Rail	\$237	\$255,200	\$293,900	\$857,900	\$1,854,300
<i>Transportation infrastructure value</i>		<i>\$1,448,700</i>	<i>\$1,841,900</i>	<i>\$14,647,900</i>	<i>\$35,851,800</i>
Water and Utility Infrastructure²¹					
Storm Drain pipeline	\$600	\$1,619,400	\$1,893,600	\$8,469,600	\$19,870,200
Wastewater pipeline	\$400	\$1,250,800	\$1,500,000	\$7,482,000	\$17,705,200
Drinking Water pipeline	\$610	\$1,724,500	\$2,376,000	\$17,497,200	\$43,070,000
<i>Utility Infrastructure value</i>		<i>\$4,595,000</i>	<i>\$5,770,000</i>	<i>\$33,449,000</i>	<i>\$80,645,700</i>
Total Combined Infrastructure Asset Value		\$136,611,000	\$148,179,000	\$615,542,700	\$1,021,311,000

A cost-benefit analysis must be undertaken by the City to evaluate adaptation options, which may include a managed retreat strategy for some public and private infrastructure, as well as evaluating coastal armoring and additional flood protection measures. As an example, very preliminary 2017 cost estimates for a new 2.8 mile West Cliff Drive could cost as much as \$145 million to construct, based on high estimates, and the cost for new revetment or armoring that would protect private homes within the hazard zone could cost \$36 million. Using the compiled hazard and vulnerability data generated by this project, coastal armor construction costs and the

²¹ Infrastructure costs are: \$600/ft for storm drains/pipes, \$400/ft for sewer, \$610/ft for water, \$280/linear ft for roads. Impacts of road and utility infrastructure were only tallied for erosion impacts (temporary flooding was assumed to pose little in replacement costs).

secondary environmental and economic impacts resulting from constructed structures, one can compare relocation costs and losses associated with abandoning vulnerable structures. These data can inform temporal cost/benefit/consequence scenarios for each section of coastline and time horizon. All of these alternatives would need to include a thorough environmental analysis for potential impacts.

This preliminary economic evaluation highlights the need for constructive discussions between city decision makers, residents, and private property owners to establish protection and adaptation policies that fairly allocate costs and weigh public and private property concerns equitably.

d. Include anticipated costs of adaption/mitigation measures and potential benefits of such strategies and structure.

Table 3 contained in Section 1f includes the adaptation measures from the CAP Update where only one measure's cost has been estimated and the remainder are unknown. As noted in the previous section (Section 3c), it is a high priority for the City to conduct a cost benefit analysis to understand the cost of each adaptation measure as compared to a business as usual development scenario. The City is pursuing funds to complete this analysis.

- e. In terms of the two primary assests within the State Grant Lands, the Municipal Wharf and Beaches, there are partial cost estimates of recommendations to bolster resiliency. For the Wharf, actions to implement to improve the Wharf's ability to withstand environmental forces and improve safety include:
 1. Widen the Wharf with vertical timber piles to increase its resistance to lateral wave and tsunami forces.
 2. Evacuate the Wharf during periods of predicted extreme waves, as occurred in 1985 and 1998
 3. Apply for a correction to the US Coast Guard to correct Chart 18685 (Monterey Bay) to indicate obstruction lights at the end of the Wharf
 4. Limit anchorage on the west side of the Wharf to outside 200 feet (see recommendation 4, Section 6 of the Wharf Master Plan). Notify the US Coast Guard of such to update the Nautical Chart and US Coast Pilot (companion text book to the Chart)
 5. Implement the West Walkway as called for in the Master Plan to protect the west side of the Wharf and buildings.

The costs of these improvements are delineated over 2030, 2060, and 210 time horizons, but are taken as a whole, as described in Table 6:

EAST PROMENADE	Description	Qty	Unit	Unit Cost	Low	High
Bents 37 to 111	New extension with hardwood deck (30' x 1,110') including sprinklering	33,300	SF	\$155	\$5,161,500	\$6,193,800
Bents 111 to 145	New extension for relocated parking with asphalt paving and sprinklering (25' x 510')	12,750	SF	\$140	\$1,785,000	\$2,142,000
Bents 111 to 145	Hardwood decking over existing structure (30' x 445')	13,350	SF	\$50	\$667,500	\$801,000
Bents 145 to 169	New extension adjacent to South Landing with hardwood decking and sprinklering	11,550	SF	\$155	\$1,790,250	\$2,148,300
Bents 169 to 185	Stepped promenade and overlook South Terminus of Promenade and sprinklering	8,800	SF	\$165	\$1,452,000	\$1,742,400
Bents 170 - 179	Ten 20-foot outriggers at 15' on center for lateral stability	10	EA	\$32,000	\$320,000	\$384,000
Guardrails	All 316 stainless with sloped top, supports at 4' on center and 316 stainless steel mesh Bents 37 to 145, 1,430 LF + Bents 145 to 185, 704 LF	2,134	LF	\$200	\$426,800	\$512,160
Primary Lighting	Hestia LED 18-foot including pole, electrification and installation along edge of promenade at 75 feet on center	32	EA	\$7,500	\$240,000	\$288,000
Wayfinding Lights	Along step-down edge of promenade between Bents 37 to 68; 89 to 111; and 147 to 167. Every 20 feet including electrification and installation	55	EA	\$1,200	\$66,000	\$79,200
Bike Racks	Landscape Forms Multiplicity Leaning Rail and Bike Rack, 2 for every primary light fixture (installed)	64	EA	\$500	\$32,000	\$38,400
Subtotal East Promenade					\$11,900,000	\$14,300,000
WEST PUBLIC ACCESS EXTENSIONS	Description	Qty	Unit	Unit Cost	Low	High
Bents 161 to 183	At existing Wharf deck level with asphalt and sprinklering	3,800	SF	\$140	\$532,000	\$638,400
Bents 77 to 135	West side public access, sloped walk to +15 MLLW, 12' x 870' with fiberglass decking and sprinklering	10,440	SF	\$150	\$1,566,000	\$1,879,200
Guardrails	Bent 161 to 183 = 355 LF; Bent 177 to 135 = 1,740 LF	2,095	LF	\$200	\$419,000	\$502,800
Subtotal West Public Access Extensions					\$2,500,000	\$3,000,000

Table 6: Costs of Recommended Wharf Improvements to Bolster Resilience to SLR

The complete discussion of resiliency efforts for the Wharf is found in the Implementation Section of the Wharf Master Plan and Section 10.2 of the Wharf Engineering Plan.

With regard to Cowell/Main beaches and Seabright beach, small to medium scale beach nourishment has been found to be a cost effective, although temporary, adaptation measure when material is available. According to the CAP Update:

“Strategic placement of river sediment at a site north of Santa Cruz could artificially increase local littoral sand abundance, which would be passively distributed down coast, benefitting subtidal areas along West Cliff as well as Cowell and Main beaches.”

Beach nourishment also helps to preserve the aesthetic and recreational value of beaches which is extremely important since these beaches attract up to one-million visitors annually. As stated in Section 3b, the loss of the City’s beaches could cause the City to lose millions of dollars annually due to a loss in annual beach-goers.

4. Description of how trustee proposes to project and preserve resources and structures that would be impacted by the sea-level rise

The City is in the process of developing a landscape scale plan for protection, preservation and retreat as previously noted. Section 3 discusses the adaptation strategies proposed and in progress to protect and preserve resources and structures impacted by SLR. Table 7 (from Appendix H of the CAP Update) also contains a list of successful past and ongoing adaptation programs and projects (including projects related to storms and flooding) that relate to activities and assets within and directly adjacent to the State Grant Area.

Table 7: Recently Completed and Ongoing Activities to Protect and Preserve Assets from SLR

Program/Project	Description	Hazard	Department /Org
Updated Emergency Operations Plan	Emergency Operations Plan is reviewed and updated annually	Multi-hazard	Fire: Emergency operations management
Ongoing Warning System	The City of Santa Cruz Fire/OES Analyst works with the SC Office of Emergency Services to manage the early warning system for evacuation of areas susceptible to flooding, tsunami inundation, seiches or dam failure	Flood Tsunami Dam failure	Fire: Emergency operations management

Program/Project	Description	Hazard	Department /Org
Ongoing design review	Working together, the Fire and Planning and Building Departments review new development design, circulation and access to ensure that development provides for minimum emergency response times and that emergency vehicles have safe and expedient passage at all times	Multi-hazard	Fire Planning and Building
Ongoing coastal protection permit review	The Planning and Building Department continues to protect and preserve the coastline and City infrastructure through the permit review process	Sea level rise hazards	Planning and Building
Revision to the Local Coastal Plan ⁺	The Planning Department is in the process of updating its LCP	Multi-hazard	Planning
Ongoing historic preservation	The Planning and Building Department encourage and support the protection of cultural, historic and architecturally significant structures to preserve neighborhood and community character as defined in the General Plan		Planning and Building
Ongoing floodplain management—Limit alteration	Public Works continues with a program to minimize the alteration of floodplains, stream channels and natural protective barriers that accommodate overflow	Flood	Public Works
NFIP compliance monitoring	The State of California Department of Water Resources monitors compliance for FEMA for cities to confirm compliance with National Flood Insurance Program	Flood	Public Works Economic Development

Program/Project	Description	Hazard	Department /Org
CRS compliance	The City of Santa Cruz annually certifies compliance with the CRS program as a part of that certification NFIP compliance components are included	Flood	Public Works Economic Development
Public awareness	Public Works (in conjunction with Planning and Building) continues to regulate development in floodplains and strives to increase public awareness of flood hazards	Flood	Public Works Planning and Building Economic Development
Increasing biodiversity	Increasing native biodiversity and maintaining terrestrial littoral transport processes along coastal bluffs of West Cliff and Natural Bridges	Biodiversity	Groundswell Coastal Ecology, CADPR, CA Native Plant Society
Increasing Coastal Resiliency using Green Coastal Infrastructure	Dune stabilization projects at Twin Lakes State Beach	Flooding, Storm, SLR	Groundswell Coastal Ecology, CADPR, CA Native Plant Society and P&R

a. Describe proposed mitigation/adaption measures, and how vulnerabilities will be addressed

The description of the proposed mitigation/adaption measures for the two primary vulnerable assets in and those adjacent to the State Grant Area is outlined in Section 3. An excerpt from the Wharf Master Plan also adds more detail on operational measures aimed at bolstering resilience:

- “2. Strengthen the Wharf and increase its resiliency to extreme weather conditions, seismic events and sea level rise.
 - Continue the regular maintenance and on-going replacement of piles, bents, stringers, and decking to enhance the condition and longevity of the Wharf provide for the continuity of stringers and caps and additional bolts or side plates at unsupported cap splice locations.

- Increase the number of vertical piles in the transverse direction (width of the Wharf) in conjunction with public improvements that benefit public access, recreational activities and boating to increase the Wharf's strength to resist forces imposed by storm waves and earthquakes.
- Provide outriggers in the deeper water area between Bents 170 and 179 connected to the existing horizontal ledgers to most effectively enhance the rigidity and reduce the sway of the Wharf in extreme weather conditions or during a seismic event.
- Limit truck traffic to the greatest extent possible to minimize damage to the paving and substrate of the Wharf."

According to the CAP Update, prioritizing coastal protection structures for upgrade and replacement was identified as a "very high priority," and investigating beach nourishment was identified as a "high" priority. With regard to upgrading and replacing coastal protection structures, proposed activities include:

"developing coastal bluff and beach management policies [LCP update] and plans [West Cliff Drive Shoreline Adaptation and Management Plan] that outline short and long term coastal bluff management strategies that can help establish protection and adaptation priorities. Future allocation of public funds to protect current infrastructure is to be prioritized and weighed against the longevity and feasibility of the proposed structures. Consider coastal armoring, beach nourishment, groin construction and retreat. Prioritize protecting public beaches, public coastal access/use, and integration of ecological functionality."

When considering beach nourishment strategies, the CAP Update proposes the following:

"small to medium scale beach nourishment has been found to be a cost effective, although temporary, adaptation measure when material is available. Strategic placement of river sediment at a site north of Santa Cruz could artificially increase local littoral sand abundance, which would be passively distributed down coast, benefitting subtidal areas along West Cliff as well as Cowell and Main beaches [State Grant Area]."

Based on the CAP Update, a plan to allow for beach nourishment from the San Lorenzo River has been designed, and is currently pending suitable funding.

b. Describe the timeframe for implementation of such measures

Table 3, *Adaptation Strategies for the Wharf and Cowell/Main/Seabright Beach* from Section 1 includes the timeframe for implementation of each

measure. Prior to the completion of the draft CAP Update in August 2017, the approach to adaptation implementation was on a project by project basis as planning documents set forth a long-term vision for adaptation but due to scientific uncertainty did not contain details. This approach was also not integrated across the City, creating fractured coastal resource management. With the CAP Update and its inclusionary and ongoing internal and external stakeholder engagement there is a more integrated, connected, and long-term approach outlined for adaptation with well defined next steps and active work on them.

As part of this approach, the City is working to develop a landscape scale plan and a monitoring/triggers/threshold program that will direct implementation in a strategic and cost effective manner. However, until these items are complete (pending funding) and a sustainable funding source for implementation is identified (in addition to City General Fund budget in capital improvement funds allocated), measure implementation will proceed on a project by project basis. The City continues to pursue external funding from the many sources available to fund this foundational work in addition to projects that implement adaptation measures. The City acknowledges that there is substantial funding for climate change adaptation and resilient infrastructure, and has been actively pursuing it. In addition, the City has been involved in a number of grant opportunities seeking to fund elements of this connected approach, which include the following:

Ocean Protection Council: *Sustained Bar Built Estuary Project on the San Lorenzo River* (Proposal pending evaluation and award announcement)

Strategic Growth Council: *Evaluating the Implications of Alternate Sea Level Rise Adaptation Strategies to inform Monterey Bay Coastline Resiliency* (Partnership with EcoAdapt; proposal pending evaluation and award announcement)

Strategic Growth Council: *Establishing a Santa Cruz Climate and Equity Center* (Partnership with University of California, Santa Cruz; proposal pending evaluation and award announcement)

PG&E's Better Together Resilient Communities grant: *Toward a climate resilient urban canopy in the City of Santa Cruz and City of Watsonville* (Partnership with Central Coast Wetlands Group; proposal pending evaluation and award announcement)

PG&E's Better Together Resilient Communities grant: *Integrating Extreme Heat into Climate Resilience Planning for California's Central Coast* (Partnership with the Central Coast Climate Collaborative and

RAND Corporation; proposal pending evaluation and award announcement)

National Federal Wildlife Foundation's National Coastal Resilience Fund grant: *Natural Infrastructure Solutions to Protect Santa Cruz's Beaches* (Partnership with Groundswell Coastal Ecology; proposal in preparation and due August 7, 2018)

With respect to the Wharf, The Wharf Master Plan and Engineering Report were accepted by the Santa Cruz City Council on October 28, 2014. At present, the City is in the process of preparing a CEQA Environmental Impact Report (EIR) which has been delayed. The initial improvements are being funded from previously issued former Redevelopment Agency bond proceeds which were released by the State Legislature in 2014.

The longer term implementation of the Wharf Master Plan is dependent on development of project financing and available grant funding. A number of options are under consideration including a local bond to fund the strengthening components of the Wharf Master and Engineering Plans. This would require a 2/3 vote of approval by City residents. Another option is a revenue bond; however in the case of the Santa Cruz Wharf, its annual rental income has historically not been sufficient to cover its operation and maintenance costs. Therefore, the Wharf expenses are currently paid from the City General Fund.

c. Describe plans to monitor impacts of sea-level rise and climate changes, as well as effectiveness of mitigation and adaption measures

A specific action prioritized in the CAP Update is establishing a monitoring, thresholds and trigger program to guide the implementation of adaptation measures. There is an emerging monitoring program being established in an ad hoc fashion (rivermouth sea-level sensor and other river/sea-level surface sensors) that will become part of a broader monitoring thresholds and triggers program. For example, according to the CAP Update, to prepare for SLR, the City proposed to install permanent tide gauges to monitor sea level or work conjunctively with agencies that intend to install gauges, and to install ground water monitoring wells to track water table rise. The City will partner with the County on installing a tidal gauge in Santa Cruz since the nearest are in Moss Landing and San Francisco, preventing localized condition monitoring.

This monitoring program will be formally designed and implemented to cover a large portion of the City's coastline through the West Cliff Drive Shoreline Adaptation and Management Plan project that is currently funded and

partially within—and adjacent to—the State Grant Area, and will be expanded to the entire city as funding and resources allow.

d. Describe any regional partnerships the trustee is part to or intending to form that would address sea-level and climate change vulnerability or increase resiliency

The City actively participates in the [Monterey Bay Regional Climate Action Compact \(Compact\)](#), an action network of government agencies, educational institutions, private businesses, non-profit, and non-governmental organizations who are committed to working collaboratively to address the causes and effects of global climate change through local initiatives that focus on economic vitality and reduce environmental impacts for the region. The City's Sustainability and Climate Action Manager facilitates the Compact's Intergovernmental Committee and is also a Steering Committee member of the newly formed [Central Coast Climate Collaborative \(4C\)](#). 4C is a membership organization fostering a network of local and regional community leaders throughout six central coast counties to address climate change mitigation and adaptation. 4C engages with other collaboratives throughout the state formed for the same purpose and recently hosted a well attended [Climate Resilience Workshop](#) (April, 2018). The City's Sustainability and Climate Action Manager is also a member of the Local Stewardship Council for the Santa Cruz World Surfing Reserve where one of three foci is on sea level rise and its impact on surfing resources.

The City also relies on a vast network of residents, non-profit partners, technical consultants, advocacy groups, and academics who are interested in advancing mutually beneficially climate resilience goals. These groups meet through the City's Climate Action Task Force Adaptation Subcommittee and the San Lorenzo River 2025 working group as well as other ad hoc collaborations.