Sea Level Rise Vulnerability Assessment Report

Santa Cruz County



Prepared for
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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Acronyms and Abbreviations

Caltrans	California Department of Transportation
CWG	Community Working Group
ESA	Environmental Science Associates
FEMA	Federal Emergency Management Agency
ft	feet
LCP	Local Coastal Program
MSL	mean sea level
NAVD88	North America Vertical Datum of 1988
SLR	sea level rise
yr	year

Definitions

100-year flood	flood that has a 1% probability of occurring in any given year. The 100-year floodplain is the extent of the area of a flood that has a 1% chance of occurring or being exceeded in any given year.
adaptive capacity	ability to anticipate, adapt to, and respond to socioecological and economic impacts due to coastal hazards and sea level rise.
backshore	extreme inland limit of the beach.
base flood elevation	determined by statistical analysis for each floodplain area and designated on FEMA FIRMs.
bluff, coastal (general use definition)	soft unconsolidated materials found in the marine terrace deposits, typically found at the top of coastal cliffs.
bluff, coastal (regulatory definition)	bank or cliff along the coast subject to coastal erosion processes. "Coastal bluff" refers to the top edge, face, and base of the subject bluff (Santa Cruz County Geologic Hazards).
bluff top	location where there is an identifiable break from the steeper cliff and bluff to the gently sloping inland areas. Also referred to as the crest of the bluff in this report.
coastal erosion processes (regulatory definition)	natural forces that cause the breakdown and transportation of earth or rock materials on or along beaches and bluffs. These forces include

	landsliding, surface runoff, wave action and tsunamis (Santa Cruz County Geologic Hazards).
coastal squeeze	loss of coastal beaches and habitat areas as sea level rise pushes shorelines landward while immovable barriers such as shoreline protection structures block their natural migration.
cliff, coastal (general use definition)	hard consolidated rock under the bluff.
dry sand beach	portion of the beach that is landward of the mean high-water mark.
dunes	areas where wave action and onshore winds have led to sand deposition, located landward of the beach.
disadvantaged community (regulatory definition)	community with an annual median household income (MHI) less than 80% of the statewide MHI (California State Water Resources Control Board). Or a census tract that is in the highest 25% of overall scoring census tracts in CalEnvrioScreen (CalEPA).
erosion, coastal	can refer to either beach narrowing or cliff/dune retreat. For cliffs, this refers to the long-term loss or removal of land due to coastal or terrestrial processes. For dunes, this refers to the removal of sediment due to coastal or terrestrial processes, but recovery is possible. For beaches, this may refer to either the long-term, short-term, or localized (see scouring) removal of sediments from the beach.
exposure	presence of people, assets, services, or natural resources in places and settings that could be adversely affected by coastal hazards and sea level rise.
Flood Insurance Rate Maps	are the official flood map of a community on which FEMA has delineated the 1% annual chance floodplain and the base flood elevations applicable to the community. Zone AE (coastal) indicates areas that have at least a 1%-annual-chance of being flooded, but where wave heights are less than 3 feet. Zone VE are coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. Base flood elevations are derived from detailed analyses and are shown at selected intervals within these zones.
impacts	are the consequences of realized risks on natural and human systems from exposure and vulnerability. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial.
nature-based solutions	projects that intentionally use natural and nature-based habitats and processes to reduce risks and deliver multiple benefits.
NAVD 88	North American Vertical Datum of 1988 (NAVD 88). The vertical control datum used for surveying.

resilience	capacity of people, assets, services, or natural resources to cope with a hazards or disturbance by responding or reorganizing in ways that maintain the system's essential function and structure while maintaining its capacity for adaptation, learning, and transformation.
risk	function of the likelihood of an adverse impact occurring and the severity of its consequences. It measures the extent to which people, assets, services, or natural resources are threatened, and includes the potential for loss, damage, or disruption.
scour, beach	the processes by which waves and currents remove sediment from the beach (usually seasonal and localized).
shoreline protection structure (regulatory definition)	any structure or material, including but not limited to riprap or a seawall, placed in an area where coastal processes operate (Santa Cruz County Geologic Hazards). Also referred to as coastal armoring in this report.
sea level rise	refers to the increase in ocean water levels due to the effects of climate change, such as the effects of ocean warming and melting of glaciers. Past and future sea level rise at specific locations on land may be more or less than the global average due to local factors (e.g., ground settling, upstream flood control, erosion, regional ocean currents).
shoreline	typically where water meets the land. In this report, it refers to the wet/dry line.
sensitivity	physical predisposition of people, species, services, infrastructure, or assets to be affected coastal hazards and sea level rise due to lack of resistance and a predisposition of the population or asset to suffer harm because of intrinsic and context conditions.
splash	occurs when waves break seaward of the coastal armoring, or where the armoring is high in relation to the wave height, and overtopping is a concentrated stream of water droplets.
toe of the cliff	location where the dry sand beach meets the base of the cliff.
total water level	the combined effect of wave run-up height, storm surge, tides, and sea level elevations.
vulnerability	the propensity or predisposition to be adversely affected by hazards. Vulnerability is widely understood to have three components including exposure, sensitivity, and adaptive capacity.

1 EXECUTIVE SUMMARY

1.1 OVERVIEW

This Vulnerability Assessment evaluates the extent and severity of coastal hazards under future conditions using a range of sea level rise (SLR) scenarios, storm recurrence intervals, and assumptions on coastal conditions. The analysis considers multiple planning horizons, including near-term (0–1 ft of SLR), mid-term (1–3 ft of SLR), and long-term (3–5 ft of SLR) conditions. Results are evaluated at a neighborhood scale to support decision-making within the Santa Cruz County Local Coastal Program update and to inform long-term adaptation strategies.

1.2 KEY FINDINGS

SLR will increase the frequency and severity of coastal hazards in Santa Cruz County. While the types of hazards will be familiar, their magnitude and extent will increase. In the near term (0–1 ft of SLR), coastal wave flooding is the dominant hazard, particularly during large storm events coinciding with high tides.

By the mid term (1–3 ft of SLR), flooding will become more frequent and widespread, with many low-lying coastal areas such as Rio del Mar Flats experiencing chronic inundation. This will likely lead to an increasing desire to rely upon coastal armoring to protect development, although in a future with higher total water levels and narrower beaches, their effectiveness may diminish over time. By the long term (3–5 ft of SLR), coastal erosion becomes the dominant hazard of concern in many areas. Cliff and dune retreat may lead to loss of land area and damage to upland development, and beach narrowing may lead to a significant loss in beach access and recreational resources.

Currently, approximately 1,500 structures are exposed to coastal hazards. By 3 ft of SLR, that increases to more than 2,200, and the probability of exposure to structures increases substantially, with more than half in the medium to very high probability categories. By 5 ft of SLR, more than half of all coastal structures, or approximately 1,200 structures, will be in a very high probability of impact to coastal hazards categories. Property value exposed to hazard (including land and structures) exceeds $1.7B by 5 ft of SLR (2024 dollars).

Neighborhood Vulnerability

The North Coast and Davenport area has relatively limited development exposure; however, Highway 1 is exposed to coastal erosion at numerous locations, with just over three-quarters of a mile of highway exposed to coastal erosion currently, and over 3 miles of highway by 5 ft of SLR.

The Twin Lakes and Corcoran area relies heavily on coastal armoring and is therefore highly sensitive to an increase in wave energy at the backshore, as well as the long-term performance of these structures. Up to 121 structures are exposed to coastal wave hazards today, and this increases steadily to 212 structures by 5 ft of SLR.

The Pleasure Point and Opal Cliffs area is primarily affected by cliff erosion. Ongoing bluff retreat, combined with the loss of beaches and surf breaks, poses the greatest risks. Coastal erosion exposes less than 20 structures today, and this increases to more than 120 structures with 5 ft of SLR.

The Seacliff, Rio del Mar, and Aptos areas represent the highest overall risk within the county. These neighborhoods include extensive low-lying development and exposure to both flooding and erosion, resulting in some of the greatest potential economic impacts. Currently, 760 structures are within a coastal hazard area, and this rises to 1,198 by 5 ft of SLR.

The La Selva Beach, Manresa, and Sunset areas are characterized by more natural and open coastline with wider beaches. While these areas have greater adaptive capacity, development at La Selva Beach, Place de Mer, Sand Dollar, and Port Watsonville remains vulnerable to long-term coastal erosion and SLR.

The Pajaro Dunes and Pajaro Valley areas face compound flooding risks from both coastal and riverine processes. 293 structures are exposed to coastal hazards, with many low-lying and front row oceanfront homes at Pajaro Dunes exposed to hazards. The inland Pajaro Valley area includes vulnerable communities with limited adaptive capacity, making the community particularly sensitive to increasing flood exposure and severity.

2 INTRODUCTION

Along Santa Cruz County's iconic coastline, the ocean is both our greatest treasure and our greatest challenge. Powerful winter storms and wave activity have always been a part of the county's history, and rising sea levels are projected to amplify these forces and increasingly threaten homes, roads, and recreation areas. This study is part of a broader update to the County's Local Coastal Program (LCP), specifically focused on addressing the risks associated with coastal hazards, and to better prepare for what's ahead. The LCP is a state-mandated plan that guides land use and development along the coast to balance environmental protection, public access, and sustainable growth. The intent of this study is to inform this effort by identifying and evaluating coastal hazard exposure, and risk to land use and structures, infrastructure, and the people and visitors to the county.

2.1 PROJECT GOALS

The goals of the Santa Cruz County Sea Level Rise Vulnerability Assessment Project are as follows:

Goal 1: Provide a clear picture of the risk associated with SLR and coastal wave hazards to the county's coastal resources.

Goal 2: Provide data to support adaptation planning that will balance private property protection with the preservation of public resources including coastal access, beaches, surf breaks, recreational amenities, and the coastline's natural beauty for future generations.

Goal 3: Inform policies to protect both the coastal environment and public interests in preparation for projected SLR and coastal hazard impacts.

2.2 REPORT OVERVIEW AND PROJECT APPROACH

This vulnerability assessment uses best-available science to evaluate coastal hazard and SLR risk on a neighborhood-scale of analysis. Supplemental materials that support this study can be found in the appendices, including background review and existing planning landscape (Appendix A), existing policy challenges (Appendix B), coastal processes and SLR (Appendix C), technical methodology (Appendix D), and supplemental tables and figures (Appendix E). The body of this report, Section 3, presents findings of the vulnerability assessment, providing a foundation for integrating SLR adaptation strategies into future planning and policy updates. Reporting of vulnerabilities is divided by six neighborhood regions of the county shoreline, and a countywide summary is provided at the end of this section.

This study is rooted in scientific analysis, but also directed and informed through engagement to ensure that decisions reflect local understanding of conditions and

community values. Early in the project, multiple venues for engagement to inform this process were established including:

- **Community Working Group:** This group brings together a core group of local residents representing a wide variety of agencies, organizations, and businesses and includes many community leaders, real-estate practitioners, and technical experts. The aim of the group is to review findings, share local knowledge, and help shape adaptation strategies.
- **Public Outreach and Engagement:** Listening sessions, pop-ups, and a public survey were used to gather input on coastal values and adaptation priorities.
- **Project Website and StoryMap:** The project website provides a bilingual platform for sharing hazard information, project updates, and draft strategies. This will be accessible to the public throughout the project.

This approach enabled a transparent process where technical work and community perspectives inform one another to guide a neighborhood scale vulnerability assessment.

2.3 STUDY AREA AND NEIGHBORHOODS

The study area encompasses the unincorporated County areas within the coastal zone boundary, extending from Año Nuevo in the north to the Pajaro River in the south (Figure 2-1). There are some minor exceptions to this. Within the Pajaro Valley and near the City of Watsonville, this study included some low-lying areas outside of the coastal zone boundary as the furthest extent of coastal hazards by 5 ft of SLR extended beyond this area. In addition, the City of Watsonville Wastewater Treatment Plant, which is an out-holding and owned by the City, has been included in the analysis and reported on; however, it will not be addressed from an adaptation strategy or policy perspective as it falls outside of the County's jurisdiction.

For the purpose of this report, unincorporated Santa Cruz County is divided into six sub-regional areas, hereinafter referred to as neighborhoods. The goal in defining neighborhoods is to identify the scale of vulnerability assessment reporting, as well as direct preferred adaptation priorities and policy strategies for different areas of the Santa Cruz County coastline. Common boundaries such as the jurisdictional boundaries of the City of Santa Cruz and the City of Capitola served as natural break points; however, other considerations were needed to further divide the remaining neighborhoods.

Neighborhood boundaries were determined through discussions with the County of Santa Cruz staff and the Community Working Group (CWG). The goal for this exercise was to group neighborhoods by common geophysical characteristics including backshore type, geology, coastal orientation and coastal hazard exposure; other considerations such as coastal permit conditions, governance considerations including homeowners associations and rural service

area boundaries, and land use and development patterns including commonly recognized neighborhood boundaries were also used to inform boundary delineation.

Listed below are the six neighborhoods, along with the associated community place names within. This list is not meant to be an exhaustive list, but it is illustrative of the variety of places that are referenced in the study. A map of these neighborhoods is presented below (Figure 2-1).

North Coast / Davenport

- Davenport
- Davenport Landing

Twin Lakes / Corcoran

- Twin Lakes
- Blacks Beach
- Sunny Cove
- 26th Ave
- Soquel Point (to South Palisades Ave)

Pleasure Point / Opal Cliffs

- Soquel Point (South Palisades Ave, Rockview Dr, and Pleasure Point Dr)
- Pleasure Point
- Opal Cliffs

Seacliff / Rio Del Mar / Aptos

- Seacliff
  - Potbelly Beach Road
  - Las Olas Drive
- Rio del Mar
- Rio del Mar Flats
  - Aptos Beach Drive
  - Rio del Mar Esplanade
- Aptos
  - Via Gaviota
  - Seascape Resort

La Selva / Manresa / Sunset

- Camino al Mar / Trestle Beach
- La Selva Beach
- Place de Mer / Oceanview Drive
- Sand Dollar Beach
- Port Watsonville

Pajaro Dunes / Pajaro Valley

- Pajaro Dunes
  - Shell Road / Shorebirds
  - Rio Boca Road / Pajaro Dunes / Pelican Point
- Lower Pajaro Valley
  - W. Beach Street and San Andreas Road.

The boundaries between the neighborhoods of Twin Lakes / Corcoran and Pleasure Point / Opal Cliffs are based on discussions with the County of Santa Cruz staff and centered on permitting conditions and maintenance agreements of coastal armoring for properties at certain address ranges around Soquel Point. The boundaries between Seacliff / Rio Del Mar / Aptos and La Selva / Manresa / Sunset centered on the divide between the rural and urban service area boundary, and generally follow the U.S. Census Block group boundary line. The boundaries between La Selva / Manresa / Sunset and Pajaro Dunes / Pajaro Valley are divided along Shell Road and the Pajaro Dunes Community and extend east along Watsonville Slough.

The neighborhood areas are meant to serve as an organizational framework for reporting coastal hazards and to approach adaptation planning. The adaptation strategies that will be explored are not considered one-size-fits-all approaches for the entire neighborhood, but will be reflective of the location-specific characteristics for each neighborhood area.

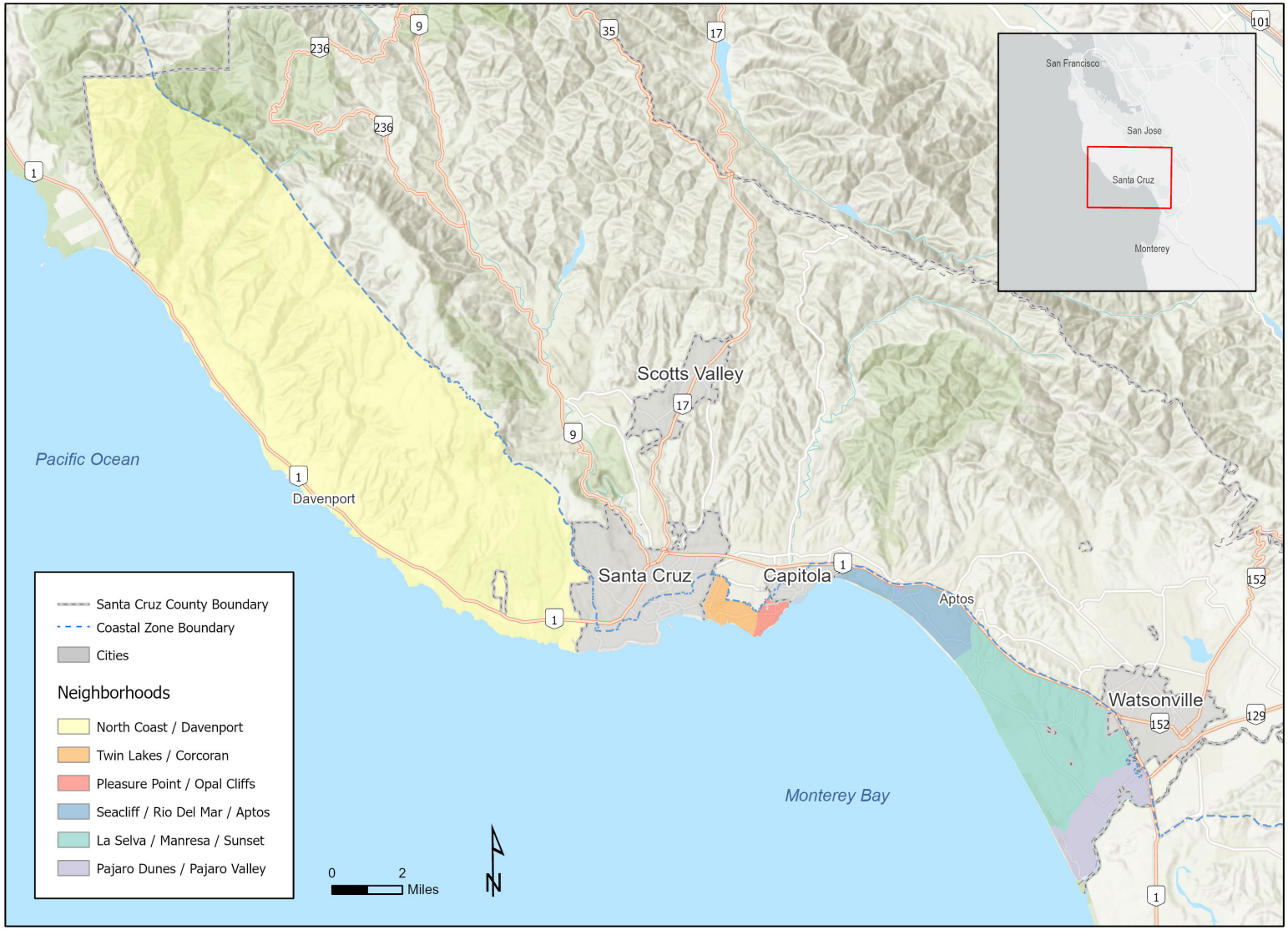


Figure 2-1. Geographic Scope and Neighborhood Areas

2.4 COMMUNITY SETTING

Santa Cruz County encompasses a 445.17 square mile area in the northern Monterey Bay region of California's Central Coast. It is bordered by San Mateo County to the north, Santa Clara County to the east, and Monterey County to the south. Santa Cruz County has four incorporated cities: Santa Cruz, Capitola, Scotts Valley, and Watsonville. The unincorporated area, including 26 census-designated places, accounts for 417 square miles of the county, and is the focus of this study.

Santa Cruz County's physical environment is diverse and includes the redwood forests of the Santa Cruz Mountains, sunny beaches of the coastal terraces, and productive agriculture in the alluvial soils in the southern Pajaro Valley. Santa Cruz County is a popular destination for tourists and a loved home for locals, with many iconic beaches, world-class surf breaks, and popular parks featuring coastal redwood forests, rugged cliffs, and beaches that support many outdoor activities including hiking, kayaking, sailing, surfing, beach volleyball, biking, running, golfing, stand-up paddle boarding, fishing, and more.

Current economic activity in the county includes agriculture and forestry; however, the largest market categories are in service trades such as education services, professional, scientific and technical services, health care, retail and accommodation and food services (Data USA 2025).

2.5 COUNTY DEMOGRAPHICS

According to the U.S. Census Bureau estimate for 2025, the total population of Santa Cruz County is 258,852 people. Of those, 50.8% identify as female, and 53.3% of the population identifies as white alone, not Hispanic, 35.8% as Hispanic, 1.9% as black alone, 3.6% as American Indian and Alaska Native alone, 5.8% as Asian alone, 0.3% as Native Hawaiian and Other Pacific Islander, alone, and 6.9% as two or more races. The median household income in 2024 dollars is $111,093, and 11.9% of the population is under the poverty line. Of those over the age of 25, 88.6% of the population have a high school diploma, and 43.9% have a bachelor's degree or higher (U.S. Census Bureau 2025). Throughout each neighborhood section and overview of each community's characteristics will be provided. This will detail scores from CalEnviroScreen on pollution burden and population vulnerability. Note that CalEnviroScreen classifies a disadvantaged community by scoring and ranking each of California's census tracts using pollution burden, sensitive populations, and socioeconomic factors. The California Environmental Protection Agency (CalEPA) typically designates the highest-scoring 25% of these census tracts as disadvantaged communities.

3 NEIGHBORHOOD VULNERABILITY ASSESSMENT

This vulnerability assessment provides a neighborhood-scale outline of the physical, demographic, and recreational characteristics of each coastal neighborhood, as well as their unique vulnerabilities to coastal hazards and SLR. This vulnerability assessment intends to support the development of coastal policy and an update to Santa Cruz County's LCP. The priority of this assessment is to identify the key community assets and public trust coastal resources at risk to SLR. For this assessment, the focus is on those community assets that are most directly affected by coastal policy changes at the local government level; namely, residential assets and their supporting infrastructure and associated amenities. This assessment also focuses on public trust resources, including the intertidal zone and adjacent coastal reserves. While the direct management of these resources is outside the direct jurisdiction of the County, they are affected by policy decisions related to management of these assets, and thus, reported in greater detail. Potential direct and indirect impacts on commercial activity and agricultural lands and activities, as well as government assets such as public utilities that are managed by non-County facility managers or entities (e.g. State Parks), are not reported in detail.

There is uncertainty about what the future will hold, and this assessment addresses uncertainty by evaluating multiple coastal erosion hazard scenarios, a range of coastal wave flooding recurrence intervals, and a probabilistic approach to reporting risk to structures. The coastal erosion scenarios center on decisions about the presence of coastal armoring by examining two scenarios: one that assumes that all existing coastal armoring remains in place through 3 ft of SLR but no new coastal armoring is built to address higher levels of SLR, and one that estimates the coastal hazard exposure and potential damages that may be expected if no coastal armoring is in place until 5 ft of SLR. Neither of these scenarios perfectly reflects reality, but these scenarios are reported to provide context for the range of coastal erosion risk to assets, infrastructure, and property.

The decision to report no coastal armoring in place until 5 ft of SLR centers on the assumption that coastal infrastructure is not finite, and this assessment assumes that unless significantly redesigned, all existing coastal protection infrastructure will be removed or no longer effective at some point in the future. The study team does not assume that all coastal armoring will no longer be present on the coastline by 5ft of SLR, but this scenario was developed to illustrate what long-term removal of armoring could look like as TWLs exceed the design parameters of current coastal armoring (see Appendix D for more details).

This assessment also takes a fine-resolution examination of the county's coastal recreational characteristics, including beach visitation and surfing, as well as projecting vulnerabilities to these resources from SLR. The future outcomes for these resources also have uncertainty and are highly dependent upon the choices that are made regarding coastal armoring and the protection and preservation of these resources.

The sections below provide a neighborhood-by-neighborhood overview of SLR vulnerabilities starting from the county's north coast and working southeast. This localized approach is intended to provide a finer-resolution understanding of how coastal hazards and SLR impacts will differ from place to place, supporting more targeted adaptation planning. The final section provides a countywide overview of vulnerabilities, and a comparison between neighborhoods to convey the timing of risk, as well as orders of magnitude in the risk between each neighborhood.

3.1 NORTH COAST / DAVENPORT

3.1.1 Overview

The North Coast / Davenport neighborhood of Santa Cruz County extends from the southern boundary of Año Nuevo State Park to the western boundary of the City of Santa Cruz, encompassing approximately 17 miles of rural coastline characterized by rugged cliffs, active agricultural lands, and scenic beaches. The small, unincorporated communities of Davenport and Davenport Landing represent the primary developed areas within this largely undeveloped coastal corridor. The region is recognized for its high scenic value and recreational use, attracting visitors for surfing, hiking, and coastal access along Highway 1 (Figure 3-1).



Figure 3-1. Left: Swing Set at Davenport Landing, Right: Laguna Creek at the Cotoni-Coast Dairies National Monument (Source: santacruz.org)

3.1.2 Community Characteristics

The North Coast / Davenport area is sparsely populated, home to fewer than 500 residents according to the 2020 U.S. Census. The community is composed of homeowners, retirees, and agricultural workers. The area includes significant tribal heritage sites, remnants of early ranching and industrial uses such as the former cement plant, and a strong recreation-based community. This area does not include any disadvantaged communities (California State Water

Resources Control Board 2020); however, it does have a population of seasonal and year-round farmworkers who reside here who may not be picked up by the census. CalEnviroScreen gives the area a score of 18, placing it in the 18th percentile statewide for cumulative pollution burden and population vulnerability, meaning the area experiences relatively low environmental and socioeconomic stressors compared to most California communities (OEHHA 2021).

3.1.3 Infrastructure and Development

Development in the North Coast / Davenport area is limited and primarily concentrated in the unincorporated communities of Davenport and Davenport Landing. There is minimal commercial development, and what is there is mostly limited to small businesses in Davenport. Most of the surrounding landscape remains in agricultural or open space use. Highway 1 is the primary transportation corridor. Although the Santa Cruz Branch Rail Line is inactive, there are plans to convert it into a multiuse bicycle and pedestrian path.



Figure 3-2. Left: Community of Davenport. Right: Davenport Landing and the Surrounding Cotoni-Coast Dairies (Source: Coastal Records Project 2013)

Key assets and infrastructure in the coastal study area include:

- Structures and utilities at Davenport and Davenport Landing
- Highway 1 and the Scott Creek and Waddell Creek bridges
- Santa Cruz Branch Rail Line and the alignment of the North Coast Rail Trail

3.1.4 Recreation and Coastal Resources

Public lands and points of interest, including Wilder Ranch State Park, Scott Creek, Waddell Creek State Beach, Davenport Landing Beach, Panther Beach, Shark Fin Cove, and the Davenport Pier ruins, provide significant ecological, cultural, and recreational value. These areas attract many county residents and out-of-town visitors for surfing, hiking, biking, fishing, tide pooling, and beachcombing. The coastline features dune systems, rocky intertidal zones,

estuaries, and steep bluffs that support diverse species and habitats. Numerous public access points and trailheads are accessible along Highway 1, with several larger beaches offering roadside parking and trails that lead directly to the shore.

Mobility data from Placer.ai highlights Panther Beach, Bonny Doon Beach, and Four Mile Beach as the most visited beaches along the North Coast, together attracting more than 70,000 visits annually (2024). These beaches stand out in their relative proximity to the City of Santa Cruz, parking availability, wide beaches, vistas, and appeal to surfers. Roughly 65% of all visits occur between May and October, with the remaining 35% occurring during the winter months. This neighborhood experiences the highest winter visitation rate among all unincorporated Santa Cruz County beaches, which may reflect their appeal to surfers.

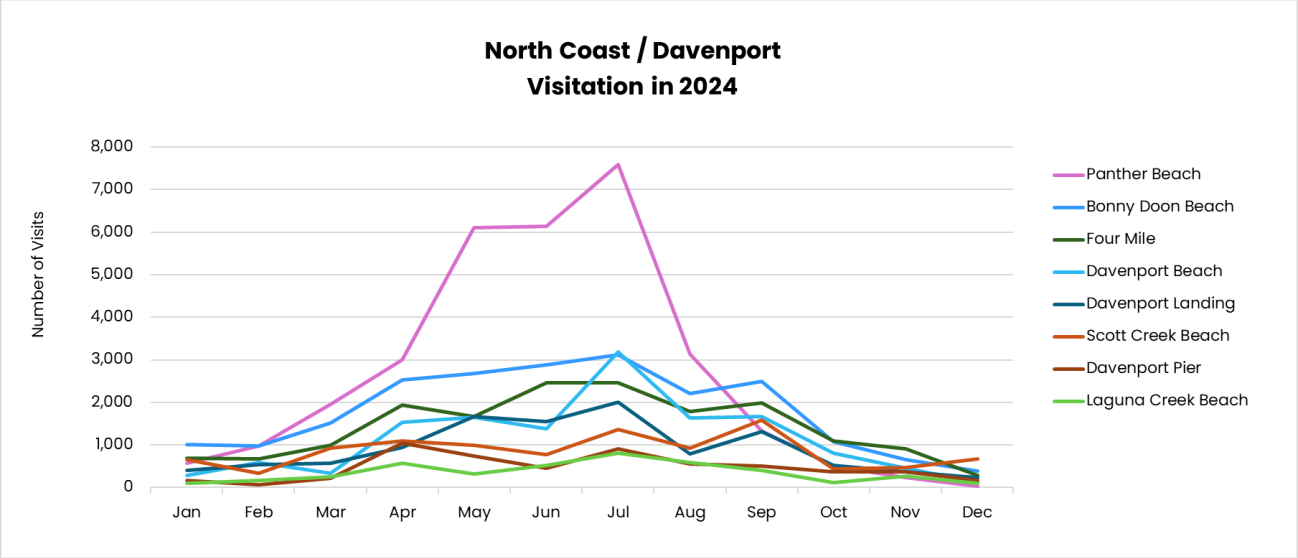


Figure 3-3. Seasonal Beach Visitation (2024)

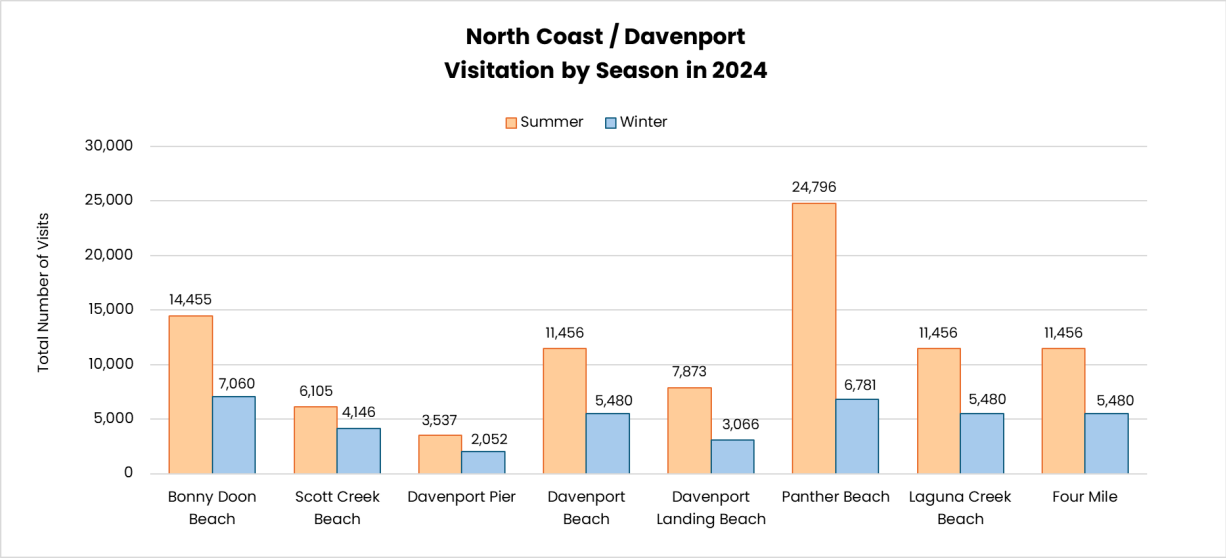


Figure 3-4. Beach Visitation Numbers between Summer and Winter (2024)

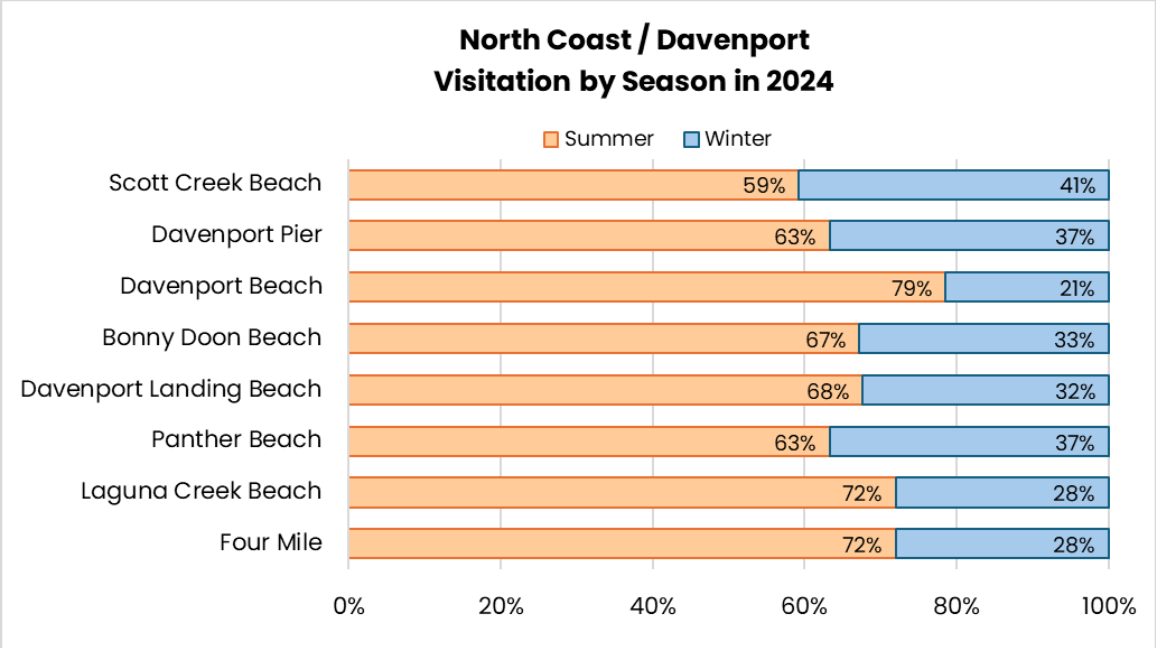


Figure 3-5. Beach Visitation Distribution between Summer and Winter (2024)

3.1.5 Coastal Processes and Hazards

3.1.5.1 Coastal Erosion

Most of the North Coast county coastline comprises unarmored and natural cliffs and dunes. The North Coast features a geological formation known as Santa Cruz Mudstone, which is bedrock material that is more erosion-resistant than the bedrock material found in more southern coastal locations of the county (e.g., the Purisima Formation). Despite this, the North Coast has experienced significant erosion over time. Figure 3-6 illustrates the erosive power of ocean waves, with the arch at Wilder Ranch State Beach disappearing over time.



Figure 3-6. Wilder Ranch State Beach. Left, 1900. Right, 2006 (Source: Gary Griggs)

3.1.5.2 Coastal Flooding

This area experiences several forms of coastal flooding driven by king tides, winter storms, and the interaction of coastal streams. High tides and king tide events regularly inundate low-lying beach areas and back-beach depressions at locations such as Wilder Ranch, Davenport Landing, Waddell Beach, and Scott Creek. This inundation occasionally reaches parking areas and beach access trails. At Waddell and Scott Creek, seasonal lagoons form in the summer when beaches accrete and close the creek outlets, leading to bathtub-like filling behind the lagoon that can cause extended flooding. During high tides or summer wave events, lagoon overtopping events can rise rapidly, exposing low-lying development and infrastructure to inundation.

Large winter swells also contribute to higher wave run-up and overtopping, which can rush across the beach and pull beach sand offshore. This results in a seasonal beach narrowing that affects beach access and can drive coastal erosion of cliffs and dunes. This type of storm-driven flooding is common at Panther Beach, Waddell Beach, and Scott Creek, and can result in overwash and bluff-toe inundation in more confined coves. In creek-mouth areas, high waves at high tide combined with high freshwater flows can produce compound flooding, causing more extreme flooding farther inland and into adjacent low-lying areas. These same high waves can cause rapid changes to lagoon and shoreline conditions. Collectively, these

processes make coastal flooding a recurring seasonal issue for Santa Cruz County's northern beaches, coastal habitats, and visitor access points.

3.1.5.3 Coastal Armoring

Coastal armoring in the North Coast / Davenport area is minimal, with only 6% of the shoreline armored. Most coastal armoring exists to protect Highway 1 and at the bridges over Scott Creek and Waddell Creek. There is no CoastSat beach width change data available for the beaches along the longest stretch of continuous armoring on the North Coast; however, historical aerial images dating back to the 1940s show that these beaches have likely narrowed along this stretch of coast (Figure 3-7).

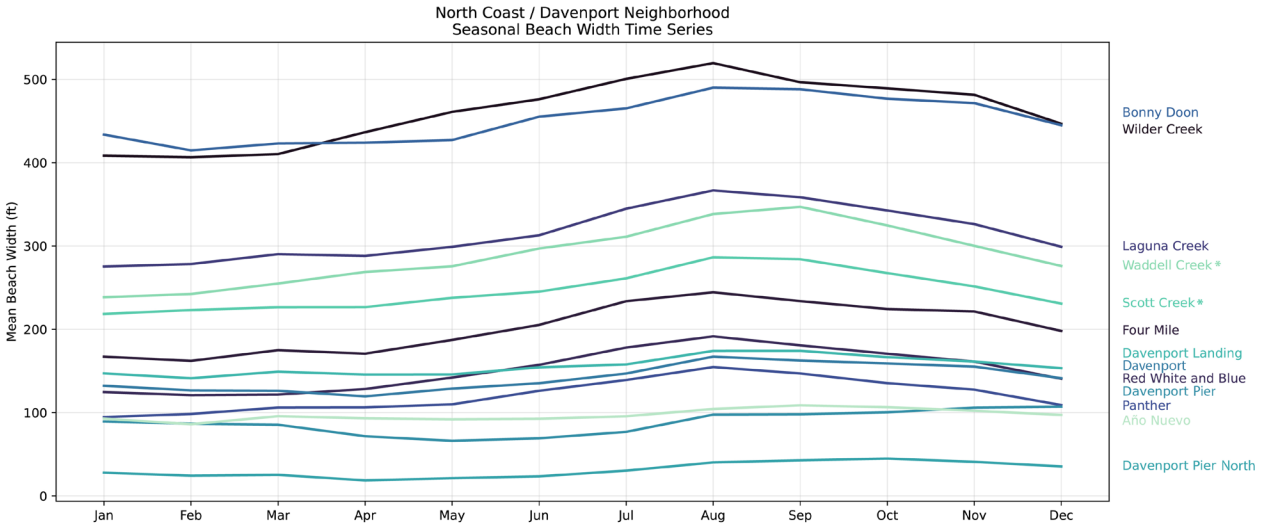


Figure 3-7. Waddell Creek Beach North. Left: Aerial image from March 1941. Right: Aerial image from February 2026

This armored stretch of coastline has seen a reduction in beach widths (Source: UCSB Library).

3.1.5.4 Beach Widths

Satellite observations over the last 40 years (1984–2024) from CoastSat reveal clear seasonal fluctuations in beach width across the North Coast county coastline. Beaches typically widen during the summer months as sand is deposited on the beach and narrow during winter storms when higher wave energy moves sand to nearshore bars. The figure below illustrates these seasonal patterns, showing average monthly beach widths over the 40-year record. On average, there is an approximate 60-ft difference between narrow winter beach widths and the wide summer beaches. Along the county's north coast, the widest beaches occur near the creek mouths and lagoons, including Bonny Doon, Wilder Creek, Laguna Creek, Waddell Creek, and Scott Creek beaches (Figure 3-8).



*partially armored

** fully armored

Figure 3-8. Seasonal Beach Width Trends by Beach (average width by month across all records from 1984 to 2024)

Beaches in lighter colors appear further north, and beaches in darker colors appear further south.

The long-term beach width trends show beach widening for several beaches, including Davenport Pier, Bonny Doon, and Laguna and Wilder beaches, and beach width reduction at Scott Creek and Waddell Creek beaches (Figure 3-9). This chart compares average beach widths from 1984–1988 to 2019–2024, and the period in the mid-1980s immediately followed one of the most erosive winters in documented history with widespread beach narrowing and erosion. As a result, the starting point of comparison for these beaches is likely narrower than the longer-term running average.

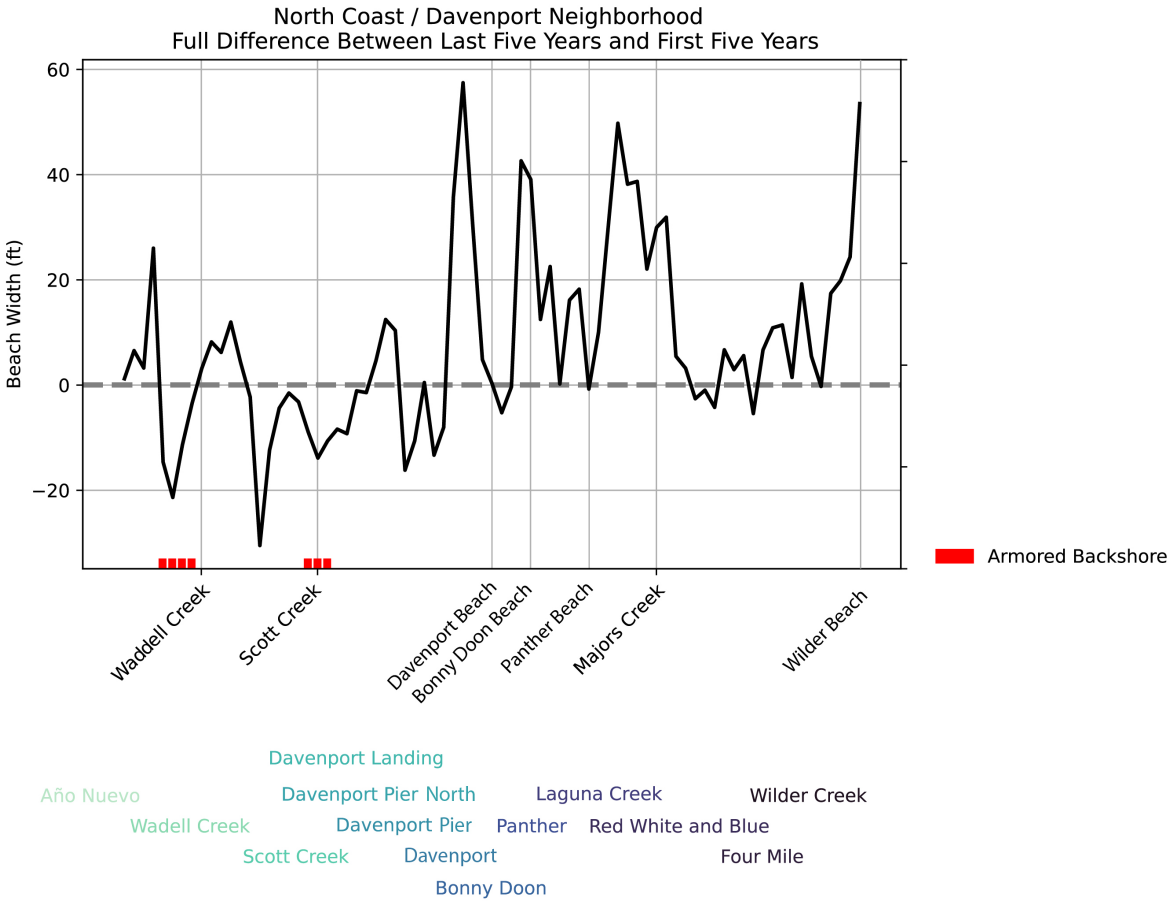


Figure 3-9. Alongshore Difference in Beach Width between the Time Periods of 1984–1989 and 2019–2024

The y-axis represents the most recent 5-year average minus the historical 5-year average. Negative numbers indicate net narrowing, and positive numbers indicate net widening. Cliff-backed shorelines have been excluded from the trend line.

3.1.6 Vulnerability to Sea Level Rise

3.1.6.1 Storm Recurrence and Sea Level Rise

With SLR, coastal flooding elevations[1] will reach more impactful flood elevations more frequently and will produce greater depths of flooding. Figure 3-10 illustrates storm recurrence intervals and flood depths with SLR.

[1] Defined by a total water level, which includes tides + wave runup + meteorological factors

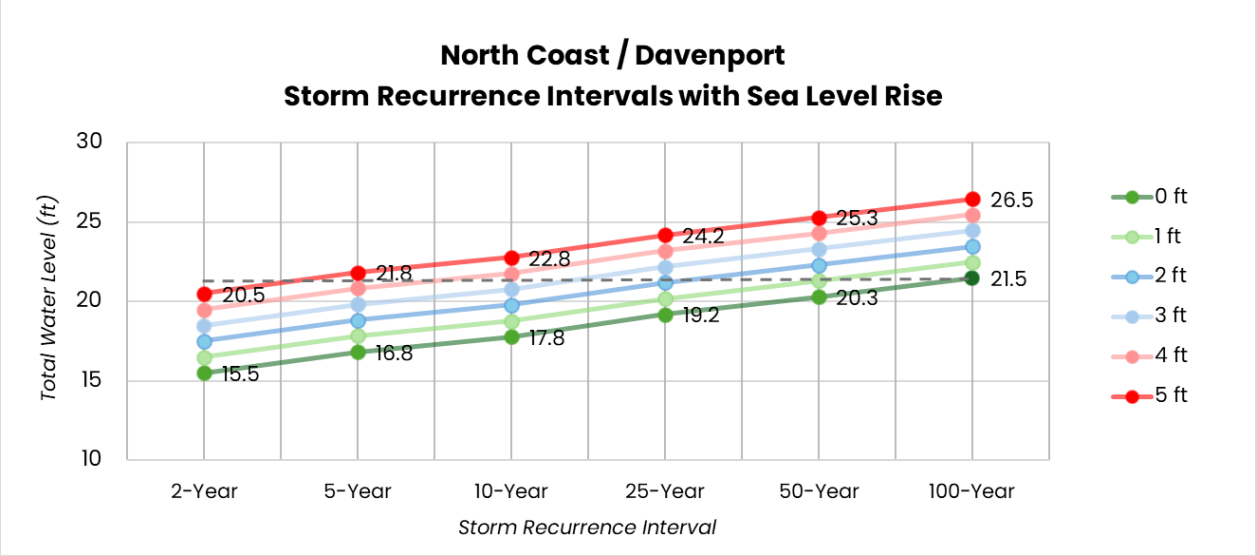


Figure 3-10. Average Storm Recurrence Intervals and Associated Total Water Levels (in ft) with SLR for all FEMA Transects in the Neighborhood

The dashed line represents the total water level associated with the current 100-yr storm.

Currently, a 100-year storm (1% annual chance) produces an average total water level of about 21.5 ft. With 1 ft of SLR, that same flooding level would occur during a 50-year storm (2% annual chance), effectively doubling how likely that total water level could be reached. With 2 ft of SLR, a similar total water level would occur during a 25-year storm (4% annual chance), and with 3 ft, during a 10-year storm (10% annual chance).

Smaller, more frequent storms will also bring higher water levels over time. Under today's sea level conditions, 2-year (50% annual chance) storms reach about 15.5 ft. With 1 ft of SLR, that increases to 16.5 ft, equivalent to what is now a 5-year storm (20% annual chance). At 2 ft of SLR, 2-year storm water levels rise to about 17.5 ft, similar to today's 10-year event.

3.1.6.2 Key Assets at Risk with SLR

As sea levels rise, the North Coast / Davenport area will experience increasing exposure to coastal hazards, including flooding, erosion, and beach loss. These impacts will affect a range of community assets, from residential structures and park facilities to Highway 1 and the region's recreational beaches.

Land Use and Structures

Figure 3-11 summarizes the number of structures exposed to coastal hazards under increasing SLR, presents the associated cost ranges for those impacts, and provides a comparative view of potential damages by hazard type.

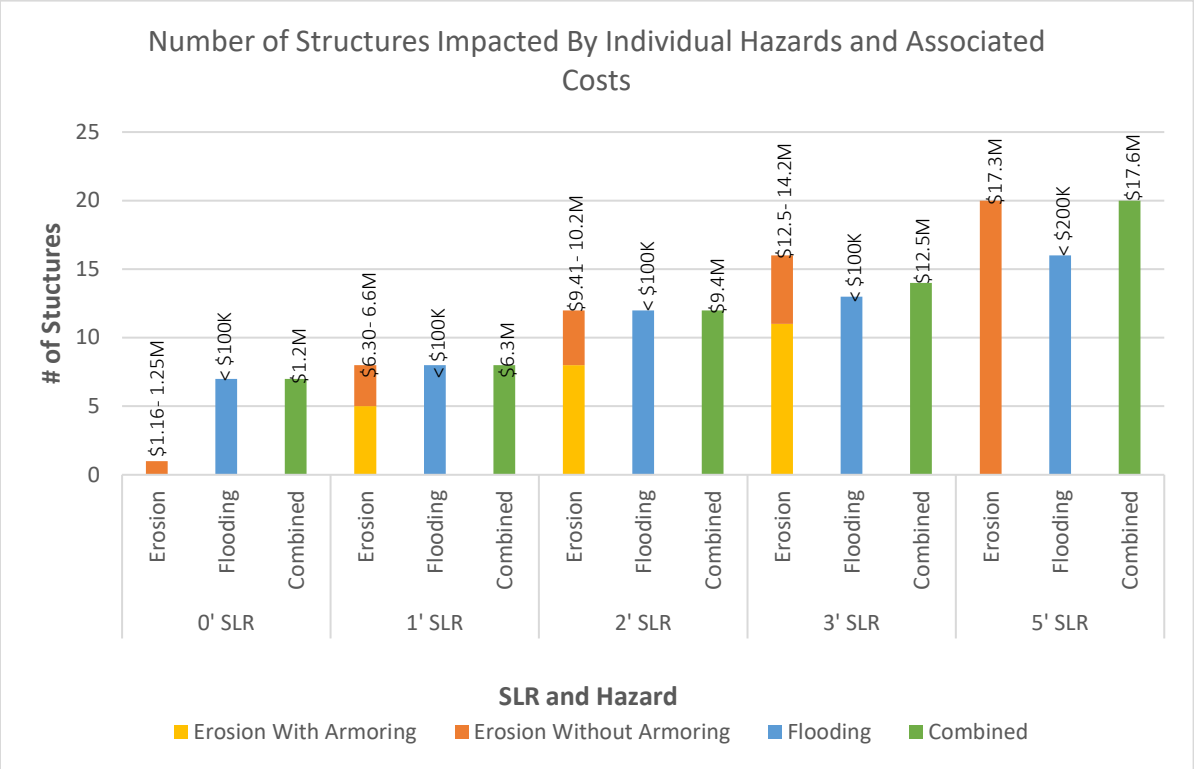


Figure 3-11. Number of Structures Exposed to Coastal Hazards and Associated Costs under Different SLR Scenarios

Costs associated with coastal erosion include the permanent loss of land value and structures. Costs associated with flooding include temporary damage to structures and contents. The combined category includes both, but removes flood damages to unarmored structures lost to erosion in prior horizons. Only structures within the 100-yr storm hazard area are included.

The North Coast / Davenport neighborhood has a large land area exposed to coastal erosion; however, the majority of this is non-market valued government-owned parkland, and thus those losses are not reflected in Figure 3-12 (further details on this can be found in Countywide Vulnerability Assessment Summary). Compared to other neighborhoods in the county, the neighborhood has very few structures exposed to coastal hazards. Coastal flooding affects about 7–16 structures across all SLR scenarios, with cumulative damages to these structures due to flooding accounting for less than $200K by 5 ft of SLR. In comparison, exposure of land area and structures to coastal erosion is much higher due to the size of the

neighborhood, but the overall damage numbers are much lower than those in the developed portions of the Santa Cruz County coastline.

Figure 3-12 illustrates the probability that a structure will experience damage due to wave exposure or coastal erosion with SLR. This assumes a more risk-averse scenario and identified all structures with the potential to be impacted during a 500-year storm event, and assumes coastal armoring is in place through 3 ft of SLR (Appendix D). **Currently**, most structures (57%) have a low chance of being impacted by coastal hazards, but by **2 ft of SLR**, most structures (57%) have a medium to high chance of being impacted by coastal hazards. By **3 ft of SLR**, half of the neighborhood's coastal structures have a high to very high probability of being impacted by coastal hazards, and by **5 ft of SLR**, half of the structures are in the very high probability category.

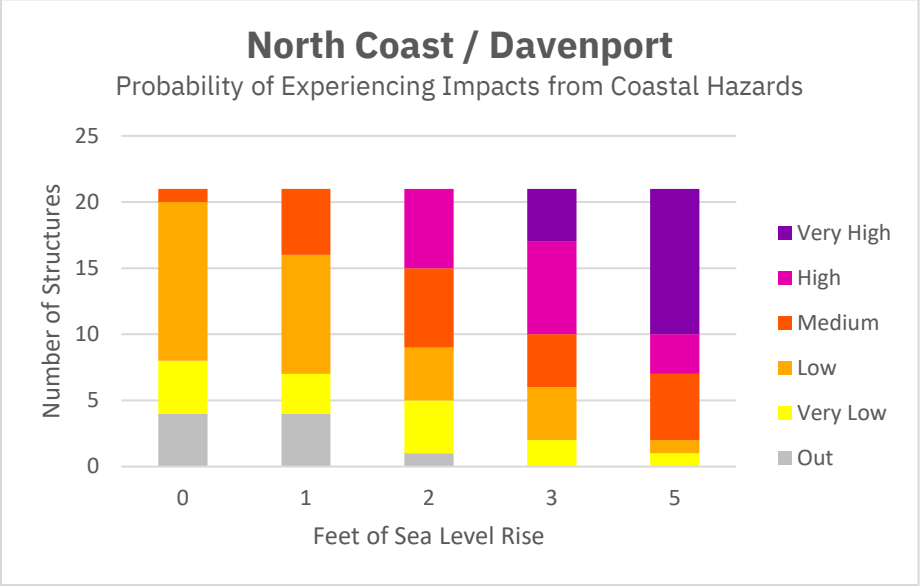


Figure 3-12. Probability of Structures Experiencing Impacts from Coastal Hazards by SLR Horizon

Assumes no adaptation measures have been taken, with armoring through 3 ft of SLR, and no armoring by 5 ft of SLR. Probabilities combine exposure to both coastal flood and erosion hazards. Flood probabilities correspond to the following: Very High = 20% or greater annual chance, High = 10%–20% annual chance, Med = 5%–10% annual chance, Low = 1%–5% annual chance, Very Low = 0.2%–1% annual chance. Erosion probabilities are related to the length of time a structure is within the erosion hazard zone, as well as the armoring condition of the backshore. See Appendix D for more details.

Roads

Currently, much of Highway 1 is elevated above the active beach and wave run-up zone, which generally limits direct impacts from storm-wave flooding. As a result, coastal erosion, rather than flooding, represents the primary coastal hazard vulnerability along Highway 1. However, there are a few low-lying areas near some of the larger creek mouths, such as Scott Creek and Waddell Creek, that are exposed to flooding during large storm events.

Highway 1 around the Waddell Creek area is currently protected by coastal armoring. However, erosion is already affecting the unarmored segments of Highway 1 near Waddell Creek, and in the absence of armoring, additional portions of the highway in this reach are projected to become exposed to coastal erosion. Similarly, the Highway 1 crossing at Scott Creek is partially armored, but is expected to be impacted by beach scouring and erosion with SLR. Just over three-quarters of a mile of highway is exposed to coastal erosion with armoring in place (Figure 3-13).

By 2 ft of SLR, multiple localized segments of Highway 1 close to the cliff-tip edge between Scott Creek and Waddell Creek by Big Creek Lumber as well as south of Davenport near Bonny Doon Beach are exposed to coastal erosion.

By 5 ft of SLR, more extensive segments of Highway 1 near Big Creek Lumber as well as south of Davenport are exposed to cliff erosion, and segments near Scott Creek and Waddell Creek are exposed to dune erosion. Approximately 3 miles of highway is exposed to coastal erosion by this horizon (Figure 3-13).

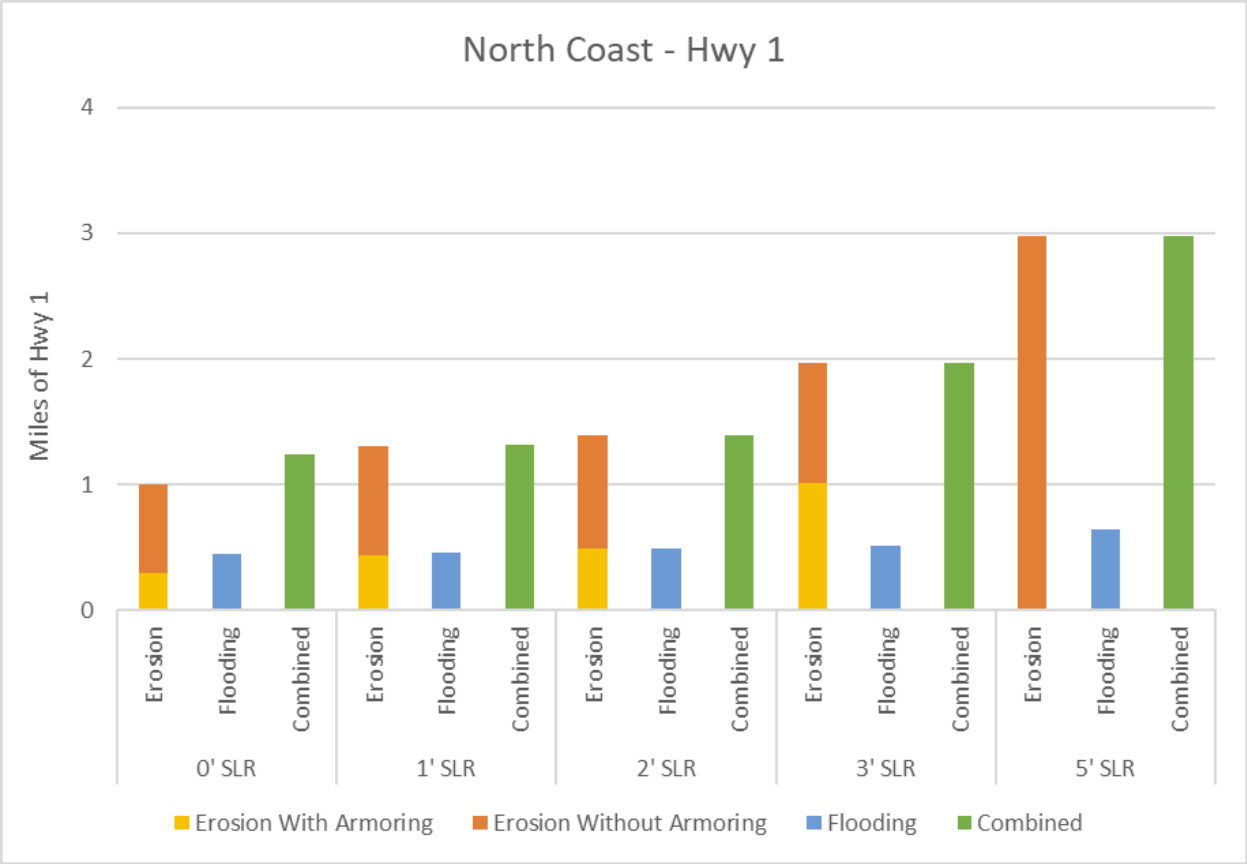


Figure 3-13. Highway 1 Miles in the North Coast / Davenport Exposed to Coastal Hazards and SLR

Results shown assume armoring is in place through 3 ft of SLR, and by 5 ft of SLR, armoring is no longer in place.

Beaches

When changes in seasonal beach widths with SLR were modeled in this study, it was assumed that the backshore position remains fixed. Though this is a safe assumption on developed coastlines, on the North Coast, many beaches have undeveloped upland areas that may have space to migrate inland. As a result, several beaches may have the ability to retain beach width in response to SLR as coastal cliffs erode.

Assuming a fixed backshore, SLR will lead to gradual narrowing of recreational beaches. Modeling results indicate that average winter beach widths decline from an average of nearly 200 ft today to under 100 ft with 3 ft of SLR, and narrow further to just above 50 ft by 5 ft of SLR (Figure 3-14).

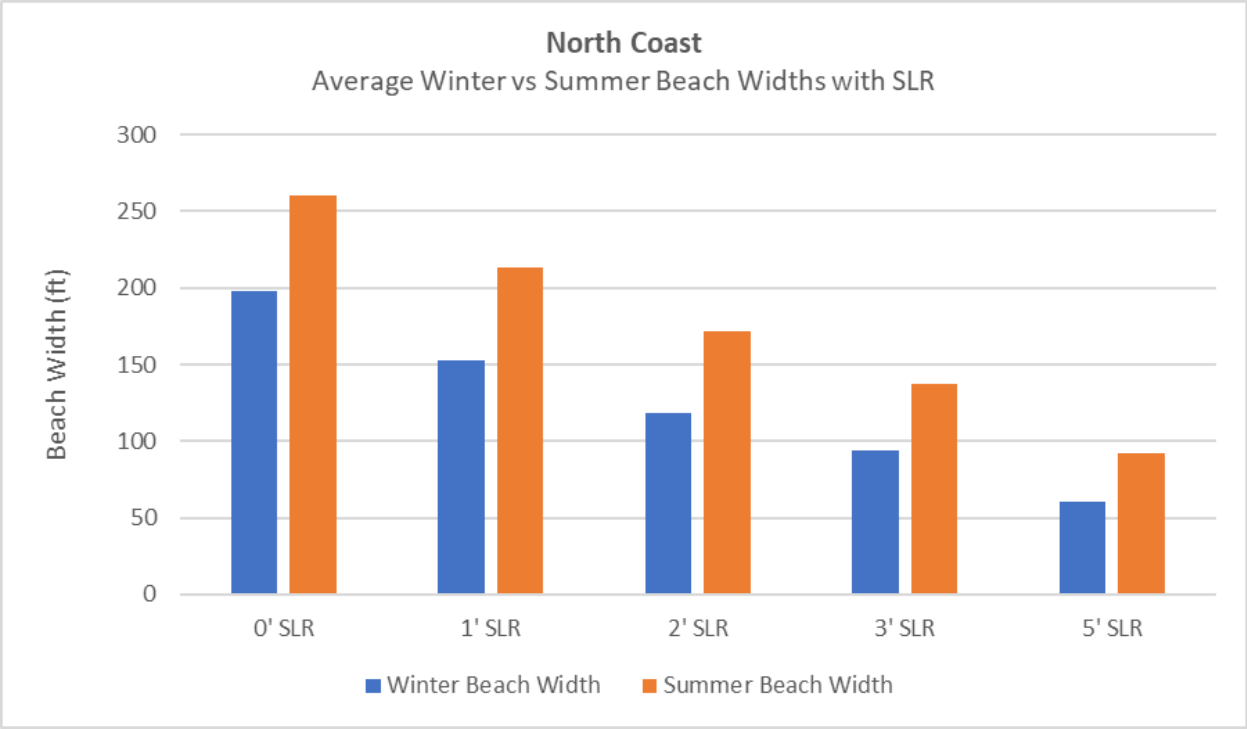


Figure 3-14. North Coast / Davenport Summer and Winter Beach Widths with SLR

Currently, cliff-backed beaches such as China Ladder and Greyhound Rock Beach (not listed explicitly in Table 3-1) are the most vulnerable to SLR. These beaches often retain little dry sand in the winter today, and many drown by 1 ft of SLR (Table 3-1).

By 2 ft of SLR, significant reductions in beach width begin occurring at many of the wider and more visited beaches, including at Davenport Landing, Panther, and Four Mile Beach. By this time horizon, Davenport Landing Beach is projected to experience nearly an 80% reduction in width, Panther Beach is projected to experience nearly a 70% reduction, and Four Mile Beach is projected to experience a 50% reduction in width (Table 3-1).

By 3 ft of SLR, several popular beaches, including Davenport Landing, Davenport Pier, and Panther Beach, experience near complete or complete loss of dry sand in the winter. Of these beaches, Davenport Landing is less constrained by Highway 1 and may have space to migrate inland in response to SLR.

By 5 ft of SLR, nearly all beaches experience a complete loss of winter beach except for the creek-mouth systems such as Waddell Creek, Scott Creek, Bonny Doon, Laguna, and Wilder Creek[2] beaches (Table 3-1).

[2] Wilder Creek Beach is a protected natural preserve and is closed to public access.

Table 3-1. North Coast / Davenport winter beach conditions with SLR

Beach	SLR (ft)				
	0	1	2	3	5
All Cliff-Backed Beaches	🔴	🟤	🟤	🟤	🟤
Año Nuevo Beach	🟢	🟡	🔴	🟤	🟤
Waddell Creek Beach *	🟢	🟢	🟢	🟢	🟡
Scott Creek Beach *	🟢	🟢	🟢	🟢	🟡
Davenport Landing	🟢	🟡	🟡	🔴	🟤
Davenport Pier	🟢	🟡	🔴	🟤	🟤
Davenport Beach	🟢	🟡	🟡	🟡	🔴
Bonny Doon Beach	🟢	🟢	🟢	🟢	🟡
Panther Beach	🟢	🟡	🟡	🔴	🟤
Laguna Creek Beach	🟢	🟢	🟢	🟢	🟢
Red, White and Blue	🟢	🟡	🟡	🟡	🟡
Four Mile	🟢	🟢	🟡	🟡	🟡
Wilder Creek	🟢	🟢	🟢	🟢	🟢

🟢 = 100 ft+, 🟡 = 25–100 ft, 🔴 = <25 ft, 🟤 = no beach

* = partially armored

Coastal Access

Much of the coastal access along the North Coast of Santa Cruz County is accommodated by trails leading along the bluff and cliff face down to the beach. Under current conditions and with minor cliff and dune erosion, most of these access points remain usable. In many cases, erosion would need to progress further inland before access is constrained.

Currently, coastal erosion exposes a large area of undeveloped open space and parkland. **By 2 ft of SLR**, trails around Davenport Landing and along the cliffs south of Davenport become increasingly constrained by erosion. Several other access locations also become more vulnerable at this stage, including parking areas at Cliffs Beach and China Ladder Beach, as well as trails and facilities at Scott Creek Beach. The Waddell Creek beachside parking lot, which has already experienced impacts related to coastal erosion and storm wave flooding, will

continue to be at risk from storm wave overtopping and beach scour impacting the maintenance of the coastal armoring structures.

By 5 ft of SLR, coastal erosion exposes the beachside parking area at Waddell Creek, and the Greyhound Rock parking area. By this horizon, many bluff-top and beach access trails along the Davenport coastline would likely need to be realigned or could be lost due to continued erosion.

Table 3-2. North Coast / Davenport key coastal access points impacted

Coastal Access	SLR (ft)				
	0	1	2	3	5
Waddell Creek Parking Area	🟢	🟢	🟡	🟡	🔴
Greyhound Rock Trails and Parking	🟢	🟢	🟡	🟡	🟡
Scott Creek Trails and Facilities	🟢	🟢	🟡	🟡	🟡
Davenport Landing Trails and Facilities	🟢	🟡	🟡	🔴	🔴
Coastal Trails Near Davenport	🟢	🟡	🔴	🔴	🔴

🟢 = functional and accessible, 🟡 = at risk from flooding, erosion, and beach loss, 🔴 = no longer accessible

3.1.6.3 Risk Summary

The North Coast / Davenport neighborhood exhibits low structural exposure to SLR hazards but high exposure to recreational areas such as beaches, parking areas, park facilities, and trails, as well as key transportation assets such as Highway 1. Many County and State Park assets and facilities such as restrooms and parking areas have a medium to high adaptive capacity because many parks have space away from hazardous areas to which these facilities could be moved. Key findings by time horizon are summarized below.

North Coast / Davenport: Near Term (0–1 ft of SLR). By 1 ft of SLR:



Eight structures are within the 100-yr flood hazard area, and one is exposed to coastal cliff erosion. This includes five residential homes at Davenport Landing that are exposed to coastal erosion and wave flooding.

Seventeen structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse hazard scenario. Five are categorized as having medium to very high probability of impact.

Two vault toilets at the Waddell Creek Parking area, the scenic lookout platform at the Scott Creek Parking area, and a storage shed located west of Highway 1 just north of Greyhound Rock County Park are exposed to coastal erosion and wave flooding.

A middle estimate[3] for cumulative combined damages to structures and land area is projected to be $6.3M. Most of this is the result of coastal cliff and dune erosion (this does not include government-owned land).



Bridges over Scott[4] and Waddell[5] creeks, where the California Department of Transportation (Caltrans) is currently evaluating replacement strategies, are exposed to coastal flooding hazards. The branch line railroad and planned coastal trail alignment near Davenport, located within approximately 30 ft of the bluff edge, are vulnerable to cliff erosion.



No major wastewater, stormwater, or water supply facilities are directly exposed.



More than 200 acres of parkland is exposed to cliff and dune erosion. Beach access, parking, and trails at Scott Creek, Waddell Creek, and Davenport Landing are exposed to dune erosion and storm flooding, reducing reliability during winter storms.

[3] Middle estimate represents one 25-yr storm and multiple smaller 5-yr storms over a 20-yr window.
[4] The Scott Creek Coastal Resiliency Project, a partnership between the Resource Conservation District of Santa Cruz County, the Santa Cruz Regional Transportation Commission, and California Department of Transportation (Caltrans) District 5, along with other state and federal resource agencies, are collaborating to develop a strategy to address the public access, conservation, and climate change resiliency of the Scott Creek estuary.
[5] The San Vicente-Waddell Coastal Resilience project team, a partnership between the Santa Cruz County Regional Transportation Commission, Santa Cruz County Resource Conservation District, and Caltrans District 5, are currently studying solutions for vulnerable areas including the Highway 1 bridge over Waddell Creek at Big Basin, the Santa Cruz Branch Rail Line corridor, and the Highway 1 bridge over San Vicente Creek at Davenport.



Waddell and Scott creeks will see greater wave overtopping and tidal exchange, leading to a change in salinity with potential effects to habitats and species.

North Coast / Davenport: Mid Term (1–3 ft of SLR). By 3 ft of SLR:



Twelve structures are within the 100-yr flood hazard area.

Twenty structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse hazard scenario. Fifteen structures are categorized as having medium to very high probability of impact.

Ten structures at Davenport Landing are vulnerable to dune erosion and coastal flooding.

A middle estimate for cumulative combined damages to structures and land area is projected to be $12.5M. Most of this is the result of coastal cliff and dune erosion (this does not include government-owned land).



Highway 1 at Scott Creek and Waddell Creek areas continues to be exposed to coastal wave hazards and dune erosion, leading to slope failure and embankment undermining of the roadway.

Highway 1 near Bonny Doon Beach is exposed to dune erosion. Cliff erosion hazards threaten areas of Highway 1 where the alignment is close to the cliff, including just north and south of Greyhound Rock County Park, at China Ladder and Cliffs Beach, and South of Davenport near Rodini Farms.



No major wastewater or water supply infrastructure is directly exposed. Stormwater drainage infrastructure is exposed at Davenport Landing.



Waddell Creek Beach parking and restrooms are exposed to wave flooding, while beaches at Davenport Pier, Davenport Landing, Panther, and Año Nuevo narrow to less than 25 ft in winter. Coastal trails and access points are increasingly exposed to erosion, though many may be realigned inland.



Increasing wave overtopping into the lagoons will affect water quality and likely cause a significant change in habitats.

North Coast / Davenport: Long Term (3–5 ft of SLR). By 5 ft of SLR:



Sixteen structures are within the 100-yr flood hazard area.

Twenty-one structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse hazard scenario. Nineteen structures are categorized as having medium to very high probability of impact.

With coastal armoring in place through 3 ft of SLR, a middle estimate for cumulative combined damages to structures and land area is projected to be $17.6M. Most of this is the result of coastal cliff and dune erosion (this does not include government-owned land).



Approximately 3 miles of Highway 1 is exposed to coastal erosion and wave hazards, with regular high-tide flooding near Waddell Creek. Pavement washouts at Scott Creek and Wadell Creek may become a regular occurrence, necessitating frequent repairs, causing long-term access issues.

Cliff erosion increasingly threatens highway segments near Greyhound Rock, China Ladder, Cliffs Beach, Scott Creek, and south of Davenport, while even armored sections near Año Nuevo and the county line face erosion that could impede access to San Mateo County.



No major wastewater or water supply infrastructure is directly exposed. Stormwater drainage infrastructure is exposed at Davenport Landing.



More than 350 acres of parkland is exposed to cliff and dune erosion, and all beaches are lost except at creek mouths, including Waddell, Scott, Bonny Doon, Laguna, and Wilder creeks, reducing recreational capacity along a coastline with ~70,000 annual visits.



The lagoon outlets may remain permanently open, significantly altering lagoon ecology and salinity regimes.

3.1.7 Key Adaptation Strategies for Consideration

Based on the exposure and vulnerability findings described above, the following list summarizes potential adaptation strategies for the North Coast / Davenport neighborhood that will be further evaluated. The County owns Greyhound Rock Park, manages access at Davenport Landing and other coastal access points, and collaborates with state and other partners at other parks and open space areas.

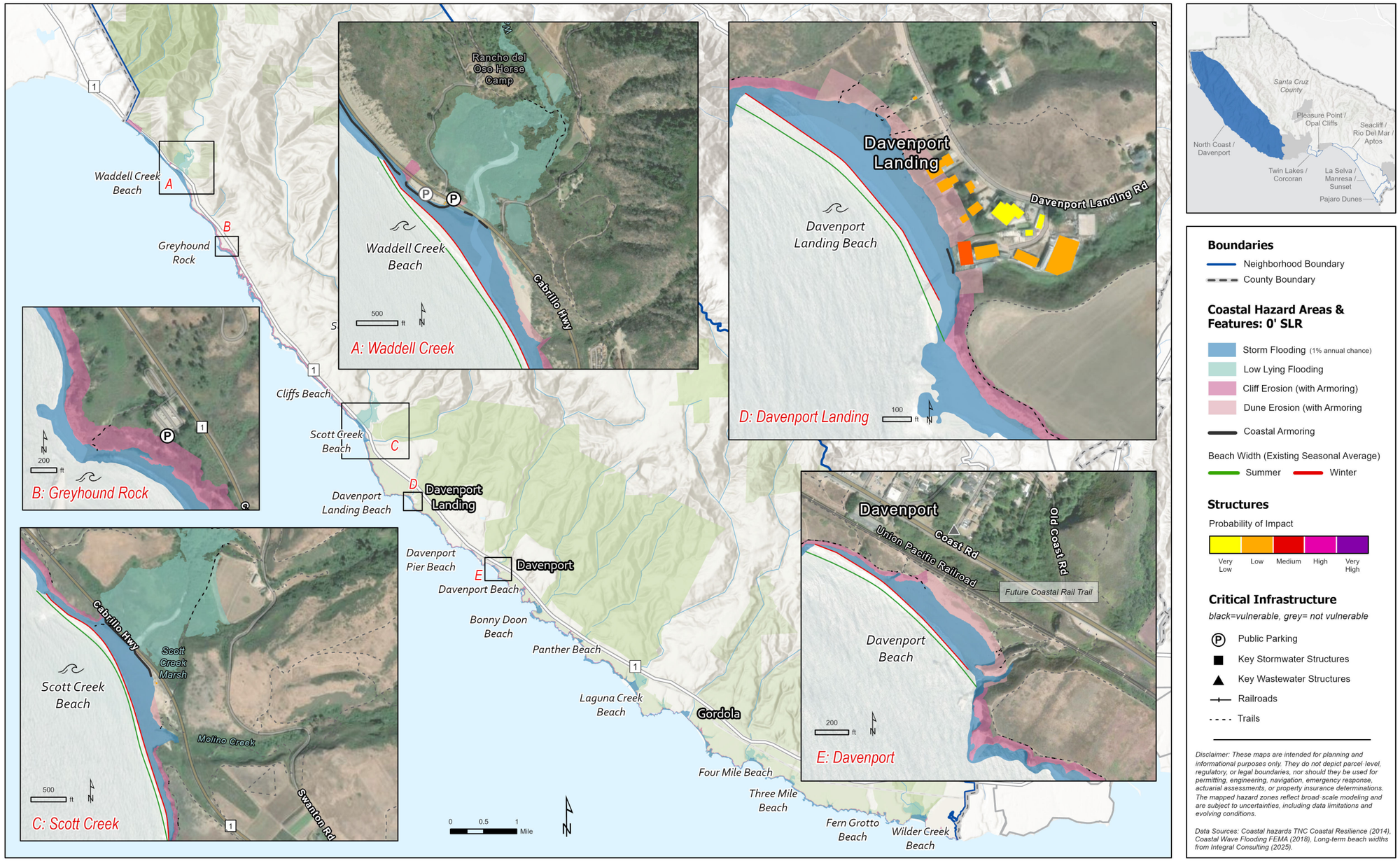
Near Term

- Planning and Alignment
  - Coastal access planning (State Parks, County Parks, Bureau of Land Management, Land Trusts, others)
  - Highway 1 planning at bridges and along cliff-backed coastlines (Caltrans)
  - Branch railroad alignment (Santa Cruz County Regional Transportation Commission and other partners)
- Nature-Based Solutions
  - Cliff and dune restoration
  - Sediment management

Mid Term-Long Term

- Managed Retreat
  - Relocation of State Park facilities and assets
  - Realignment and raising of sections of Highway 1
  - Realignment of the Branch Railroad.

North Coast / Davenport - Coastal Hazard Areas: 0 ft SLR with Existing Armoring



Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 0' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (with Armoring)
- Dune Erosion (with Armoring)
- Coastal Armoring

Beach Width (Existing Seasonal Average)
- Summer
- Winter

Structures

Probability of Impact: Very Low, Low, Medium, High, Very High

Critical Infrastructure

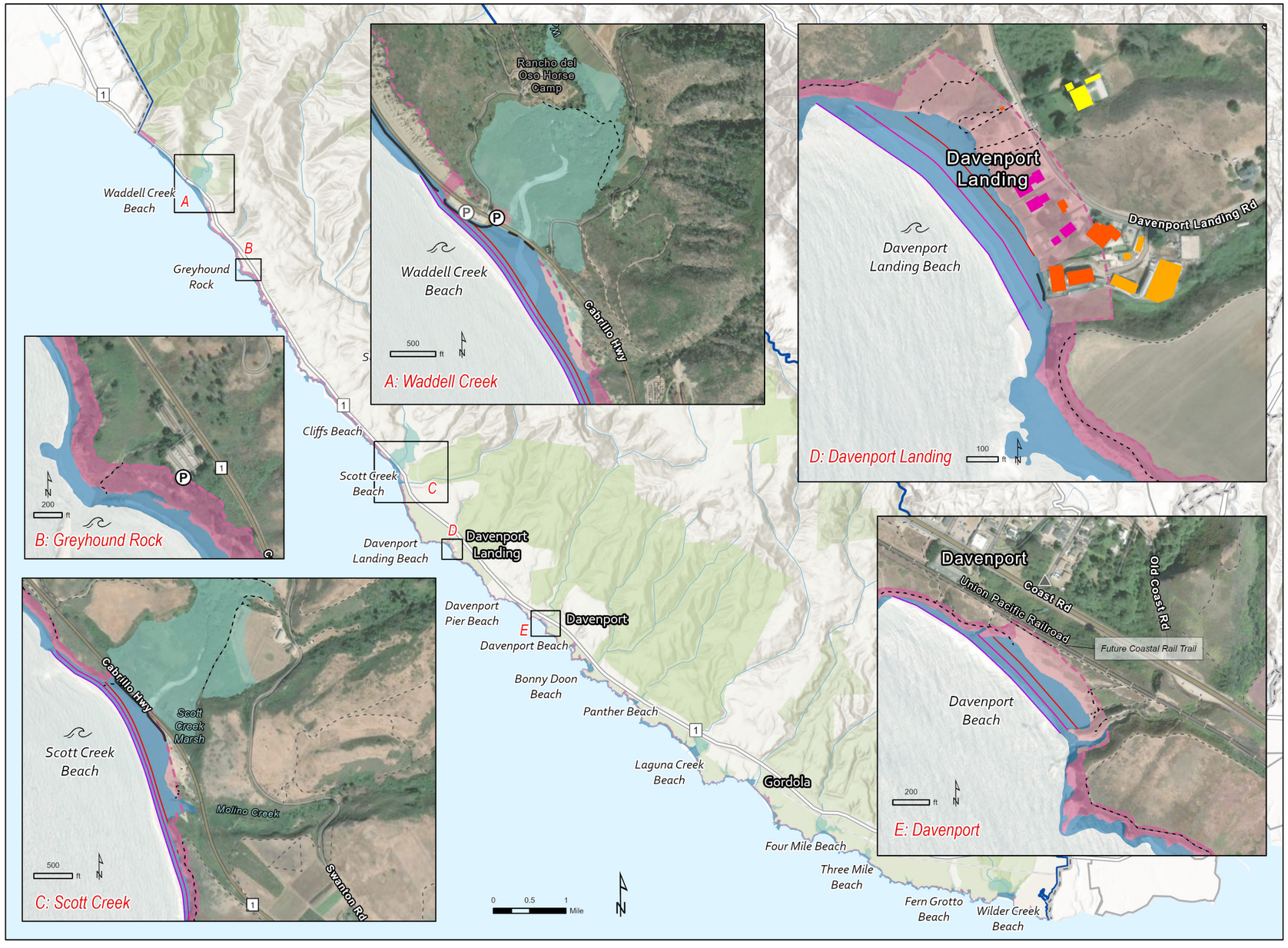
black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-15. North Coast / Davenport SLR Vulnerability Map—0 ft of SLR with Existing Armoring

North Coast / Davenport - Coastal Hazard Areas: 2 ft SLR with Existing Armoring





Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 2' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (with Armoring)
- Dune Erosion (with Armoring)
- Erosion Extent without Armoring
- Coastal Armoring

Winter Beach Width (ft of SLR)

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Structures

Probability of Impact

Very Low | Low | Medium | High | Very High

Critical Infrastructure

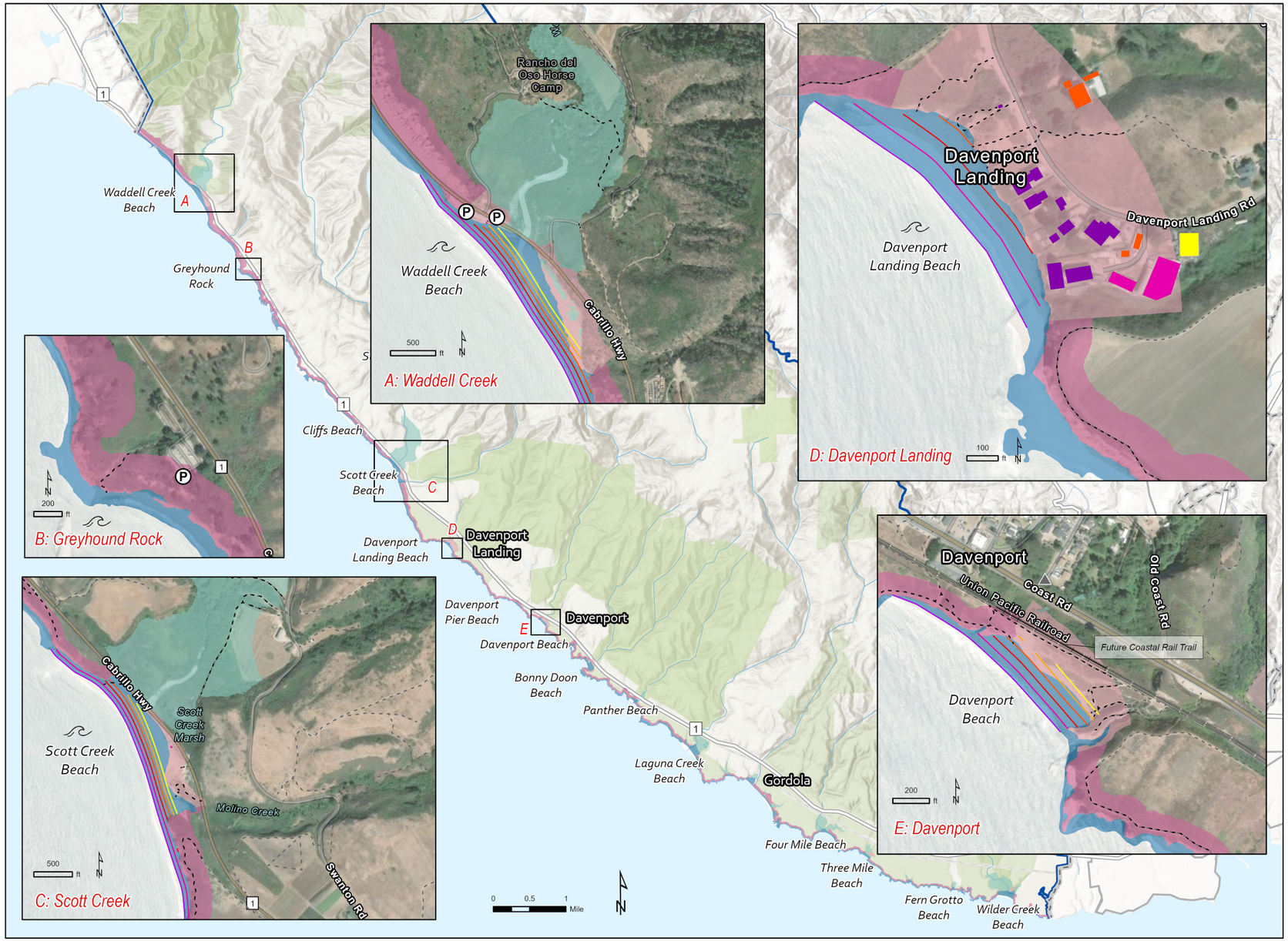
black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-16. North Coast / Davenport SLR Vulnerability Map—2 ft of SLR with Existing Armoring

North Coast / Davenport - Coastal Hazard Areas: 5 ft SLR without Existing Armoring





Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 5' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (without Armoring)
- Dune Erosion (without Armoring)

Winter Beach Width (ft of SLR)
0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Structures
Probability of Impact
Very Low | Low | Medium | High | Very High

Critical Infrastructure
black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-17. North Coast / Davenport SLR Vulnerability Map—5 ft of SLR without Existing Armoring

3.2 TWIN LAKES / CORCORAN

3.2.1 Overview

The Twin Lakes / Corcoran neighborhood lies along the central coast of Santa Cruz County between the City of Santa Cruz boundary and Soquel Point, and encompasses approximately 1.6 miles of coastline. It is characterized by sandy beaches, coastal promontories, and a series of coastal lagoon systems. The neighborhood coastline is a densely developed residential area serviced by East Cliff Drive, the main coastal transportation corridor running east–west connecting the City of Santa Cruz to Capitola. This arterial road runs through three low-lying coastal lagoons: Schwan Lagoon, Corcoran Lagoon, and Moran Lake. The area is characterized by its coastal homes, small local businesses, and a mix of beach and lagoon environments that are highly popular for recreation and coastal access.



Figure 3-18. Black Point (Source: Friends of Corcoran Lagoon Beach)

3.2.2 Community Characteristics

The Twin Lakes / Corcoran area is one of the most densely populated coastal neighborhoods in unincorporated Santa Cruz County. The community consists primarily of single-family homes, small multi-family units, and vacation rentals. The population reflects a blend of permanent residents and seasonal visitors. The neighborhood's proximity to both the beach and lagoon environments creates a unique blend of residential and recreational land use. Within the neighborhood boundary, 36% of the area (as defined by census tract boundaries) is designated as a disadvantaged community (California State Water Resources Control Board 2020), and the average CalEnviroScreen score is 26, placing it in the 26th percentile statewide for cumulative

pollution burden and population vulnerability. This indicates that the neighborhood experiences low to moderate environmental and socioeconomic stressors compared to many other communities in California (OEHHA 2021).

3.2.3 Infrastructure and Development

Land use in this neighborhood is primarily residential, with many homes situated close to the shoreline bluffs and along the margins of local lagoons. Commercial activity is limited to small businesses and restaurants concentrated along East Cliff Drive. Key infrastructure includes the Santa Cruz Harbor entrance and the major transportation corridors of East Cliff Drive, 7th Avenue, and Portola Drive.

Critical wastewater infrastructure consists of a restroom and the Schwan Lake Pump Station at Twin Lakes State Beach near 7th Avenue, and a wastewater conveyance pipe and force main beneath East Cliff Drive. This conveyance pipe travels from the Santa Cruz Harbor to the County's Lode Street Facility under East Cliff Drive and Portola Road, and traverses a low-lying area adjacent to Schwan Lake. Further, critical sewer infrastructure also underlies East Cliff Drive at Schwan and Moran lagoons.

The DA Porath Pump Station is located at the Lode Street Facility, and additional wastewater pump stations include the 15th Avenue Pump Station near Bonita Lagoon, the Rodeo Pump Station near Portola Drive, and the Moran Pump Station at the upper end of Moran Lake by Placer Street.

Public access is supported by state park facilities, parking areas, and paved coastal trails. Many portions of the shoreline have been armored with seawalls and revetments to protect development and infrastructure.

Key assets and infrastructure in the coastal study area include:

- Santa Cruz Harbor entrance
- Restroom and wastewater pump at Twin Lakes Beach
- Wastewater conveyance pipe and force main under East Cliff Drive
- Critical transportation corridors include East Cliff Drive, Portola Drive, and 7th Avenue.

3.2.3.1 Santa Cruz Harbor and Dredging

Santa Cruz Harbor requires regular dredging because its entrance jetties interrupt natural longshore sediment transport, causing sand to accumulate in the harbor channel and adjacent upcoast areas at Seabright Beach. Without dredging, the channel would quickly shoal and limit safe navigation in and out of the harbor. The Harbor District conducts this dredging in the wintertime and places the sand downcoast on Twin Lakes Beach to maintain the downcoast sediment supply for beaches. According to data sent from the Port Director (Holland 2025, pers. comm.), for the past four years (2020–2024), the dredge operation bypassed on average

~210,000 cubic yards of sand annually. However, there can be significant variability in the dredge volumes depending on upcoast sediment supply, San Lorenzo River discharge, and funding and equipment operations. These operations are permitted by the U.S. Army Corps of Engineers, and the current permits limit the placement locations and the time period during which dredging can occur. While this practice helps offset some impacts, the harbor has altered natural coastal processes by trapping sand and widening up-coast beaches such as Seabright Beach, while also influencing beach widths and the timing of sand supplied to downcoast beaches.

3.2.4 Recreation and Coastal Resources

The coastal lagoons, shoreline cliffs, surf breaks, and sandy beaches of the Twin Lakes / Corcoran neighborhood support both recreational activities and ecosystem services. Schwan Lake, Corcoran Lagoon, and Moran Lake serve as coastal wetlands with ecological and hydrological functions providing important habitat for birds, fish, and amphibians. The neighborhood's recreational amenities include Twin Lakes State Beach, the eastern end of the Santa Cruz Harbor, volleyball courts, and nearby walking and cycling routes along East Cliff Drive. Twin Lakes State Beach and its adjacent pocket beaches are heavily used for swimming, surfing, kayaking, and beachgoing. The area is also home to five popular surf breaks: The Harbor, Murph Bar, Black's Beach, Sunny Cove, 26th Avenue, and Santa Moes. These surf breaks attracted as many as 130,000 surf visits in 2024.[6]

The natural and recreational character of the area contributes to high year-round visitation, particularly during the summer months. Twin Lakes Beach is the most visited beach in the unincorporated County, drawing just under 200,000 visits in 2024, with an even distribution between the beach area from the harbor to Schwan Lagoon, and the eastern area known as Black's Beach. Moran Lake Beach and Corcoran Lagoon Beach also saw notable use, with an estimated 20,800 and 17,000 visits, respectively (Figure 3-19 and Figure 3-20). Visitation is highly seasonal, with approximately 81% of all beach visits occurring between May and October. Corcoran Lagoon Beach, which, unlike many nearby beaches, retains a dry sandy beach throughout the winter, has a significantly higher distribution of wintertime visits than other beaches in the neighborhood (Figure 3-21).

Sunny Cove Beach is excluded from the beach-width analysis as beach-width data were not available. Sunny Cove Beach receives an estimated 70,000 annual visits, which would make it the third most-visited beach in this neighborhood.

[6] These estimates are based on likely parking locations for visitors to each surf break, and do not include visits by local residents living near the breaks that they surf. For the surf-focused study, people were only counted if their phone remained in the area for more than 45 minutes. It is unlikely that beach visitors will leave their phone in the car for this length of time, and also have it with them on the beach to be captured in both locations. The potential for double-counting is therefore considered to be limited, and outweighed by the number of people who do not bring a phone at all and are therefore not identified in mobility data.

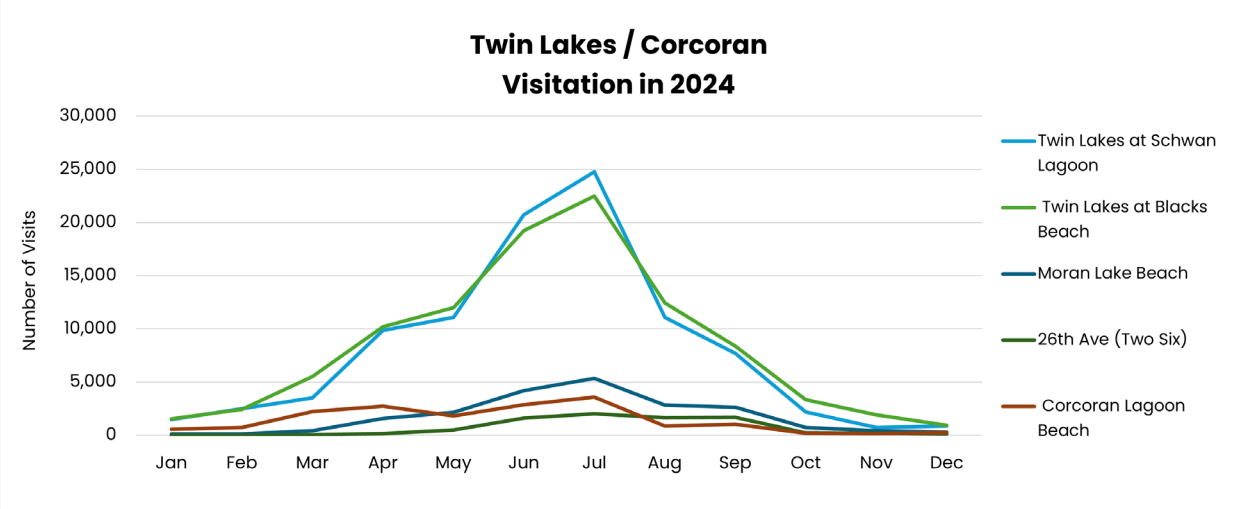


Figure 3-19. Beach Visitation (2024)

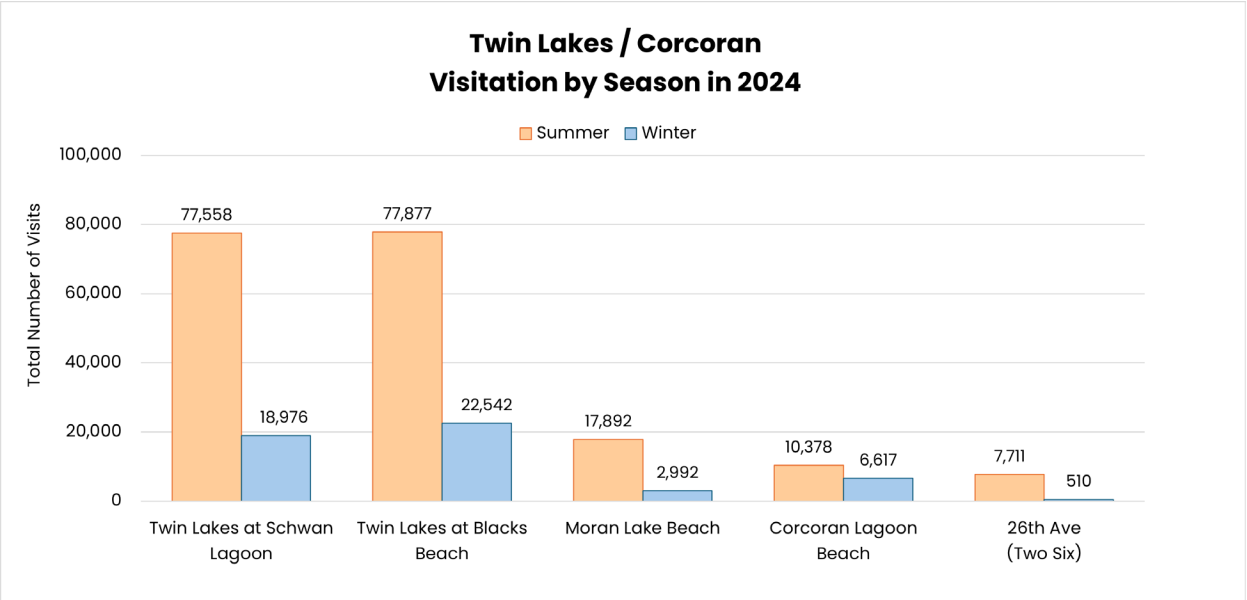


Figure 3-20. Beach Visitation Numbers for Summer and Winter (2024)

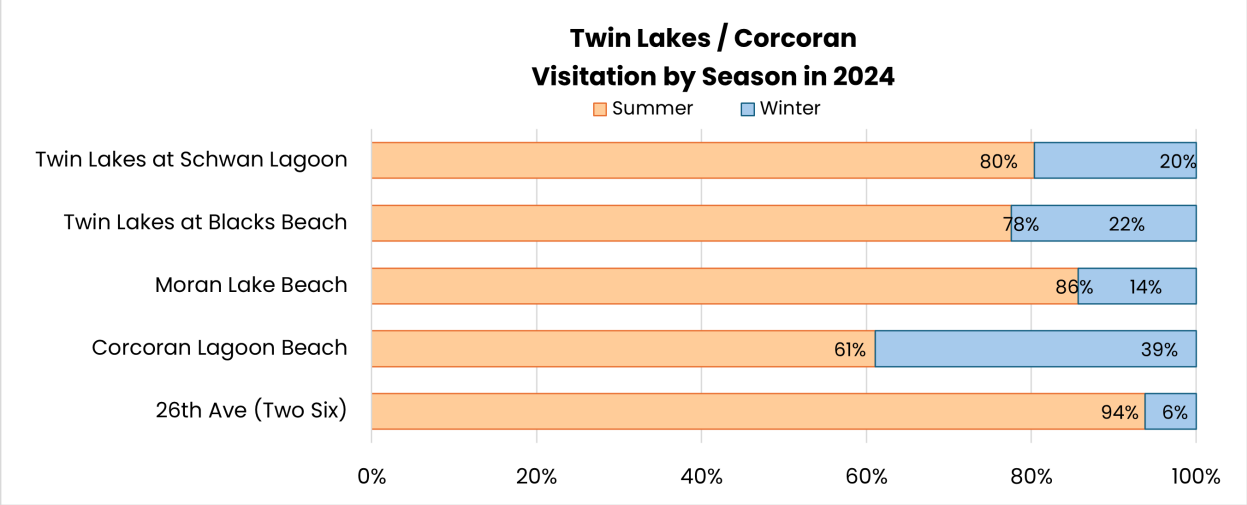


Figure 3-21. Beach Visitation Distribution (2024)

3.2.5 Coastal Processes and Hazards

3.2.5.1 Coastal Erosion

Lithologic and stratigraphic differences in the Purisima Formation, which forms the sea cliff in this area, explain the headland and pocket beach formations in this area. These geological conditions, when combined with the presence or absence of a protective beach, have produced highly variable historical erosion rates. Before 1945, much of this coastal area was rural in character, coastal armoring was not present, and the beaches were wider than today (Figure 3-22). As the area developed, armoring was emplaced to protect that development, and when the Santa Cruz Harbor jetty was constructed, upcoast sand was impounded, and areas like 26th Avenue Beach have narrowed significantly. Today, 26th Avenue Beach often completely disappears in the winter.



Figure 3-22. Aerial Images of Corcoran Lagoon and Moran Lake Areas. Left: March 1931, Right: May 2024

Note the significant increase in coastal development, the emplacement of coastal armoring, and the reduction in beach width between Corcoran Lagoon and Moran Lake (Source: UCSB, Google Earth)

3.2.5.2 Coastal Flooding

The Twin Lakes / Corcoran neighborhood experiences recurrent coastal flooding during extreme high tides and winter storms. Along Twin Lakes State, Corcoran Lagoon, and Moran Lake beaches, wave run-up during large swell events at high tide annually reaches and overtops East Cliff Drive, requiring temporary closure due to flooding of roadways, parking areas, and adjacent pedestrian infrastructure (Figure 3-23). Elevated sea levels and storm wave overtopping combined with stormwater accumulation at Corcoran Lagoon and Moran Lake can raise lagoon water levels, resulting in localized flooding along shoreline paths, park areas, and the edges of nearby residential properties[7]. Several historical storm events have produced direct wave impacts to homes along the most exposed sections of shoreline, notably near Moran Lake and Soquel Point. These flooding and wave-impact events lead to periodic coastal access disruptions, localized infrastructure damage, and contribute to back-beach and dune erosion.

[7] Santa Cruz County is currently conducting a Coastal Lagoons & East Cliff Drive Resiliency Study to evaluate nature-based adaptation strategies to increase resilience to sea level rise for the three coastal lagoons (Schwan Lagoon, Corcoran Lagoon, and Moran Lagoon)



Figure 3-23. East Cliff Drive Wave Overtopping Events. Top Left: Corcoran Lagoon (County of Santa Cruz), Top Right: Moran Lake (Source: Mike Guth). Bottom Left: Corcoran Lagoon (Source: David Revell), Bottom Right: Overhead of Corcoran Lagoon and East Cliff Drive in 2018 (Source: Friends of Corcoran Lagoon Beach)

3.2.5.3 Coastal Armoring

Twin Lakes / Corcoran neighborhood is one of the most heavily armored segments of the county shoreline, with 66% of the coastline armored and 91% of all structures fronted by coastal armoring. As exemplified in Figure 3-24, nearly all residential development is protected by seawalls or revetments. In total, 2.5 miles of armoring along the coast safeguard more than 200 bluff-top structures, as well as critical utilities that are co-located under East Cliff Drive and multiple local roads.



Figure 3-24. Coastal Armoring along 26th Avenue Beach and Corcoran Lagoon Beach (Source: Estately.com)

Along the entire neighborhood, beaches without armoring are about 275 ft wider than those with armoring. One area of the coastline that has not been armored is the southern portion of Black's Beach, with the upland area at the end of 14th Avenue managed by California State Parks (Figure 3-25). Because the backshore has been allowed to erode naturally in this location, the beach is notably wider than in armored areas immediately to the west.

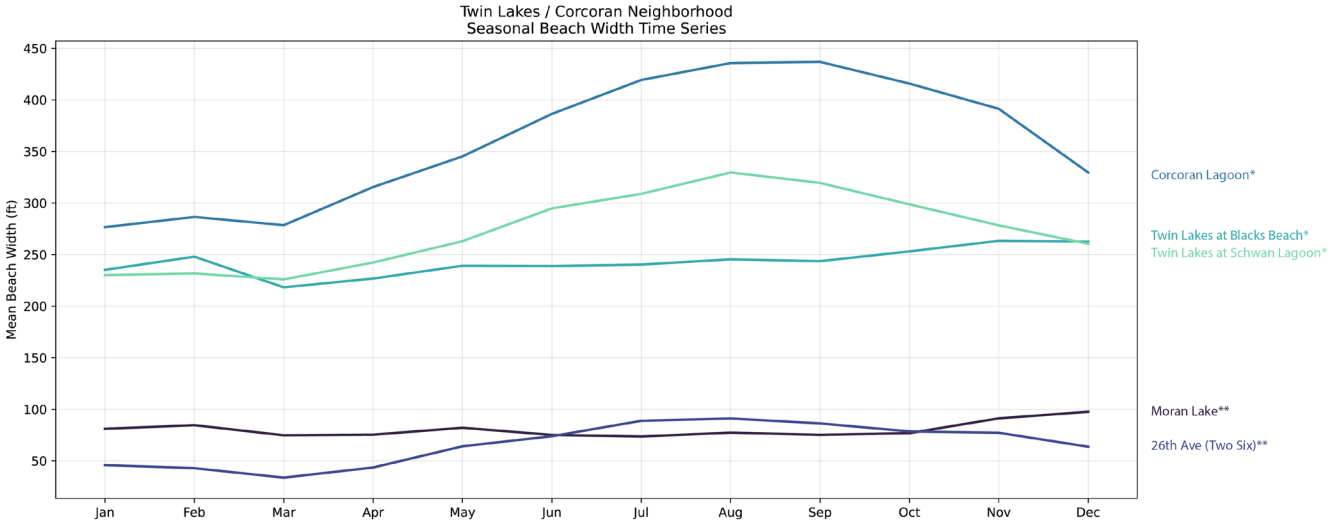


Figure 3-25. Black Beach. Left: The Narrow, Armored Portion of Black's Beach That Often Impedes Lateral Access along the Beach. Center: The Unarmored Portion of Black's Beach, Owned by State Parks (Source: Coastal Records Project, August 2024). Right: As Seen from the Beach, Looking West (Source: Integral 2025).

3.2.5.4 Beach Widths

Satellite observations over the last 40 years (1984–2024) from CoastSat reveal that beach widths are highly variable throughout this neighborhood, with wider stretches of beach at the coastal lagoons (note the wider beach at Corcoran Lagoon in Figure 3-26). Along other

stretches such as 26th Avenue Beach and between Twin Lakes Beach and Blacks Beach, the area is currently experiencing coastal squeeze and often has very little to no dry sand beach in the winter. Figure 3-26 illustrates these seasonal patterns, and on average, there is a 55-ft difference between winter beach widths and the summer beaches in this neighborhood. The largest seasonal variability is at Corcoran Lagoon and Twin Lakes Beach, with a 100- to 150-ft difference between average maximum and minimum beach widths. There is significantly less seasonal variability along the narrow-armored beaches further east. Part of the reason the seasonal variability is lower in this neighborhood compared to others can be explained by the sand dredging to maintain a navigational channel at the Harbor, which is done in the wintertime.



*partially armored
** fully armored

Figure 3-26. Seasonal Beach Width Trends by Beach (average width by month across all records from 1984–2024)

Lighter colors appear further west, and darker colors appear further east.

These armored coastal beaches within the Twin Lakes / Corcoran neighborhood have experienced an increasing erosional trend, and CoastSat beach width data indicate an average summer beach narrowing of about 1 ft per year since the mid-1980s. The beaches between Corcoran Lagoon and Moran Lake, including Two-Six beach, have experienced the largest net loss in beach width (Figure 3-27). As these already narrow beaches continue to lose beach width, backshore development will see higher exposure to coastal wave hazards, and armoring will deteriorate more quickly, increasing maintenance requirements.

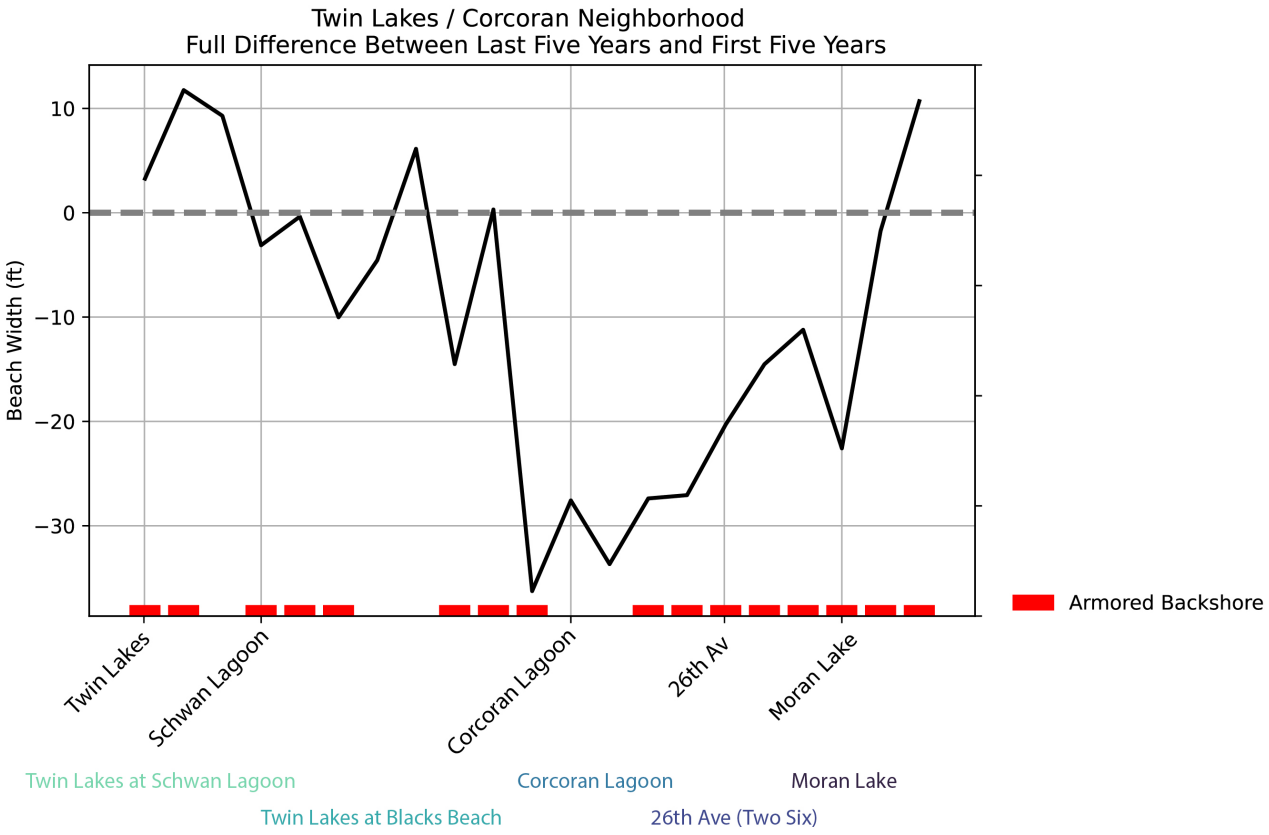


Figure 3-27. Alongshore Difference in Beach Width between the Time Periods of 1984–1989 and 2019–2024

Negative numbers indicate net narrowing, and positive numbers indicate net widening. Cliff-backed shorelines have been excluded from the trend line.

3.2.6 Vulnerability to Sea Level Rise

3.2.6.1 Storm Recurrence and Sea Level Rise

With SLR, coastal flooding elevations will reach more severe flood elevations more frequently and will produce greater depths of flooding. Consider the total water levels that are projected with a 1% annual chance or 100-yr storm under different sea level scenarios in Figure 3-28. At current sea levels, a 100-yr storm produces a total water level of 21.4 ft. However, as seas rise by just 1 ft, this same water level will occur during a 50-year storm (2% annual chance), effectively doubling the frequency of such severe flooding. The pattern accelerates dramatically with further SLR: at 2 ft of rise, 21-ft flood levels occur at the 25-yr interval (4% annual chance), and at 3 ft of rise, it will happen as often as every decade (10% annual chance).

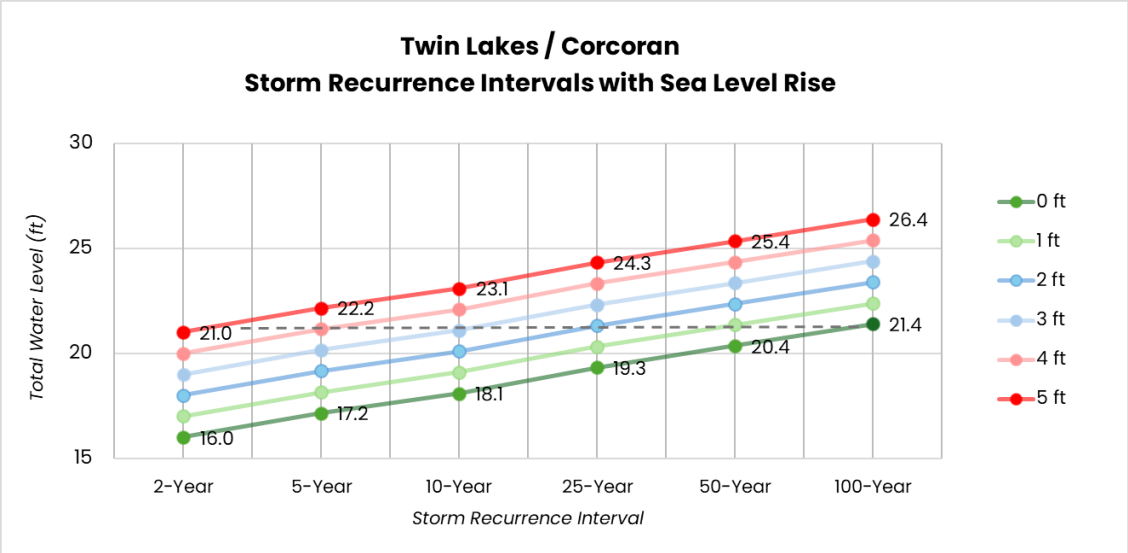


Figure 3-28. Average Storm Recurrence Intervals and Associated Total Water Levels (in ft) with SLR for all FEMA Transects in the Neighborhood.

Dashed line represents the total water level associated with the current 100-yr storm.

This shift in storm recurrence intervals affects not just the most extreme events but also moderate flooding that the neighborhood experiences regularly. Under current conditions, the area sees average total water levels of 16 ft during typical 2-year storm events (50% annual chance). At 1 ft of SLR, this baseline shifts upward to 17 ft, equivalent to what is currently a 5-year storm event (20% annual chance). At 2 ft of SLR, this reaches 18 ft, matching today's 10-year storm levels (10% annual chance). More frequent flooding and higher flood waters will be especially problematic for the low-lying coastal development around the mid-county lagoons, as is exemplified by the low-lying development at Corcoran Lagoon in Figure 3-29.



Figure 3-29. Corcoran Lagoon Condos, Built on the Beach above Wood Pilings. Left: Condition with an Eroded Beach. Right, Conditions during High Tides in the Winter. (Source: Dave Revell)

3.2.6.2 Key Assets at Risk with SLR

As sea levels rise, the Twin Lakes / Corcoran neighborhood will experience increasing exposure to coastal hazards, including more frequent tidal flooding around the coastal lagoons, storm-driven wave flooding, higher likelihoods of wave overtopping, and accelerated shoreline erosion. These conditions will create transportation corridor challenges on East Cliff Drive, impacting emergency access, and access for homeowners, businesses, and State Parks. With SLR, these impacts are expected to intensify, reducing beach widths, increasing inundation during high tide and storm events, and placing additional pressure on neighborhood infrastructure and coastal access.

Land Use and Structures

Figure 3-30 summarizes the number of structures exposed to coastal hazards under increasing SLR, presents the associated cost ranges for those impacts, and provides a comparative view of potential damages by hazard type.

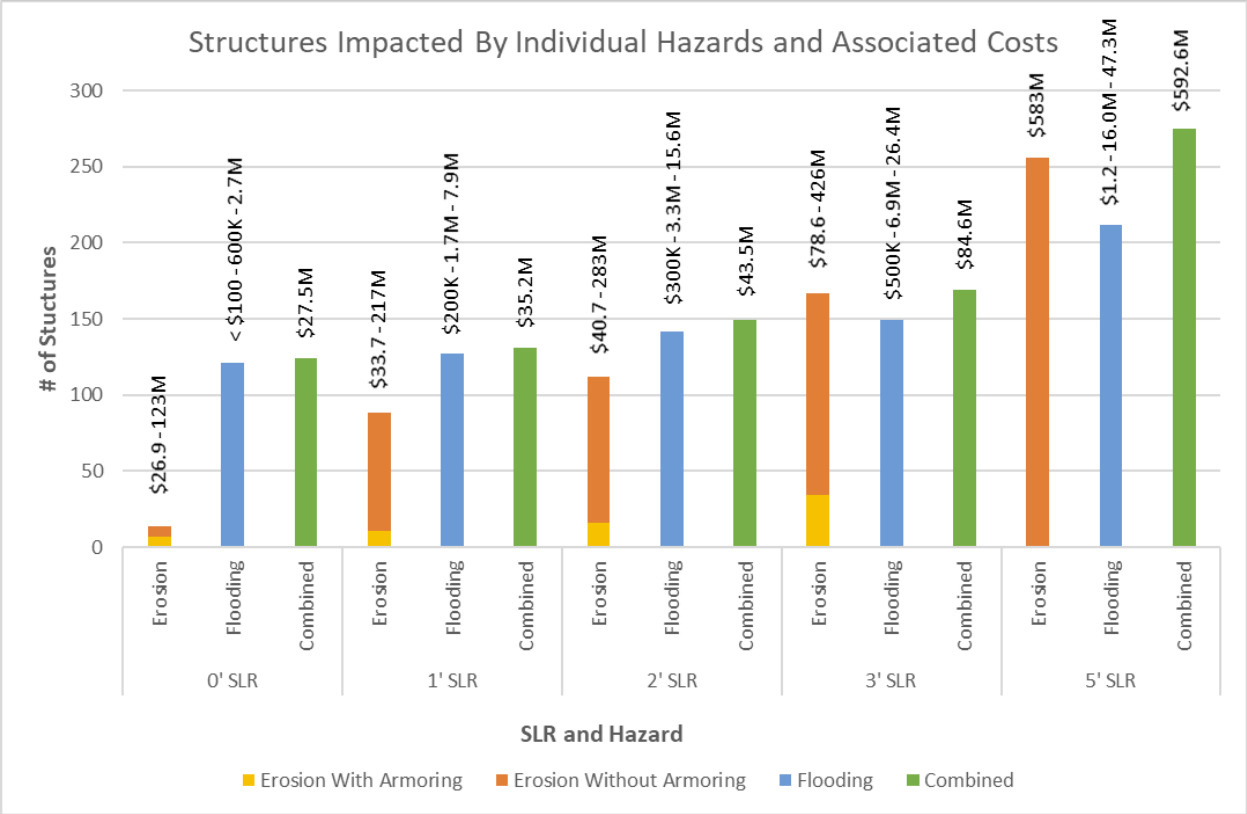


Figure 3-30. Twin Lakes / Corcoran Number of Structures Experiencing Impacts from Coastal Hazards and Associated Costs under Different SLR Scenarios

Costs associated with coastal erosion include the permanent loss of land value and structures. Costs associated with flooding include temporary damage to structures and contents. The combined category includes both, but removes flood damages to unarmored structures lost to erosion in prior horizons.

Coastal flooding is the primary hazard of concern in the near term, exposing up to 121 structures today and increasing steadily to 212 structures by 5 ft of SLR. Flood-related damage estimates to residential structures also increases consistently from a middle estimate of $600K to a high estimate of $2.7M in flood damages, to between $16.0M and $47.3M of cumulative damages by 5 ft of SLR.[8]

Under **current** conditions, the most exposed areas to coastal hazards are the homes around Black Point, Soquel Point, and low-lying homes around the coastal lagoons and creeks. At Black Point, high wave exposure has led to undercutting of the coastal cliffs, leading to a higher

[8] This high estimate of by 5 ft of SLR represents a highly unlikely case that all coastal properties continue to be repaired and rebuilt in place, and that no adaptation measures are adopted.

probability of coastal erosion in addition to the wave damage. Between Moran Lake and Soquel Point, high wave exposure and the relatively low cliffs (between 20 and 30 ft NAVD88) mean these homes are exposed to coastal wave hazards now. **By 2 ft of SLR**, the complete loss of beach at 26th Avenue beach will lead to significantly more wave energy impacting the coastal armoring. Assuming that the armoring remains in place by 2 ft of SLR, the homes in this area will be increasingly threatened by coastal wave overtopping.

Erosion impacts remain relatively low while armoring is present, but increase significantly if armoring is removed. With armoring in place, coastal erosion affects a relatively small number of structures, primarily those around the unarmored sections of the coast around Blacks Beach and inner Sunny Cove. Without armoring, 41 structures are exposed today, and this rises to 256 structures by 5 ft of SLR. Damages and losses to structures and property rise dramatically from $26.9M today with armoring in place, to $583M by 5 ft of SLR assuming all the armoring is no longer in place or functional by that time. With the same assumptions, total combined damage estimates escalate from $27.5M today, to more than $592M in cumulative damages and losses with 5 ft of SLR.

Figure 3-31 illustrates the probability that a structure will experience damage due to wave exposure or coastal erosion with SLR. This assumes a more risk-averse scenario and identified all structures with the potential to be impacted during a 500-year storm event, and assumes coastal armoring is in place through 3 ft of SLR (see Appendix D). **Currently**, of the 275 coastal structures, 144, or close to half, are completely out of a coastal hazard zone. Of the remaining structures in a hazard zone, 73% are in the low or very low category (representing a 1% annual chance event or less). By **2 ft of SLR**, many additional structures are likely to be impacted by coastal hazards, with only 66 structures, or close to 25%, still outside all hazard zones, and 88 structures, or 42% of exposed structures, located in a medium to very high probability category. By **5 ft of SLR**, 211 structures, representing most of the coastal structures in the study area, are in a medium-to-very high probability category. By this horizon, all of the homes directly adjacent to the coast are at a very high probability of experiencing coastal hazards.

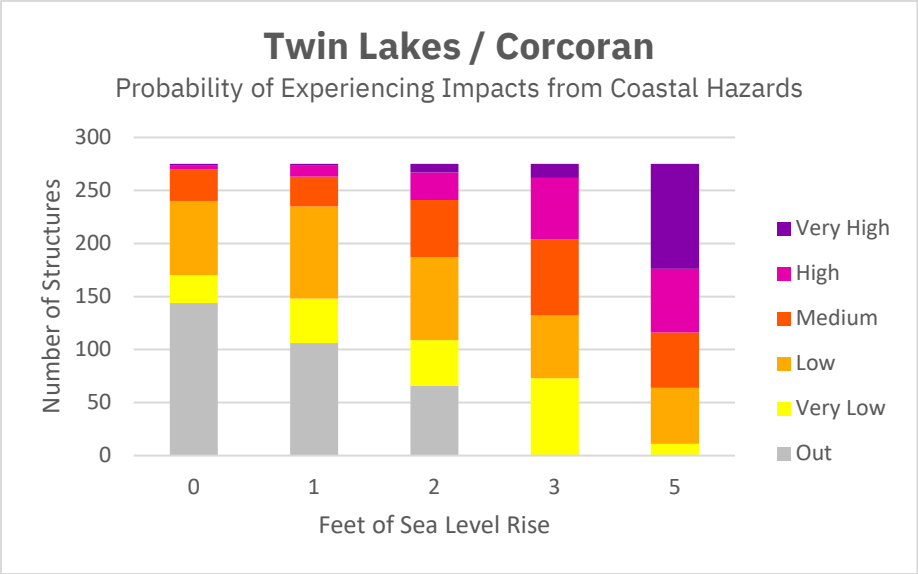


Figure 3-31. Probability of Structures Experiencing Impacts from Coastal Hazards by SLR Horizon

Probabilities combine exposure to both coastal flood and erosion hazards. Flood probabilities correspond to the following: Very High = 20% or greater annual chance, High = 10%–20% annual chance, Med = 5%–10% annual chance, Low = 1%–5% annual chance, Very Low = 0.2%–1% annual chance. Probability of erosion is related to the length of time a structure is within the erosion hazard zone, as well as the armoring condition of the backshore. See Appendix D for more details.

Roads

Currently, East Cliff Drive experiences annual flooding during large storm events, especially around Schwan Lakes, Moran Lake, and Corcoran Lagoon, with approximately 0.4 miles in total of roadway impacted (Figure 3-32 and Figure 3-33). At Schwan Lagoon, the lowest area of East Cliff Drive is around 14 ft, meaning it currently lies under the 2-yr flood elevation. At Corcoran Lagoon, the lowest area of road is even lower, at around 11 ft. At Moran Lake, the lowest area of roadbed is around 16 ft, but this area of coastline experiences higher wave exposure than Schwan and Corcoran lagoons, and experiences just as frequent overtopping and flooding. The only other areas of road vulnerable to coastal hazards are East Cliff Drive at Twin Lakes State Beach and Portola Drive (Figure 3-32). At Twin Lakes Beach between the 5th Avenue roundabout and the bend in the road at 9th Avenue, the roadway lies between 18 and 22 ft. While this section of roadway is currently armored, SLR will increase the exposure of the backshore to storm wave attack and wave overtopping. **By 2 ft of SLR**, Portola Drive just east of the Live Oak Branch Library will be exposed to coastal flooding. **By 5 ft of SLR,** all of East Cliff Drive near Twin Lakes State Beach and Portola Drive at Corcoran Lagoon and Rodea Creek Gulch are exposed to coastal hazards.

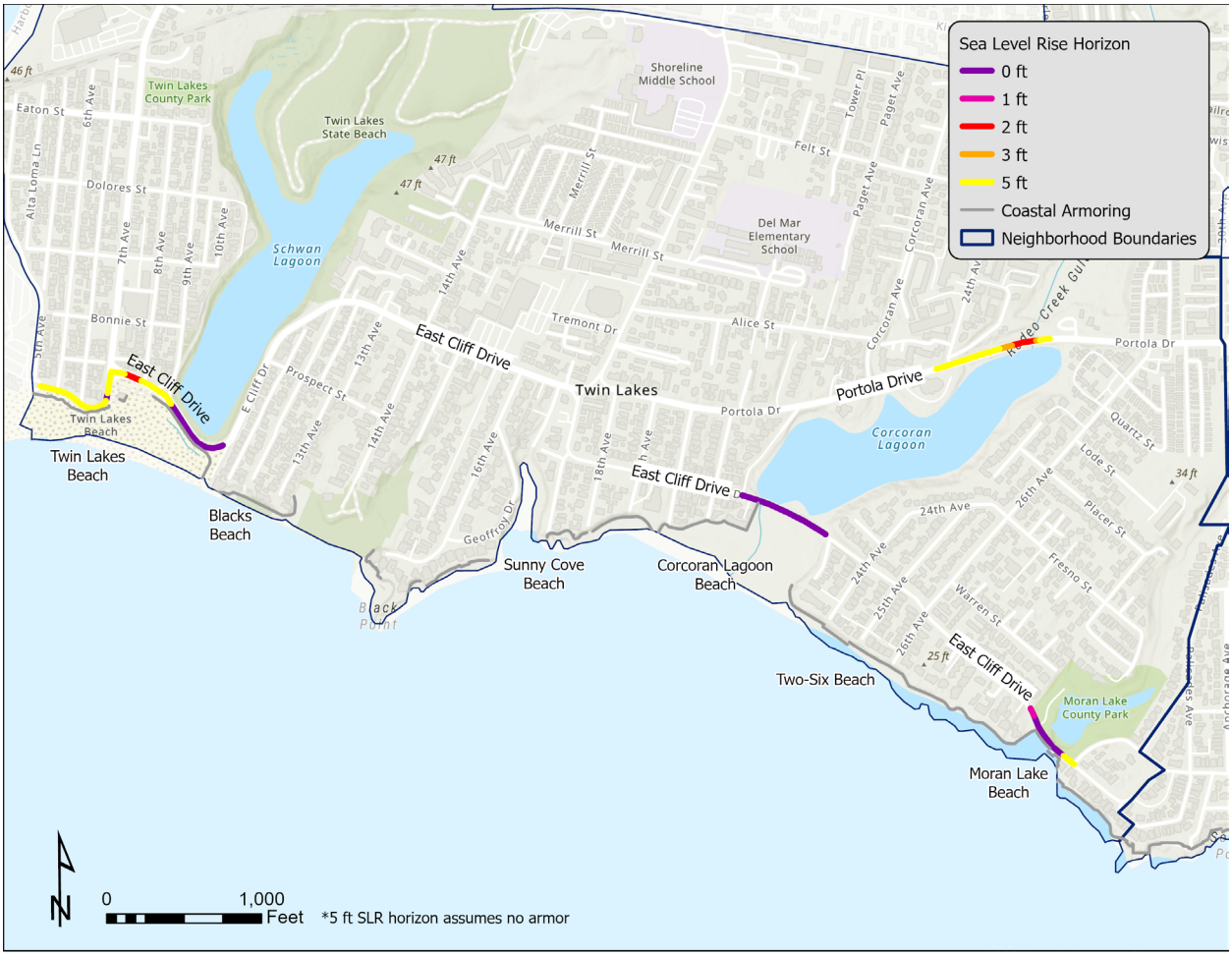


Figure 3-32. Segments of Major Roadways Exposed to Coastal Hazards under Different SLR Scenarios

This does not Include local residential streets. Results shown assume armoring is in place through 3 ft of SLR, and by 5 ft of SLR, armoring is no longer in place.

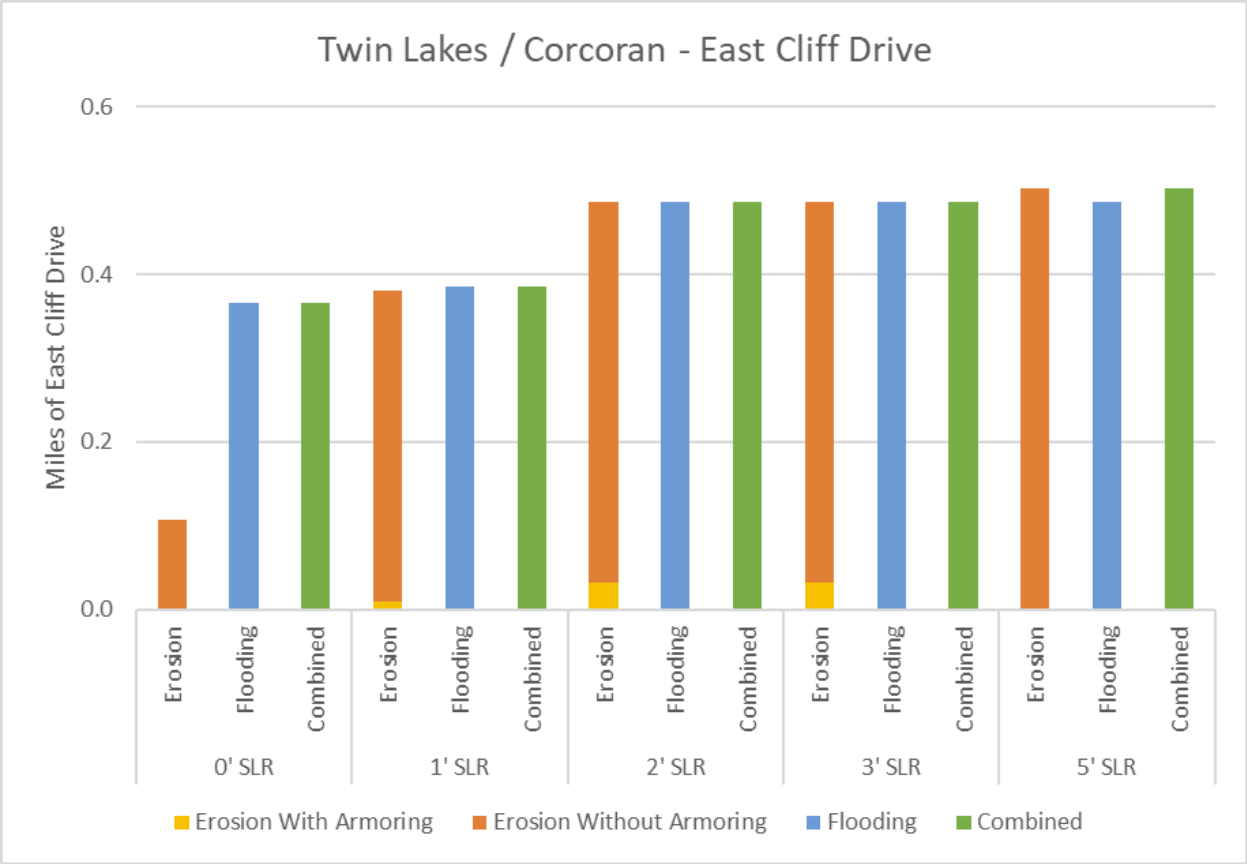


Figure 3-33. Miles of East Cliff Drive Exposed to Coastal Hazards across SLR Scenarios within the Twin Lakes / Corcoran Neighborhood

Wastewater, Stormwater, and Water Supply Infrastructure

Currently, the restroom and Schwan Lake Pump Station at Twin Lakes State Beach are protected by armoring (armoring is frequently buried beneath sand); however, the location on the beach makes the structures vulnerable. Critical wastewater infrastructure underlies East Cliff Drive at Schwan and Corcoran Lagoon and Moran Lake, and past failures have led to raw sewage entering the lagoons and ocean. There is critical wastewater force main that runs under East Cliff Drive in front of Schwan Lake, which is low-lying and is annually overtopped by waves. The roadway and underlying force main are currently protected by coastal armoring; however, without armoring, that infrastructure could be at risk to coastal erosion.

By **1 ft of SLR**, the restroom and pump station at Twin Lakes State Beach is projected to experience regular flooding and increased exposure to beach scour and coastal erosion. By **2 ft of SLR**, only Twin Lakes State Beach between 7th and 9th Avenues, Black's Beach at Bonita Lagoon, and Schwan Lagoon Beach are projected to retain dry sand in any season. This will place significant pressure on sections of the co-located utilities under East Cliff Drive and the smaller neighborhood roadways. The co-located utilities under Portola Drive will also be

exposed to coastal flooding. By **5 ft of SLR**, the 15th Avenue Pump Station located in a low-lying area behind Bonita Lagoon may be exposed to coastal wave flooding. The DA Porath Pump Station, Moran Lake Pump Station, and Rodeo Pump Station fall right outside the coastal flooding hazard zone.

Table 3-3. Twin Lakes / Corcoran key wastewater infrastructure at risk with SLR

Wastewater Infrastructure	SLR (ft)				
	0	1	2	3	5
Schwan Lake Pump Station at Twin Lakes State Beach	🟢	🟡	🔴	🔴	🔴
East Cliff Wastewater Force Main	🟡	🟡	🔴	🔴	🔴
15th Avenue Pump Station	🟢	🟢	🟢	🟢	🟡

🟢 = safe, 🟡 = exposed to wave flooding and only exposed to erosion without armoring, 🔴 = exposed to wave flooding and erosion, and even with armoring, seasonal beach scouring threatens this infrastructure

Coastal Access

Currently, low-lying areas of the Moran Lake parking lot are exposed to temporary flooding during storm events. The on-street parking around Sunny Cove is at risk of coastal erosion. Assuming coastal armoring is in place, the parking areas for Twin Lakes Beach are protected. By **2 ft SLR,** the parking lot at Moran Lake and the parking lot near Corcoran Lagoon off East Cliff Drive are exposed to flooding, and portions of the parking area for Sunny Cove is increasingly exposed to erosion. By **5 ft of SLR**, nearly all coastal public access points are vulnerable to coastal erosion or storm wave flooding.

Table 3-4. Twin Lakes coastal access assets at risk with SLR

Coastal Access	SLR (ft)				
	0	1	2	3	5
Twin Lakes/East Cliff Drive Parking	🟢	🟢	🟡	🟡	🔴
Moran Lake Parking and Trails	🟡	🟡	🟡	🟡	🔴
Sunny Cove Parking and Trails	🟡	🟡	🟡	🔴	🔴

🟢 = accessible, 🟡 = at risk from flooding, erosion, and beach loss, 🔴 = no longer accessible

Surfing

An analysis of local surf conditions was conducted to identify the wave and tide combinations under which each surf break in this neighborhood is considered surfable, and to determine how often those conditions occur during daylight hours. **Currently**, Santa Moes, 26th Avenue, and Wind and Sea are surfable most frequently (44% to 40% of the time), while the harbor is surfable the least (11% of the time).

Surf modeling results show a substantial decline in surfable conditions as sea levels rise. By **1 ft of SLR**, surfability at Murph Bar and Sunny Cove drops to below 20%. By **2 ft of SLR**, many surf breaks in this neighborhood become rarely surfable, with only Santa Moes being surfable more than 20% of the time. By **3 ft of SLR**, most breaks are functionally extinct or rarely surfable, and by **5 ft of SLR**, none of the neighborhoods' surf spots are projected to be functioning (Table 3-5).

Table 3-5. Percent of daylight hours during which a surf break is surfable

Surfing	SLR (ft)				
	0	1	2	3	5
The Harbor	🔴	🔴	🔵	🔵	🔵
Murph Bar	🟡	🔴	🔴	🔵	🔵
Blacks Beach	🔴	🔴	🔴	🔵	🔵
Sunny Cove	🟡	🔴	🔴	🔴	🔵
Santa Moes	🟢	🟡	🟡	🔴	🔵
26th Avenue	🟢	🟡	🔴	🔴	🔵
Wind and Sea	🟢	🟡	🔴	🔴	🔵

🟢 >50%, very regularly
🟢 = 35%–50%, regularly
🟡 = 20%–35%, regularly
🔴 = 5%–20%, rarely
🔵 = <5%, functionally extinct

Beaches

Beaches in the Twin Lakes neighborhood narrow steadily with SLR, with winter beach widths decreasing from around 190 ft today to under 20 ft with 3 ft of SLR. Summer beaches remain wider than winter beaches but narrow considerably from an average of roughly 240 ft today, to about 40 ft with 3 ft of SLR, with an almost complete loss of dry sand beach at 5 ft of SLR

(Figure 3-34). The only area that retains a dry sand summer beach is at Corcoran Lagoon Beach.

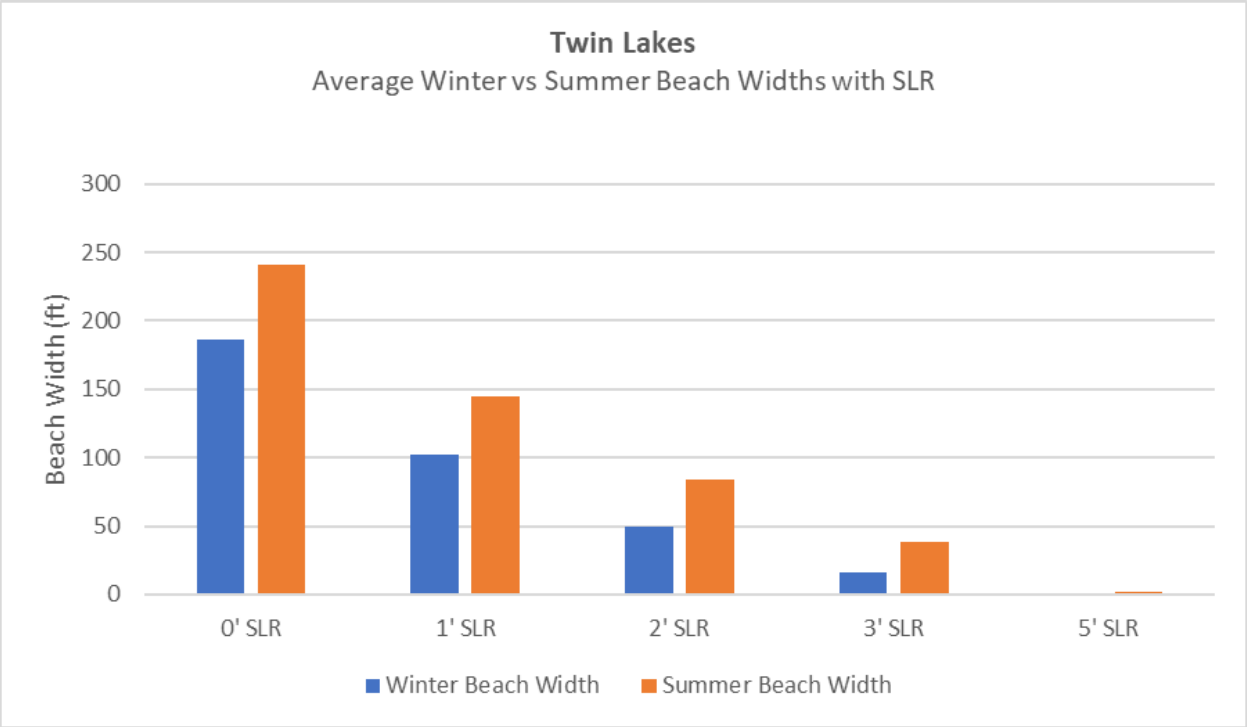


Figure 3-34. Twin Lakes / Corcoran Summer and Winter Beach Widths with SLR

By 1 ft of SLR, Schwan Lake, Blacks, and Corcoran Lagoon beaches are projected to experience more than a 50% decline in winter beach width, and 26th Avenue will experience complete loss of dry sand in the winter. **By 2 ft of SLR**, Moran Lake Beach reaches complete loss. **By 3 ft of SLR** Schwan Lake, Blacks, and Corcoran Lagoon beaches become very narrow, and **by 5 ft of SLR**, transition to complete winter beach loss (Table 3-6).

Table 3-6. Twin Lakes winter beach loss locations

Beaches	SLR (ft)				
	0	1	2	3	5
Twin Lakes at Schwan Lagoon *	🟢	🟢	🟡	🔴	🟤
Twin Lakes at Blacks Beach *	🟢	🟢	🟡	🔴	🟤
Corcoran Lagoon Beach *	🟢	🟢	🟢	🟡	🟤
26th Ave (Two Six) **	🟡	🟤	🟤	🟤	🟤
Moran Lake Beach **	🟡	🔴	🟤	🟤	🟤

🟢 = 100+ ft, 🟡 = 25–100 ft, 🔴 = <25 ft, 🟤 = no beach

* = partially armored
** = fully armored

3.2.6.3 Risk Summary

The Twin Lakes / Corcoran neighborhood exhibits higher exposure to SLR hazards than some of the other neighborhoods due to its low-lying shoreline, interconnected lagoon systems, and proximity to wave-exposed beaches. Rising tides, storm wave flooding, and coastal erosion increasingly threaten residential areas, park facilities, key beach access points, and low-elevation roadways such as East Cliff Drive. Underlying East Cliff Drive are critical utilities that will be potentially complex and costly to adapt. Key findings by time horizon are summarized below.

Twin Lakes / Corcoran: Near Term (0–1 ft of SLR). By 1 ft of SLR:



One hundred twenty-one structures are within the 100-yr flood hazard area, and seven structures are exposed to coastal cliff and dune erosion assuming armoring is in place.

Two hundred seventy-five structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse hazard scenario, and 40 are categorized as having medium to very high probability of impact.

Many coastal structures have already experienced storm wave-related damage from prior coastal storms. Some of the most vulnerable areas are the structures along East Cliff Drive and South Palisades Avenue from Moran Lake to Soquel Point.

Low-lying homes, including those around Moran Lake, are exposed to coastal flooding.

The area around Black Point has experienced significant erosion due to wave attack on the coastal cliffs. Undercutting of the cliffs and large sea caves are evident, threatening cliff-top properties and development.

Given the largely armored coastline and the elevation of most coastal homes, damage estimates related to flooding could vary from $200K in calmer conditions up to $7.9M in stormier conditions.[9]

With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $35.2M.



Low-lying segments of East Cliff Drive at Schwan (~14 ft), Corcoran (~15 ft), and Moran (~16.5 ft) lagoons are already vulnerable to coastal wave overtopping. With 1 ft of SLR, these elevations fall within the 2-yr (50% annual chance) flood level, leading to frequent roadway flooding.



The wastewater force main beneath East Cliff Drive near Schwan Lagoon and wastewater pipes near Corcoran Lagoon and Moran Lake are vulnerable to flooding and scouring during high tides and storms, increasing spill risk during extreme events. The Schwan Lake Pump Station at Twin Lakes State Beach State Beach is exposed to periodic flooding.



26th Avenue Beach, which receives approximately 10,000 annual visits, is already highly constrained and is likely to lose usable beach area due to coastal squeeze with 1 ft of SLR. Surf breaks at Murph Bar and Sunny Cove become rarely surfable.



Coastal lagoons will see greater wave overtopping and tidal exchange, leading to a change in salinity with potential effects to habitats and species.

[9] Calm conditions are represented as multiple small storms (5-yr recurrence or less) over a 20-yr window, and stormier conditions represent multiple large storms over a 20-yr window (one 100-yr, one 25-yr, and multiple smaller storms).

The County is currently conducting a study of projected SLR impacts to coastal lagoons.[10]

Twin Lakes / Corcoran: Mid Term (1–3 ft of SLR). By 3 ft of SLR:



One hundred forty-nine structures are within the 100-yr flood hazard area, and 34 structures are exposed to coastal cliff and dune erosion assuming armoring is in place.

Two hundred seventy-five structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse hazard scenario, and 143 are categorized as having medium to very high probability of impact.

With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $84.6M.



East Cliff Drive will continue to be exposed to chronic flooding, coastal storm wave overtopping, and exposure to beach scour and dune erosion. This could lead to pavement washouts and erosion of underlying materials.

Portola Drive at Corcoran Lagoon and Rodeo Creek Gulch may experience flooding during large storm events.



Stormwater drainage infrastructure near the lagoon systems will become increasingly overtopped. The Schwan Lake Pump Station at Twin Lakes State Beach is exposed to frequent flooding and wave impacts, creating a high risk of service disruption and environmental contamination. Co-located utilities along Portola Avenue are exposed to flooding.

[10] The County of Santa Cruz is currently conducting the Santa Cruz Coastal Lagoons & East Cliff Drive Resiliency Study. This technical feasibility study is looking at nature-based adaptation strategies to increase resilience to SLR for the three coastal lagoons.



If the backshore remains fixed in its current armored location, nearly all beaches will disappear. Moran Lake Beach is projected to experience complete winter beach loss, and Twin Lakes Beach experiences near-complete winter beach loss with some summer beach width remaining, reducing recreational capacity for a neighborhood that supports more than 200,000 yearly beach visits. Most surf breaks will be rarely surfable or functionally extinct.



Increasing wave overtopping into the lagoons will affect water quality and likely cause a significant change in habitats.

Twin Lakes / Corcoran: Long Term (3–5 ft of SLR). By 5 ft of SLR:



Two hundred and twelve structures are within the 100-yr flood hazard area, and 256 structures are exposed to coastal cliff and dune erosion.

Two hundred seventy-five structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse hazard scenario, and 211 homes are categorized as having medium to very high probability of impact.

The Live Oak Library, which lies at the back of Corcoran Lagoon off Portola Drive, is exposed to flooding.

With coastal armoring in place through 3 ft of SLR, up to $583M in property assets is projected to be exposed to coastal erosion hazards, and cumulative recurrent flood damages could amount to $16M to $47.3M. A middle estimate for cumulative damages and losses is 592.6M.



East Cliff Drive will be subject to chronic inundation, with dune erosion exposing substantial portions of the roadway. Portola Drive at Corcoran Lagoon and Rodeo Creek Gulch is projected to experience more frequent flooding.



Co-located utilities along East Cliff Drive and Portola Avenue will become increasingly exposed to coastal hazards. The 15th Avenue Pump Station near Bonita Lagoon is exposed to flooding.



With armoring in place, all beaches are lost or functionally unusable due to coastal squeeze, all surf breaks become functionally extinct, and public access infrastructure (parking areas, trails, and beach stairways) is severely constrained or no longer usable.



The lagoon outlets may remain permanently open, significantly altering lagoon ecology and salinity regimes.

3.2.7 Key Adaptation Strategies for Consideration

Based on the exposure and vulnerability findings described above, the following list summarizes potential adaptation strategies for the Twin Lakes / Corcoran neighborhood that will be further evaluated. Note that while there are multiple property owners in and around the lagoons, the County of Santa Cruz manages Corcoran Lagoon and Moran Lagoon, and Schwan Lagoon is owned and managed by State Parks. The County also manages coastal access location at multiple locations including Rockview Overlook and Sunny Cove.

Near-Term

- Planning and Alignment
  - Coastal access planning (State Parks)
  - Coastal property owners
  - Coastal resource advocates
  - Harbor district
- Nature-Based Solutions
  - Bluff, dune, and lagoon restoration
  - Sand management
- Accommodation
  - Stormwater improvements
  - Upgrade and raise utility and transportation infrastructure (e.g. East Cliff Drive)

Mid-Term

- Protection
  - Groin at Soquel Point

  - Raise armor
- Nourishment
- Managed Retreat
  - Relocating beach development (e.g., bathroom from Twin Lakes Beach)
- Accommodation
  - Stormwater improvements
  - Raising utility and transportation infrastructure

Long-Term

- Managed Retreat
  - Relocation and realignment of roads, infrastructure, and upland development.

Twin Lakes / Corcoran - Coastal Hazard Areas: 0 ft SLR with Existing Armoring

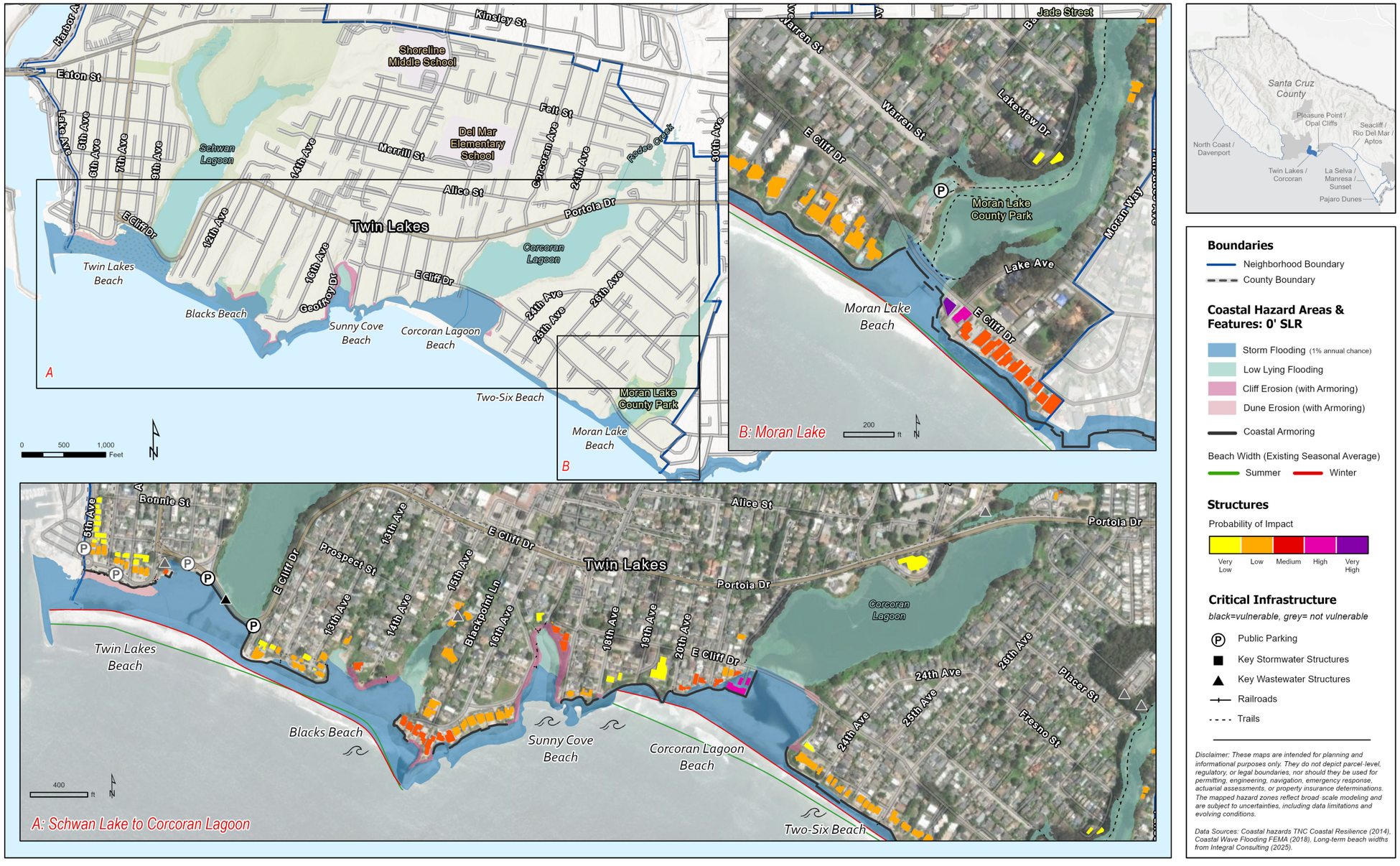
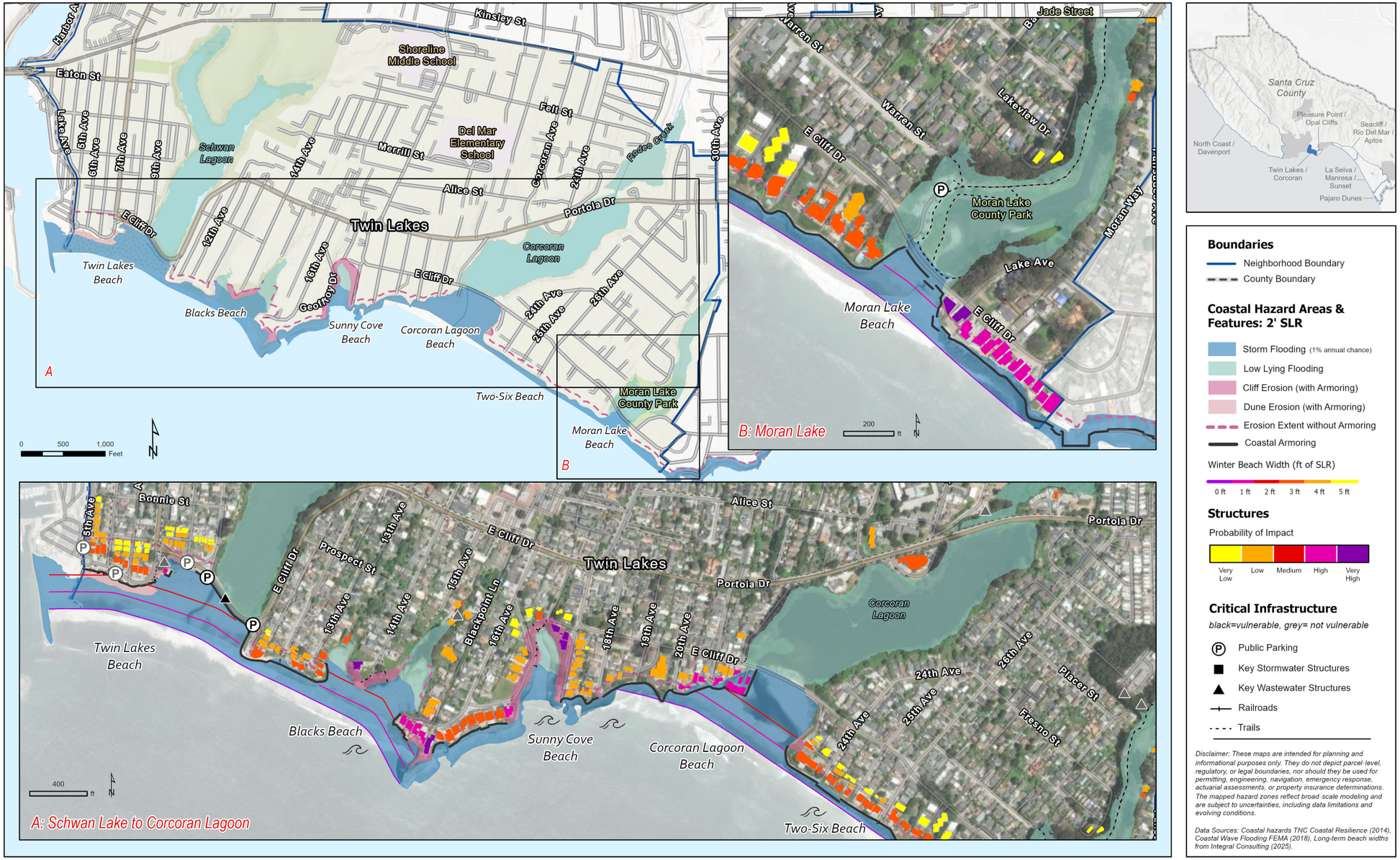


Figure 3-35. Twin Lakes / Corcoran SLR Vulnerability Map—0 ft of SLR with Existing Armoring

Twin Lakes / Corcoran - Coastal Hazard Areas: 2 ft SLR with Existing Armoring



Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 2' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (with Armoring)
- Dune Erosion (with Armoring)
- Erosion Extent without Armoring
- Coastal Armoring

Winter Beach Width (ft of SLR)
0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Structures
Probability of Impact
Very Low | Low | Medium | High | Very High

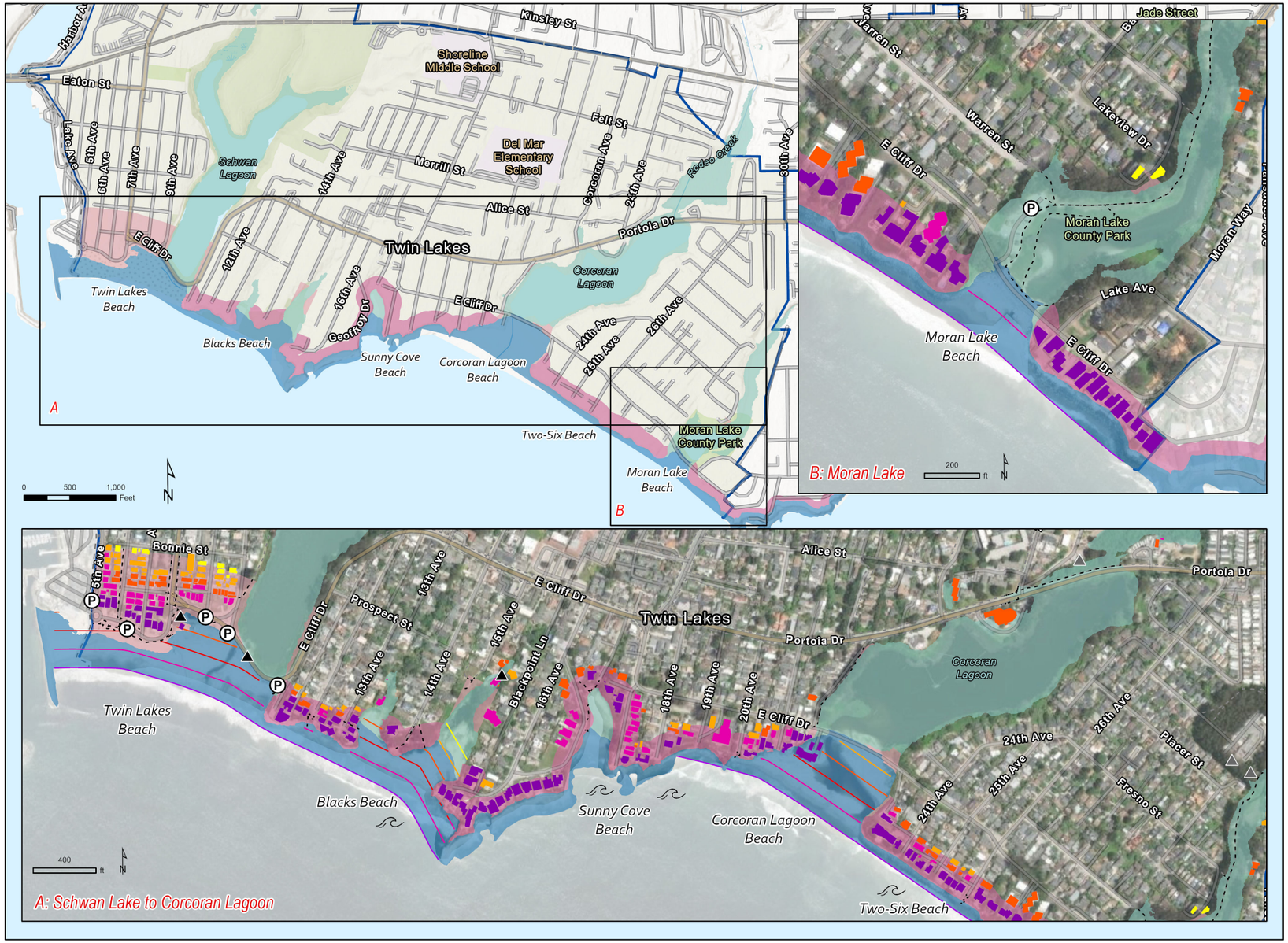
Critical Infrastructure
black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-36. Twin Lakes / Corcoran SLR Vulnerability Map—2 ft of SLR with Existing Armoring

Twin Lakes / Corcoran - Coastal Hazard Areas: 5 ft SLR without Existing Armoring





Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 5' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (without Armoring)
- Dune Erosion (without Armoring)

Winter Beach Width (ft of SLR)

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Structures

Probability of Impact

Very Low | Low | Medium | High | Very High

Critical Infrastructure

black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-37. Twin Lakes / Corcoran SLR Vulnerability Map—5 ft of SLR without Existing Armoring

3.3 PLEASURE POINT / OPAL CLIFFS

3.3.1 Overview

The Pleasure Point / Opal Cliffs neighborhood lies between Soquel Point in the west to the end of Opal Cliff Drive and the Capitola City line in the east, encompassing approximately 1.6 miles of coastline. This highly developed residential and recreational area is defined by steep coastal bluffs, popular surf breaks, and a mix of single-family homes, apartments, and small businesses. The area is renowned for its surf culture, coastal access points, and scenic bluff-top trails that draw both residents and visitors year-round.

This cliff-backed shoreline is unique for the county because it has a southeast-facing coastline, leading to very narrow beaches due to the oblique angle of the waves compared to the shoreline. The beaches in this neighborhood sit atop a reef shelf exposed during low sand levels and low tides. Atop the coastal cliff lies residential development which backs the entirety of the shoreline along Pleasure Point Drive and Opal Cliff Drive. Along the East Cliff Drive promenade, there is a very popular walking and biking route with amazing ocean views of the surf along Pleasure Point (Figure 3-38). There are a small handful of vertical access locations to the coast; these are found at Rockview Drive County Park, Pleasure Point Park, off Pleasure Point Drive, at The Hook County Park, and at Opal Cliff Park (aka Privates) located off Opal Cliff Drive. Many of these coastal accessways are used to access beaches, coastal resources and tide pooling locations, and world-class surf breaks, and they experience very high recreational use.







Figure 3-38. Waves at Pleasure Point, Pleasure Point Path, Tide Pooling, and Staircase Accessway at Privates (Source: County of Santa Cruz)

3.3.2 Community Characteristics

Pleasure Point and Opal Cliffs are densely populated coastal neighborhoods with a strong surf and beach culture. The community includes a mix of long-term residents, rental properties, and seasonal visitors. The neighborhood's demographic profile reflects a coastal suburban character with a mix of income levels and a high value placed on ocean access and recreation. Within the neighborhood boundary, 22% of the area is designated as a disadvantaged community (California State Water Resources Control Board 2020), and the average CalEnviroScreen score is 15, placing it in the 15th percentile statewide. This indicates a low cumulative pollution burden and population vulnerability (OEHHA 2021).

3.3.3 Infrastructure and Development

Development along Pleasure Point and Opal Cliffs is primarily residential, with dense clusters of single-family homes, multifamily units, and vacation rentals located in proximity to the coastal cliffs. Much of this development is protected by an assortment of seawalls and revetments that have been constructed and expanded over several decades. Commercial activity is limited, with most businesses concentrated along 41st Avenue and Portola Drive, aside from the Point Market on East Cliff Drive.

Key infrastructure includes East Cliff Drive and its associated utilities, and the coastal bluff stabilization structures that protect the East Cliff Drive, and neighborhood's stormwater and wastewater networks—portions of which run close to the cliffs. The cliff-top multiuse path along East Cliff Drive, the Pleasure Point County Park overlook, multiple public beach stairways, and other coastal access points form a continuous public access corridor along the cliff top, and they require regular maintenance due to ongoing coastal erosion. Throughout the neighborhood, various shoreline armoring infrastructure are maintained through a combination

of County and private efforts, and all of these armoring structures are in various conditions with many unknown permit statuses.



Figure 3-39. Beach Access Stairway at Opal Cliffs Park (Privates) (Source: C. Stratton)

Key assets and infrastructure in the coastal study area include:

- Transportation networks including East Cliff Drive and Opal Cliff Drive
- Multiple surf and beach access coastal stairways and the East Cliff Drive pedestrian path
- Soil nail walls protecting East Cliff Drive, public water and wastewater infrastructure, and the East Cliff Drive multiuse trail.

3.3.4 Recreation and Coastal Resources

Pleasure Point and Opal Cliffs are among the most heavily used coastal recreation areas in Santa Cruz County, known internationally for their world-class, year-round surfing. The neighborhood includes 12 well-known surf breaks, including Rockview, Sewer Peak, 1st Peak Pleasure Point, 2nd Peak Pleasure Point, Jacks/38th, Drainpipes, the Hook, Sharks Cove, Privates, and Trees. These surf breaks attracted more than 250,000 surf visits in 2024. These figures exclude recreational surfing by local residents, as cell phone mobility estimates were used to enumerate visitors, who had a home location outside the defined surf break parking locations.

Beaches in this area are generally narrow and exposed primarily at lower tides, with a few small pocket beaches providing more reliable access. The coastal bluffs, intertidal zones, and pocket beaches support habitat for marine life while also offering recreational opportunities including walking, tide pooling, and beachgoing. The East Cliff Drive multiuse trail offers continuous pedestrian and cycling access with panoramic coastal views, making it a key recreational corridor for residents and visitors alike.

In many coastal access locations, the narrow beaches cause marine safety challenges, especially during high tides and larger winter swell events when the beaches disappear. These high tide and wave events create turbulent conditions, making it difficult for surfers to enter and exit the water. Fugitive riprap can also make ingress and egress from the ocean difficult during high tides.

Due to the narrow spatial extent of the beaches and their seasonal nature, location data for these beaches were limited. Collectively, both beach areas hosted an estimated 12,700 beach visits in 2024. Privates Beach hosted the most visits in the month of June with a total of 1,700 estimated visits, and Pleasure Point Beach has an estimated 1,300 visits at peak season (Figure 3-40).

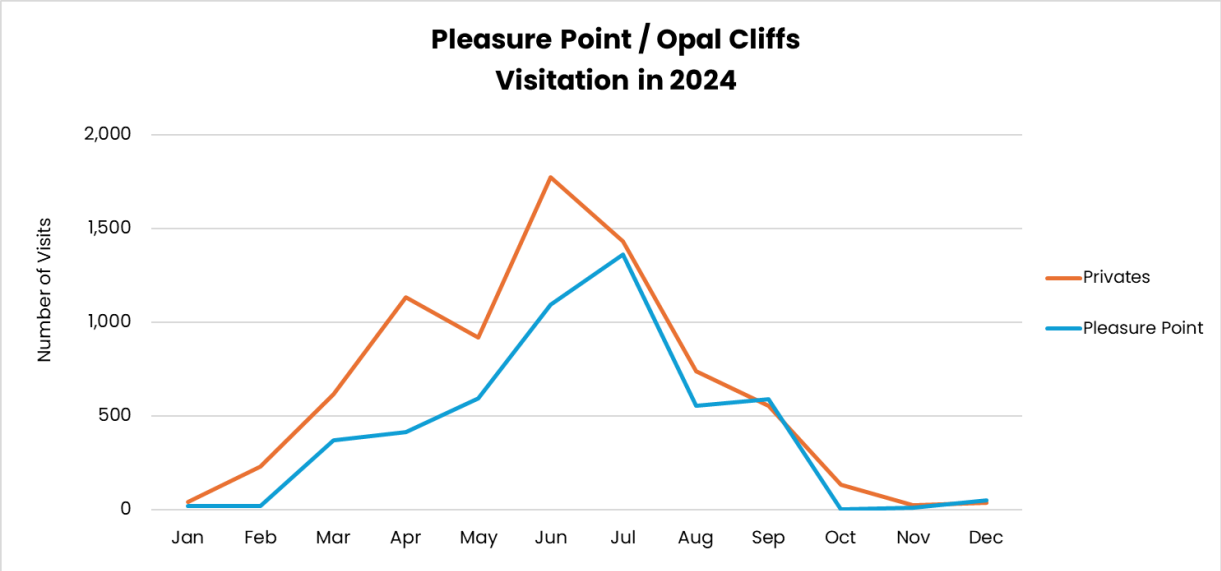


Figure 3-40. Beach Visitation (2024)

Pleasure Point encompasses both 35th Avenue and 38th Avenue beaches.

These visitation figures capture only visitors who stay on the beach, leaving out short-term beach visits, visitors of the upland areas, as well as surfers in nearby parking areas and in the surf lineup. Given that many residents and visiting surfers leave their phones behind while surfing, visitation numbers are likely dramatically higher. Similar to other county neighborhoods, most of these beach visits occurred during the summer months, during which

an estimated 78% of all visits at these two beach areas occurred (Figure 3-41 and Figure 3-42).

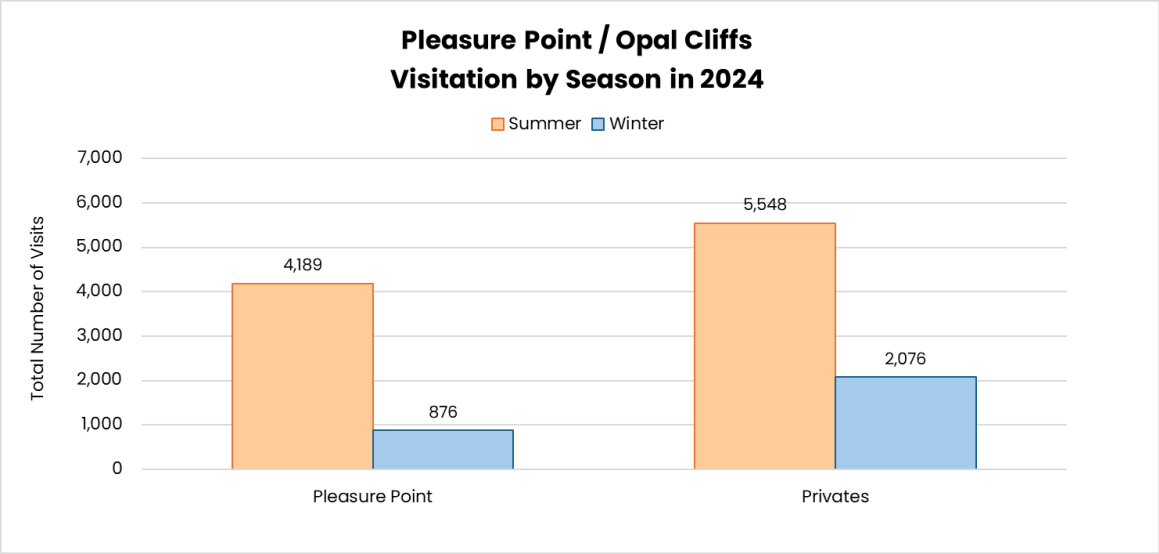


Figure 3-41. Beach Visitation Numbers for Summer and Winter (2024)

Pleasure Point encompasses both 35th Avenue and 38th Avenue beaches.

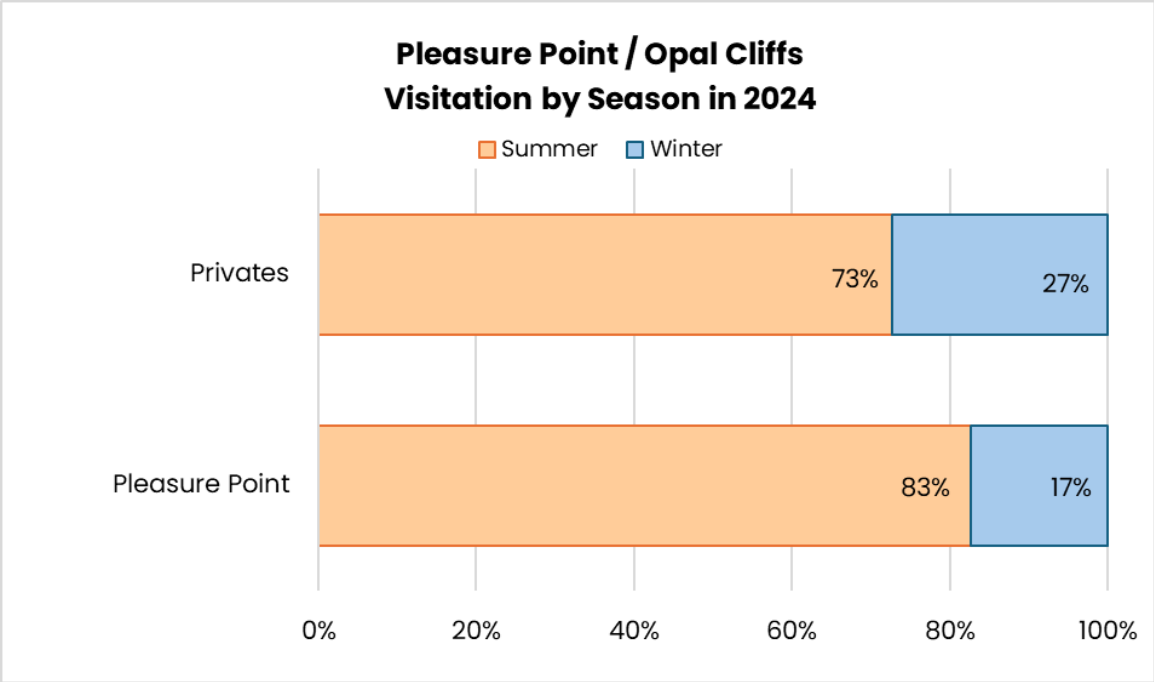


Figure 3-42. Beach Visitation Distribution (2024)

Pleasure Point encompasses both 35th Avenue and 38th Avenue beaches.

3.3.5 Coastal Processes and Hazards

3.3.5.1 Coastal Erosion

The Pleasure Point / Opal Cliffs neighborhood has a long history of chronic coastal erosion driven by winter storm events, high-energy wave conditions, and the area's erodible coastal cliffs. Beaches in this neighborhood are perched atop a rock shelf and are usually a narrow thin layer of sand only fully exposed at lower tides, offering limited storm wave buffering (Figure 3-43).

The cliffs in this neighborhood rise from Soquel Point to Capitola in this neighborhood. Homes in the southern part of this neighborhood are vulnerable to coastal wave overtopping, especially those around Pleasure Point Drive. Wave run-up and splash over often reach the softer coastal bluff terrace, further contributing to coastal erosion. Local observations have shown a steady cliff retreat over the past several decades, with erosion hot spots occurring near exposed bluff faces and stormwater outfalls. Protective armoring has slowed erosion in some locations but has not eliminated cliff retreat entirely. Currently, coastal erosion affects cliff stability, threatening segments of the East Cliff Drive multiuse trail, and limiting shoreline transgression leading to coastal squeeze.



Figure 3-43. Cliffs near Opal Cliffs Park and Privates Beach.

Note the multiple strata of the cliffs (Source: Los Angeles Times)

3.3.5.2 Coastal Flooding

In addition to coastal erosion impacts, the neighborhood experiences periodic coastal access disruptions during high tides and storm events, which can flood beach access stairways and temporarily inundate pocket beaches. During these events, many of the beach areas are completely submerged, reducing coastal access and increasing exposure of the cliffs to wave attack. In the western extent of this neighborhood, the homes along Pleasure Point Drive and S. Palisades Avenue have been subject to coastal wave exposure, most recently during the winter storm event of 2023.

3.3.5.3 Coastal Armoring

Cliff failure along East Cliff Drive has occurred periodically over time, resulting in the transition from a two-way to a one-way road. Over time, it became clear that continued erosion would ultimately undermine East Cliff Drive, threatening this vital transportation artery and limiting pedestrian and bicycle use. After a study by the U.S. Army Corps of Engineers in the early 1990s, the County Board of Supervisors directed staff to pursue a strategy of cliff stabilization with pedestrian and beach access improvements. Final construction of the textured shotcrete tie-back seawall and other pedestrian improvements were completed in 2012 (Figure 3-44). The seawall portion of the project was constructed between 32nd and 36th Avenue and at the end of 41st Avenue and included two replacements and one new beach access stairway, as well as the removal of riprap and rubble on the beach. The upper bluff improvements consisted

of a pedestrian path, bicycle path, landscaping, safety railings, and improvements to Pleasure Point Park (Santa Cruz County Redevelopment Agency 2026).

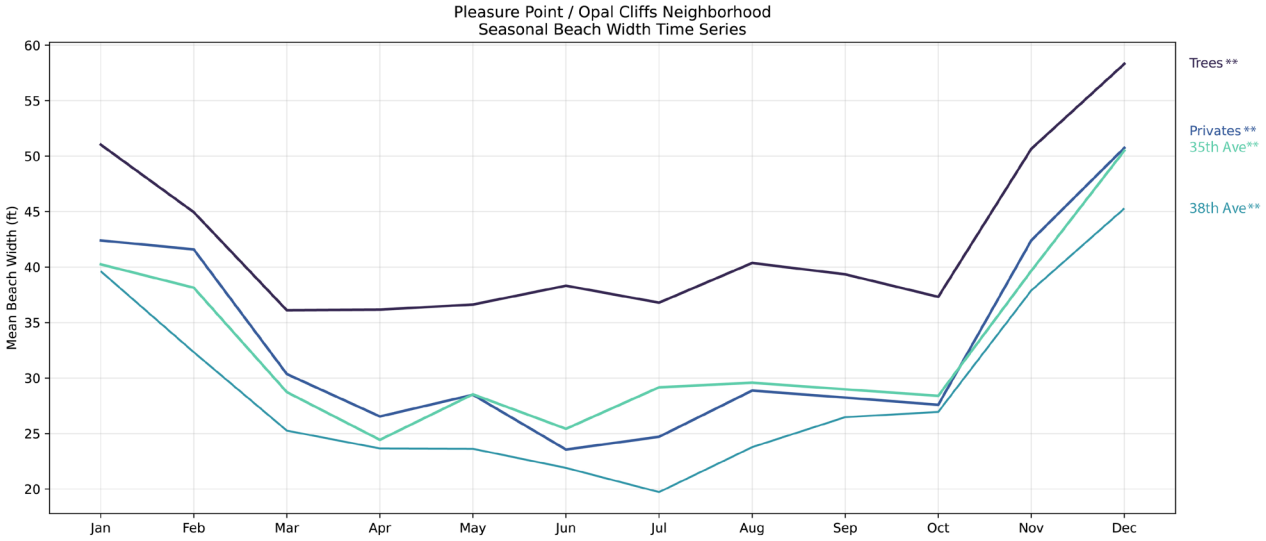


Figure 3-44. Pleasure Point Before and After Seawall Construction (Source: Gary Griggs)

Currently, much of the shoreline is armored with concrete seawalls, riprap, and bluff stabilization such as soil nail tieback structures to protect homes, roadways, and utilities from chronic erosion. The only area that remains unarmored is known as the dirt farm, a 600-ft stretch of coastline between Madrone Avenue (near Jacks) and Manzanita Avenue. Throughout the armored sections, public stairways are integrated into these installations to maintain beach access. Approximately 82% of the shoreline is armored, and 91% of residential structures are located behind armoring.

3.3.5.4 Beach Widths

This Pleasure Point / Opal Cliffs neighborhood has some of the narrowest beaches in the county. Unlike other neighborhoods, winter beach widths tend to be wider than summer beaches. This is a result of the harbor dredge bypass program that largely occurs in the winter and provides additional sand to the system. On average, there is an approximately 5- to 20-ft difference between the relatively wider winter beaches and the narrower summer beaches (Figure 3-45). The beach furthest to the east, Trees, experiences the widest beach widths as it is adjacent to a rocky outcrop which impounds sand.



*partially armored

** fully armored

Figure 3-45. Seasonal Beach Width Trends by Beach (average width by month across all records from 1984–2024)

Lighter colors appear further west, and darker colors appear further east.

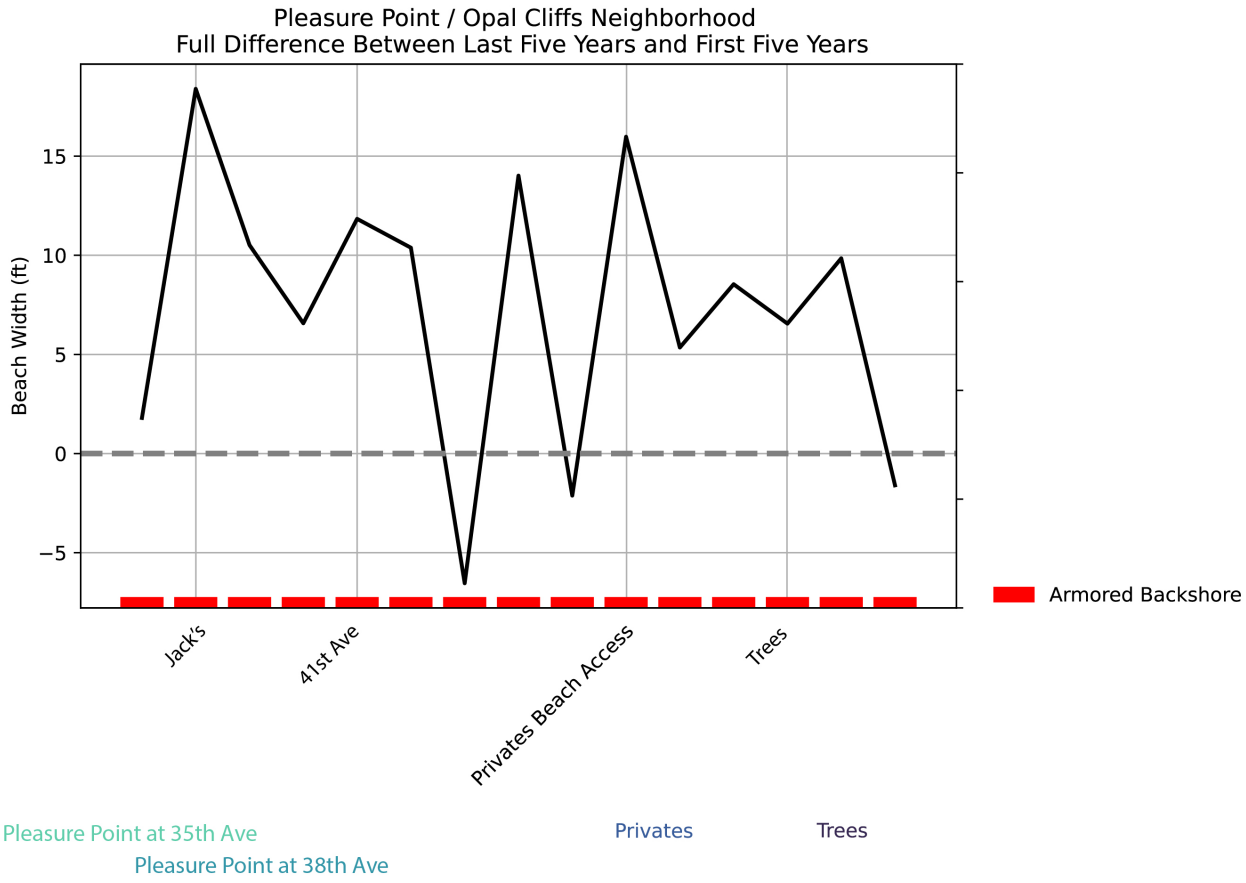


Figure 3-46. Alongshore Difference in Beach Width between the Time Periods of 1984–1989 and 2019–2024

Negative numbers indicate a net narrowing, and positive numbers indicate a net widening. Cliff-backed shorelines with no beaches are excluded from the trend line.

3.3.6 Vulnerability with Sea Level Rise

3.3.6.1 Storm Recurrence and Sea Level Rise

Stormwater levels in the Pleasure Point / Opal Cliffs neighborhood will increase steadily with SLR, leading to more frequent wave overtopping, coastal erosion, and impacts to coastal armoring. Due to the high cliffs and narrow beaches in this area, average total water levels are higher for this neighborhood due to a steeper wave runup angle. Currently, a 100-yr storm (1% annual chance) produces a water level of about 32.2 ft. With 2 ft of SLR, that same level would occur during a 50-year storm (2% annual chance), and with 5 ft, during a 10-year storm (10% annual chance) (Figure 3-47).

Smaller more frequent storms will also bring higher water levels over time. A typical 2-year storm (50% annual chance) reaches about 23.1 ft today; with 2 ft of SLR, it increases to 25 ft, similar to today's 5-year storm (20% annual chance), and with 3 ft, it approaches today's 10-year event (10% annual chance).

The East Cliff Drive roadway along Pleasure Point lies at ~34–38 ft, and by 3 ft of SLR, extreme storm events could bring wave run-up to this elevation. As sea levels rise, this would increase the likelihood of wave overtopping and lead to an increased chance of cliff and bluff failure.

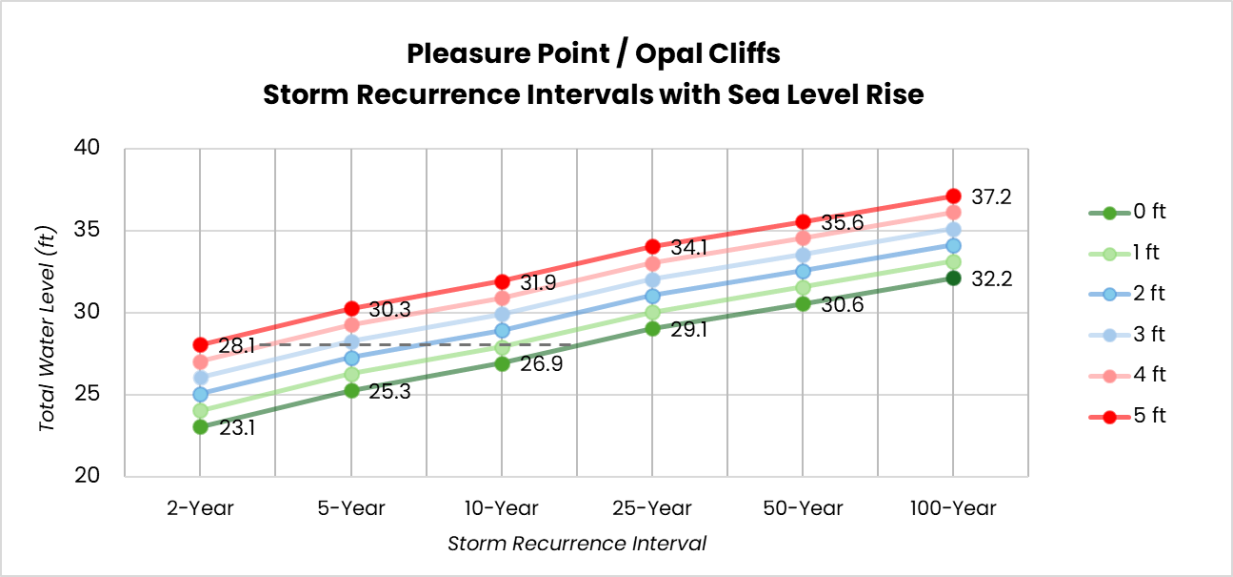


Figure 3-47. Average Storm Recurrence Intervals and Associated Total Water Levels (in ft) with SLR for all FEMA Transects in the Neighborhood

Dashed line represents the total water level associated with the current 100-yr storm.

3.3.6.2 Key Assets at Risk with SLR

As sea levels rise, the Pleasure Point / Opal Cliffs neighborhood will experience increasing exposure to coastal hazards, particularly coastal erosion, wave impacts, and beach loss. These hazards threaten residential properties along the bluff edge, public access infrastructure, shoreline recreation areas, and the stability of East Cliff Drive. The limited undeveloped space around the East Cliff Drive corridor will lead to important community discussions about priorities between vehicles, parking, and pedestrians, such as those that have occurred and are ongoing in other places in the county such as West Cliff Drive in the City of Santa Cruz and Cliff Drive in Capitola.

Land Use and Structures

Figure 3-48 summarizes the number of structures exposed to coastal hazards under increasing SLR, presents the associated cost ranges for those impacts, and provides a comparative view of potential damages by hazard type.

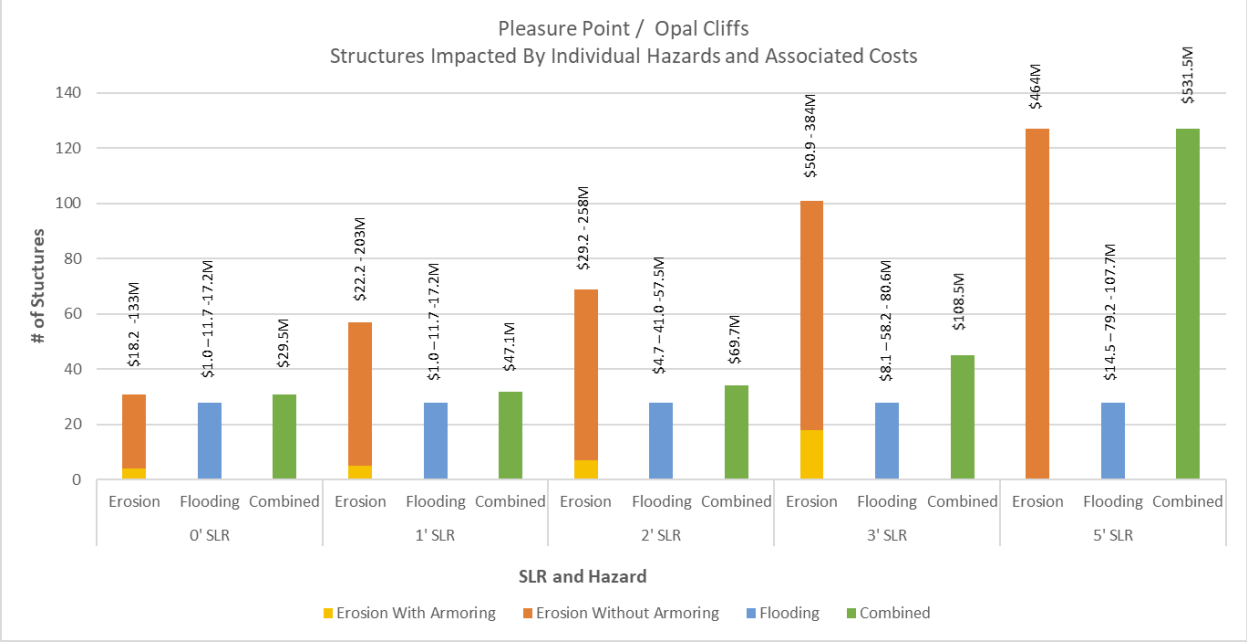


Figure 3-48. Number of Structures Exposed to Coastal Hazards and Associated Costs under Different SLR Scenarios

Costs associated with coastal erosion include the permanent loss of land value and structures. Costs associated with flooding include temporary damages to structures and contents. The combined category includes both, but removes flood damages to unarmored structures lost to erosion in prior horizons.

In the Pleasure Point / Opal Cliffs neighborhood, erosion and flooding impacts increase with SLR, but erosion becomes the more significant coastal hazard into the future if existing armoring fails or is not maintained.

Due to the nature of the higher cliffs throughout this neighborhood, coastal wave flooding exposes 28 structures throughout all time horizons, primarily to the homes off South Palisades Avenue and Pleasure Point Drive around Soquel Point. Projected damages to those properties escalate with SLR, with associated damages on the order of $11.7M to $17.2M under current conditions, and escalating to an estimated $41M to $57.5M in cumulative damages by 2 ft of SLR. By 5 ft of SLR, estimated damages reach roughly $79.2M to $107.7M. While flooding causes a persistent and costly cleanup, the projected exposure is moderate compared to erosion which threatens substantially more land area and structures in this neighborhood.

Exposure to coastal erosion has a strong response to SLR and the presence or absence of armoring. Assuming armoring in place remains effective, erosion exposes less than 20 structures across all SLR horizons, and associated damages remain comparatively low. In contrast, without armoring, exposure goes from 31 structures today to more than 120 structures with 5 ft of SLR. Corresponding damages and losses rise dramatically, from tens of millions of dollars under current conditions to several hundred million dollars at higher SLR horizons.

Overall, Pleasure Point is moderately vulnerable to flooding but increasingly sensitive to coastal erosion with SLR. Over time, the presence, condition, and potential failure of armoring is a key factor shaping future structural risk to upland development and infrastructure.

Figure 3-49 illustrates the probability a structure will experience damage due to wave exposure or coastal erosion with SLR. This assumes a more risk-averse scenario and identified all structures with the potential to be impacted during a 500-year storm event, and assumes coastal armoring is in place through 3 ft of SLR (see Appendix D). Currently, 22 structures around Rockview and Pleasure Point have a high probability of experiencing impacts from coastal hazards due to high exposure to coastal wave hazards. Forty-five structures along Opal Cliff Drive have a low probability of impact, as there is no exposure to coastal wave hazards; however, despite most properties being armored, there is a chance of cliff erosion threatening these homes if coastal armoring should fail.

By **1 ft of SLR**, many of the cliff top homes along Rockview and Pleasure Point move towards a very high probability of experiencing impacts from coastal hazards, and the properties along Opal Cliff Drive move towards a medium probability to experiencing impacts. By **2 ft of SLR**, the properties along Opal Cliff Drive move into a high probability of impact, mostly due to their proximity to the cliff top edge, and the increased probability of erosion as the coastal cliff comes under increased wave attack due to SLR. By this horizon, 31 structures on the inland side of East Cliff Drive are categorized as having a low to very low probability of experiencing impacts. By **5 ft of SLR**, the cliff-top properties along Opal Cliff Drive move into a very high probability, and the properties on the inland side of East Cliff Drive move into a high probability of experiencing impacts due to exposure to coastal erosion.

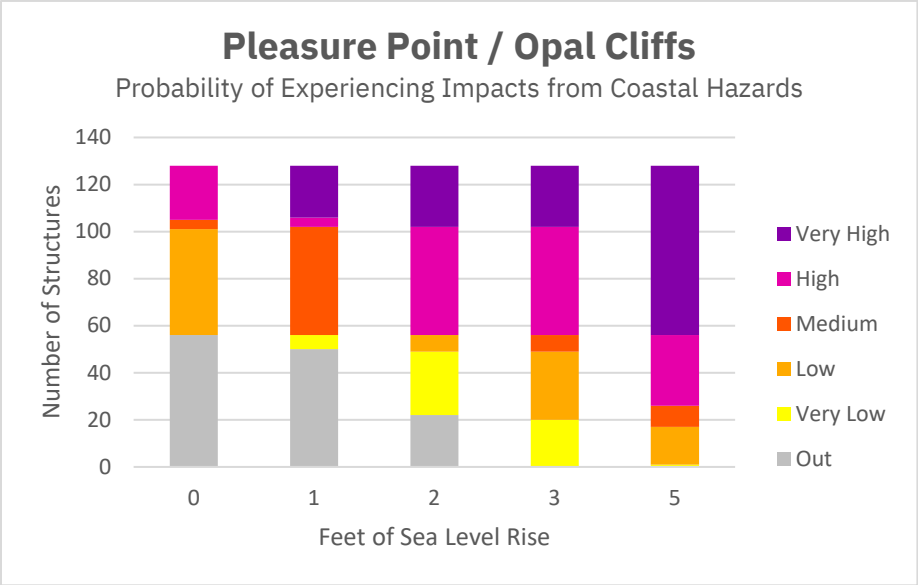


Figure 3-49. Probability of Structures Experiencing Impacts from Coastal Hazards by SLR Horizon

Probabilities combine exposure to both coastal flood and erosion hazards. Flood probabilities correspond to the following: Very High = 20% or greater annual chance, High = 10%–20% annual chance, Med = 5%–10% annual chance, Low = 1%–5% annual chance, Very Low = 0.2%–1% annual chance. Probability of erosion is related to the length of time a structure is within the erosion hazard zone, as well as the armoring condition of the backshore. See Appendix D for more details.

Roads

Between 32nd Avenue and 41st Avenue, East Cliff Drive includes approximately one-half mile of roadway where the cliff-top edge is directly adjacent to the East Cliff Drive multiuse pathway, including the segment between 33rd Avenue and 36th Avenue and a short section just west of Larch Lane. These segments are all currently protected by coastal armoring, as illustrated in Figure 3-50, and would otherwise be exposed to coastal erosion in the absence of that armoring. By 2 ft of SLR, the unarmored portion of East Cliff Drive near the dirt farm is exposed to cliff erosion. Exposure to this area expands through 3 ft of SLR. By 5 ft of SLR, and assuming armoring is no longer in place, the entire stretch of East Cliff Drive between 32nd Avenue and 41st Avenue is exposed to cliff erosion, as well as segments of Opal Cliff Drive (Figure 3-51).

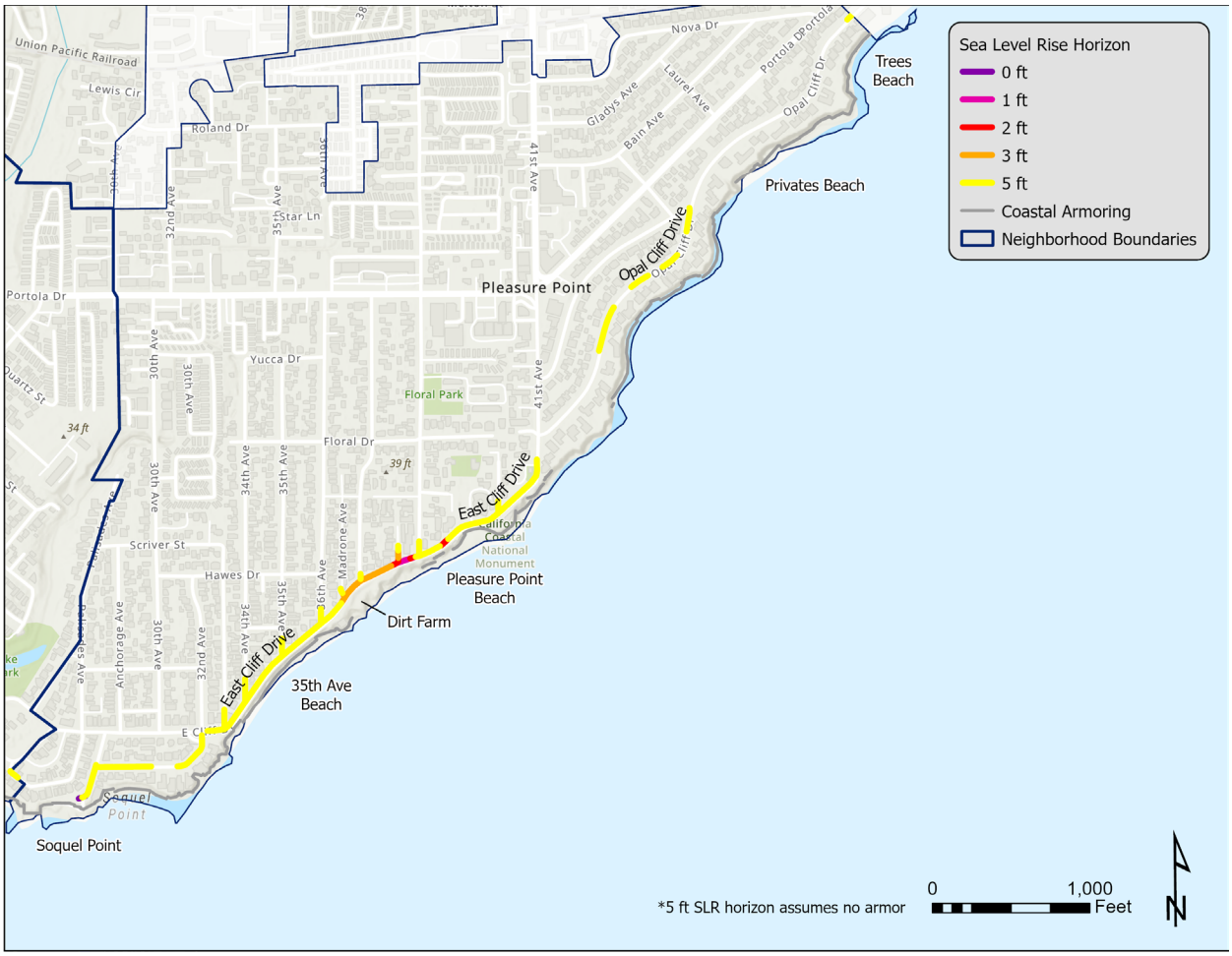


Figure 3-50. Segments of Major Roadways Exposed to Coastal Hazards under Different SLR Scenarios

Results shown assume armoring is in place through 3 ft of SLR, and by 5 ft of SLR, armoring is no longer in place.

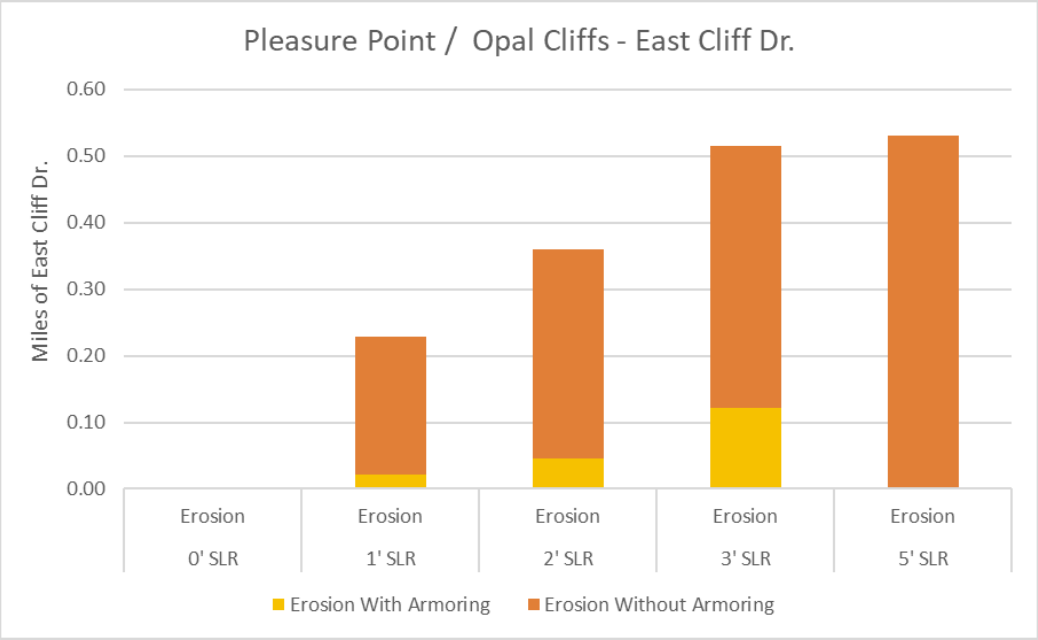


Figure 3-51. Miles of East Cliff Drive Exposed to Coastal Hazards with SLR

Results shown assume armoring is in place through 3ft of SLR, and by 5ft of SLR, armoring is no longer in place. Coastal wave flooding is not a direct hazard of concern for transportation infrastructure in this neighborhood.

Wastewater, Stormwater, and Water Supply Infrastructure

Along East Cliff Drive, wastewater and water supply lines are located in proximity to the cliff-top edge and would be vulnerable to coastal erosion in the absence of existing armoring. Continued SLR and wave attack will increase the risk of cliff failure, which could lead to damages to these utilities.

Beaches

Average winter beach width within the Pleasure Point neighborhood is limited, averaging just under 40 ft under current conditions. Reduced sand supply from upcoast harbor entrapment has further constrained beach recovery, resulting in summer beach widths that are typically narrower than winter conditions. Because these beaches are already narrow, both winter and summer beach widths are projected to be lost completely by 1 ft of SLR, and potentially sooner under erosive storm conditions.

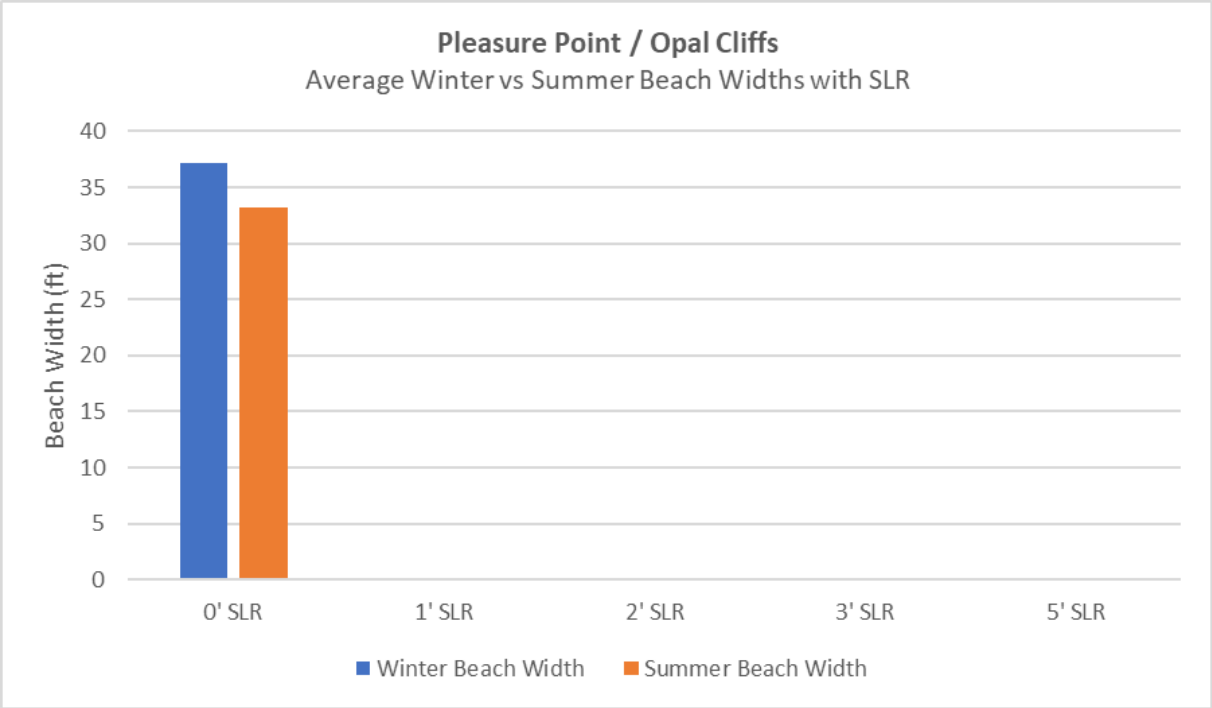


Figure 3-52. Pleasure Point / Opal Cliffs Summer and Winter Beach Widths with SLR

Table 3-7. Pleasure Point winter beach loss locations

Beaches	SLR (ft)				
	0	1	2	3	5
Pleasure Point Park Beach (35th Avenue) **	●	●	●	●	●
Pleasure Point Park Beach (38th Avenue) **	●	●	●	●	●
Privates Beach (Opal Cliffs Park) **	●	●	●	●	●
Trees Beach**	●	●	●	●	●

● = 100+ ft, ● = 25–100 ft, ● = <25 ft, ● = no beach

* = partially armored
** = fully armored

Surfing

As sea levels rise, this neighborhood's surf breaks see a decline in consistency and quality; for example, currently, most of this neighborhood's surf breaks are consistent and function during at least half of all daylight hours, providing reliable and accessible surf throughout the day.

With just 1 ft of SLR, this number drops to just four surf breaks maintaining that same level of consistency. The decline continues at 2 ft of SLR, at which point no surf break has a higher level of consistency than 41% of daylight hours (Table 3-8).

As Santa Cruz County surf breaks decline in consistency and wave quality, this neighborhood will likely experience more intense crowding as functioning surf breaks absorb excess capacity from users of surf breaks that have been lost.

Table 3-8. Percent of daylight hours during which surf break is surfable with SLR

Surfing	SLR (ft)				
	0	1	2	3	5
Rockview	●	●	●	●	●
Sewer Peak	●	●	●	●	●
1st Peak Pleasure Point	●	●	●	●	●
2nd Peak Pleasure Point	●	●	●	●	●
Jacks/38th	●	●	●	●	●
Drainpipes	●	●	●	●	●
The Hook	●	●	●	●	●
Sharks Cove	●	●	●	●	●
Privates	●	●	●	●	●
Trees	●	●	●	●	●

● >50%, very regularly
● = 35%–50%, regularly
● = 20%–35%, regularly
● = 5%–20%, rarely
● = <5%, functionally extinct

Coastal Access

Under existing conditions, all beach access points within the Pleasure Point / Opal Cliffs neighborhood are frequently affected by flooding during high tides and storm wave events, which can temporarily impact access (Table 3-9). Coastal erosion is a significant concern for many of the coastal access stairways, which threatens to undermine these structures. By 1 ft of SLR, the integrity and functionality of all these coastal access locations are severely diminished and threatened unless significant improvements are made. Although currently protected by coastal armoring, the East Cliff Drive walking path will become increasingly

exposed to erosion. By 5 ft of SLR, the public parking lot at The Hook is projected to be exposed to erosion.

Table 3-9. Pleasure Point / Opal Cliffs coastal access impacts with SLR

Coastal Access	SLR (ft)				
	0	1	2	3	5
Rockview	🟡	🔴	🔴	🔴	🔴
Pleasure Point Stairs	🟡	🔴	🔴	🔴	🔴
36th Avenue Stairs	🟡	🔴	🔴	🔴	🔴
38th Avenue Stairs	🟡	🔴	🔴	🔴	🔴
The Hook Stairs	🟡	🔴	🔴	🔴	🔴
Privates Stairs	🟡	🔴	🔴	🔴	🔴
East Cliff Walking Path	🟡	🟡	🟡	🟡	🔴
The Hook Public Parking	🟢	🟢	🟢	🟢	🟡

🟢 = accessible, 🟡 = at risk from flooding, erosion, and beach loss, 🔴 = no longer accessible

3.3.6.3 Risk Summary

The Pleasure Point / Opal Cliffs neighborhood exhibits high exposure to SLR hazards due to the density of cliff top development. Although much of the area is currently armored, coastal erosion is projected to increasingly threaten residential areas, key beach access points, and East Cliff Drive. Key findings by time horizon are summarized below.

Pleasure Point / Opal Cliffs: Near Term (0–1 ft of SLR). By 1 ft of SLR:



Twenty-eight structures are within the 100-yr flood hazard area, and five structures are exposed to coastal cliff erosion assuming armoring is in place.

Seventy-eight structures are within an erosion hazard area assuming a more risk-averse hazard scenario, and 78 are categorized as having medium to very high probability of impact.

With coastal armoring in place, a middle estimate of cumulative damages and losses from flooding and erosion is projected to be $47.1M.



East Cliff Drive is protected by coastal armoring. Without armoring in place, many sections of the roadway would be vulnerable to coastal erosion including from 33rd Avenue to 36th Avenue, and just west of Larch Lane.



Co-located utilities under East Cliff Drive are protected by coastal armoring. Without armoring, many utilities would be exposed to coastal erosion.



Stairways and coastal access structures experience increased exposure to storm wave impacts, while surf breaks at Jacks/38th and Drainpipes become rarely surfable. Beach width recovery diminishes and may no longer occur with 1 ft of SLR, reducing recreational capacity along beaches that support approximately 12,700 annual visits.



Tidepools will experience increased inundation, reducing the extent and persistence of intertidal habitat and shifting conditions toward more continuously submerged rocky shoreline.

Pleasure Point / Opal Cliffs: Mid Term (1–3 ft of SLR). By 3 ft of SLR:



Properties will continue to experience cliff and bluff instability and undercutting of the cliffs.

Twenty-eight structures are within the 100-yr flood hazard area, and 18 structures are exposed to coastal cliff erosion assuming armoring is in place.

One hundred twenty-eight structures are within an erosion hazard area assuming a more risk-averse hazard scenario, and 79 are categorized as having a medium to high probability of impact.

Increasing coastal armoring maintenance would be required to continue to protect upland development.

With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $108.5M.



East Cliff Drive may experience more frequent wind-driven wave splash and erosion, reducing roadway reliability and increasing maintenance needs.



Short segments of co-located utilities under East Cliff Drive at the Dirt Farm are exposed to coastal erosion. The remainder of the co-located utilities are protected by armoring.



Beaches remain absent, and stairways and coastal access structures are no longer functional. Continued reliance on coastal armoring will further degrade surf quality, with surf breaks at Drainpipes, Jacks/38th, The Hook, Sharks Cove, Privates, and Trees becoming rarely surfable or functionally extinct.



Loss of intertidal habitat continues.

Pleasure Point / Opal Cliffs: Long Term (3–5 ft of SLR). By 5 ft of SLR:



Twenty-eight structures are within the 100-yr flood hazard area, and 127 structures are exposed to coastal cliff erosion.

One hundred twenty-eight structures are within an erosion hazard area assuming a more risk-averse hazard scenario, and 111 are categorized as having medium to high probability of impact.

Cliff and bluff retreat threatens all the cliff-top properties and homes.

With coastal armoring in place through 3 ft of SLR, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $531.5 M.

	Assuming no armoring in place with 5 ft of SLR, cliff erosion threatens more than 1 mile of East Cliff Drive from 32nd Avenue to 41st Avenue. If coastal erosion passes the first row of cliff-top homes, segments of Opal Cliff Drive will be exposed to coastal erosion.
	All co-located utilities under East Cliff Drive are threatened by cliff erosion. Utilities under Opal Cliff Drive may be threatened by cliff erosion.
	Beaches remain absent, and all surf breaks are functionally extinct. If coastal armoring is not maintained, public parking at the end of 41st Avenue (The Hook) may begin to experience erosion impacts.
	Loss of intertidal habitat continues.

3.3.7 Key Adaptation Strategies for Consideration

Based on the exposure and vulnerability findings described above, the following list summarizes potential adaptation strategies for the Pleasure Point / Opal Cliffs neighborhood that will be further evaluated. The County owns Pleasure Point County Park, The Hook County Park, and Opal Cliffs Park (Privates), and manages multiple coastal access locations at Pleasure Point.

Near-Term

- Planning and Alignment
  - Coastal property owners
  - Coastal resource advocates

Mid-Term

- Protection
  - Groin(s), headland augmentation and/or nearshore reef structures
  - Soil nail or tie back wall with vertical and horizontal access

Long-Term

- Managed Retreat
  - Relocation and realignment of roads, infrastructure, and upland development.

Pleasure Point / Opal Cliffs - Coastal Hazard Areas: 0 ft SLR with Existing Armoring



Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 0' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (with Armoring)
- Dune Erosion (with Armoring)
- Coastal Armoring

Beach Width (Existing Seasonal Average)
- Summer
- Winter

Structures

Probability of Impact

Very Low | Low | Medium | High | Very High

Critical Infrastructure

black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-53. Pleasure Point / Opal Cliffs SLR Vulnerability Map—0 ft of SLR with Existing Armoring

Pleasure Point / Opal Cliffs - Coastal Hazard Areas: 2 ft SLR with Existing Armoring





Boundaries

- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 2' SLR

- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (with Armoring)
- Dune Erosion (with Armoring)
- Erosion Extent without Armoring
- Coastal Armoring

Winter Beach Width (ft of SLR)

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Structures

Probability of Impact

Very Low | Low | Medium | High | Very High

Critical Infrastructure

black=vulnerable, grey= not vulnerable

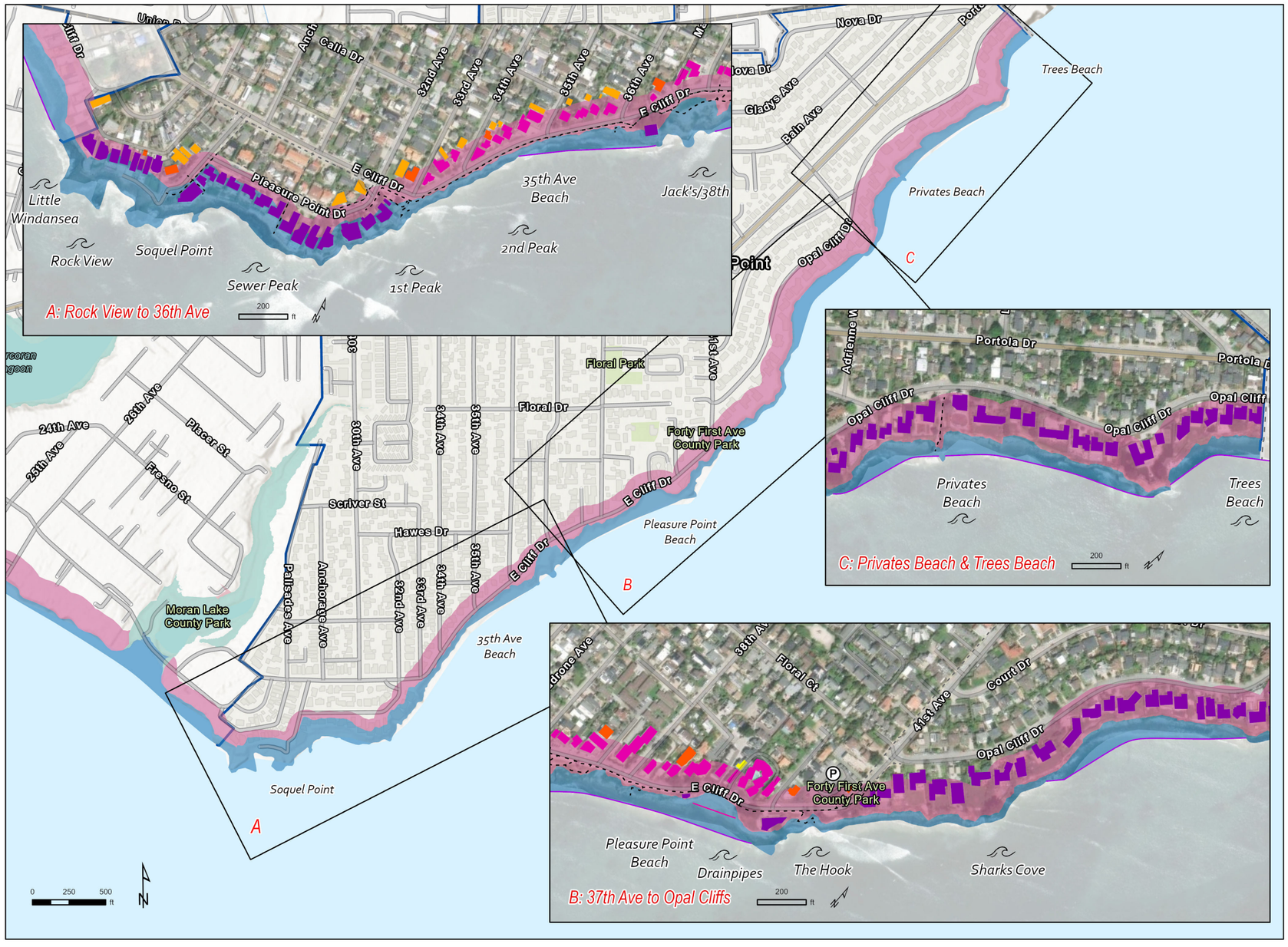
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-54. Pleasure Point / Opal Cliffs SLR Vulnerability Map—2 ft of SLR with Existing Armoring

Pleasure Point / Opal Cliffs - Coastal Hazard Areas: 5 ft SLR without Existing Armoring





Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 5' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (without Armoring)
- Dune Erosion (without Armoring)

Winter Beach Width (ft of SLR)
0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Structures
Probability of Impact
Very Low | Low | Medium | High | Very High

Critical Infrastructure
black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-55. Pleasure Point / Opal Cliffs SLR Vulnerability Map—5 ft of SLR without Existing Armoring

3.4 SEACLIFF / RIO DEL MAR / APTOS

3.4.1 Overview

The Seacliff / Rio del Mar / Aptos neighborhood extends from New Brighton State Beach to Seascape, encompassing just over 4 miles of coastline. The area includes several iconic coastal landmarks such as Seacliff State Beach, the S.S. *Palo Alto* (Cement Ship), and the Rio del Mar Esplanade (Figure 3-56). This is a largely cliff-backed coastline with wide beaches and a high concentration of low-lying development built along the backshore. The low-lying development includes residential communities, State Park facilities and campgrounds, and parking areas.



Figure 3-56. The Rio del Mar Esplanade and Beach Island Housing Development (Source: Visit Santa Cruz County)

3.4.2 Community Characteristics

This neighborhood includes a mix of permanent residences, vacation rentals, and visitor-serving accommodations. The Seacliff area is dominated by cliff-top and beach-level homes, while Rio del Mar features denser housing within the Aptos Creek floodplain. Beach Drive is immediately downcoast of Rio del Mar and consists of several vacation homes situated both on the beach side of the roadway and incised into the sea cliff (Figure 3-31). Further south, the Seascape development is a planned resort community and was constructed in the 1980s and 1990s and is largely set back 100 ft or more from the cliff top edge (Figure 3-31). The local population reflects a blend of year-round residents and seasonal visitors, with strong connections and economic dependency on beach recreation and tourism.



Figure 3-57. Left: Housing Development at the End of Beach Drive. Right: Seascape Resort Development

An example of post-Coastal Act development that is set back from the coastal cliffs (Source: Coastal Records Project)

This neighborhood does not contain any disadvantaged communities (California State Water Resources Control Board 2020) and the average CalEnviroScreen score is low, placed within the 18th percentile statewide for cumulative pollution burden and population vulnerability. This indicates a low cumulative pollution burden and population vulnerability (OEHHA 2021).

3.4.3 Infrastructure and Development

Residential development is concentrated in three key zones: the Seacliff State Beach area, the Rio del Mar flats adjacent to Aptos Creek, and the upland neighborhoods of Aptos. Seacliff includes beachfront homes and public park facilities, while Rio del Mar features older coastal homes and mixed-use areas within the floodplain that floods frequently during rain events.

Key infrastructure includes State Park facilities at Seacliff State Beach, the S.S. *Palo Alto* (Cement Ship) and seawall, and the Aptos Creek bridge at Rio del Mar. The neighborhood's coastal transportation network consists of State Park Drive / Las Olas Drive, Rio del Mar Esplanade and Boulevard, and Beach Drive, as well as smaller segments including Potbelly Beach Road in the north and the private gated homes at Via Gaviota.

Stormwater and wastewater infrastructure are concentrated near Aptos Creek and Esplanade, and the Seacliff Beach parking area, where frequent inundation causes maintenance challenges. In addition, the existing gravity flow stormwater drainage system in Rio del Mar has inadequate conveyance that has led to ponded flood issues. Along Las Olas Drive and State Park Drive, multiple utilities run beneath the back beach under the road, and manholes have been exposed by wave flooding during large swell events in the past. Following the January 1983 storm event, one section of pipe was severed and a half million gallons of raw sewage poured into Monterey Bay daily for 2 weeks (Griggs and Johnston 1983) (Figure 3-58).

The seawall protecting the Cement Ship and lower parking lot has experienced repeated storm damage and continues to have ongoing maintenance challenges.



Figure 3-58. Erosion Damage at Potbelly Beach following the Winter Event of 1982/1983 with Exposed Utility Pipes (Source: G. Griggs)

Key assets and infrastructure in the coastal study area include:

- Private and public access roads and underground utilities
- Seacliff State Park facilities, including a visitor center, picnic shelters, bathrooms, and parking lots
- Eight wastewater pump stations serve residential development and beach areas.

3.4.4 Recreation and Coastal Resources

Seacliff State Beach and Rio del Mar State Beach are major recreational destinations in Santa Cruz County, drawing thousands of annual visitors for swimming, walking, picnicking, and surfing in addition to daily use by local residents. The historic S.S. *Palo Alto* (Cement Ship) remains a defining cultural landmark at Seacliff, despite its advanced deterioration and the recent removal of the access pier following the 2023 storm wave events. California State Parks manages most of the public accesses in this neighborhood, supporting year-round coastal use.[11]

The Seacliff / Rio del Mar / Aptos neighborhood is home to some of the most-visited beaches in unincorporated Santa Cruz County, and taken as a whole, these beaches hosted approximately 330,000 visits, accounting for 37% of all visits to County beaches in 2024. When dividing this

[11] State Parks launched a study to better understand Seacliff State Beach's vulnerabilities and opportunities to improve resilience. More information can be found at: https://www.seacliffresilience.org/

continuous stretch of sand into smaller sections, the southernmost beaches of Beer Can Beach (Sumner Beach) and Seascape Beach (73,200 and 64,000 total visits, respectively), and the Seacliff State Beach (72,900 total visits) received the most visits. In fact, these beach sections made up more than half of all beach visits from all beach areas in this neighborhood (Figure 3-59 and Figure 3-60).

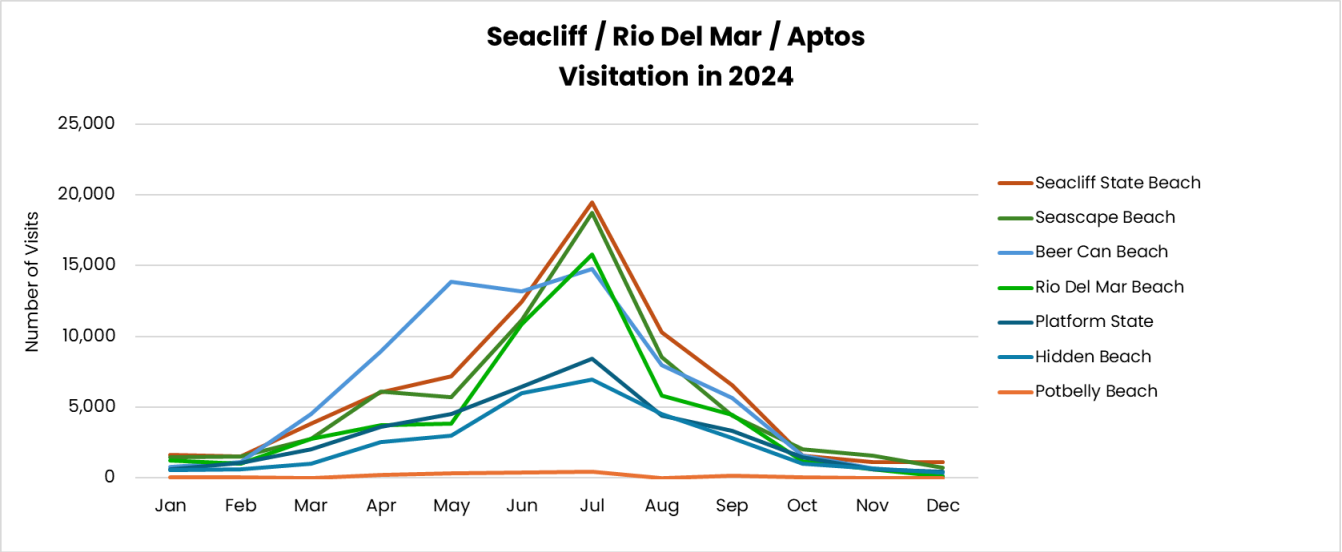


Figure 3-59. Seasonal Visitation (2024)

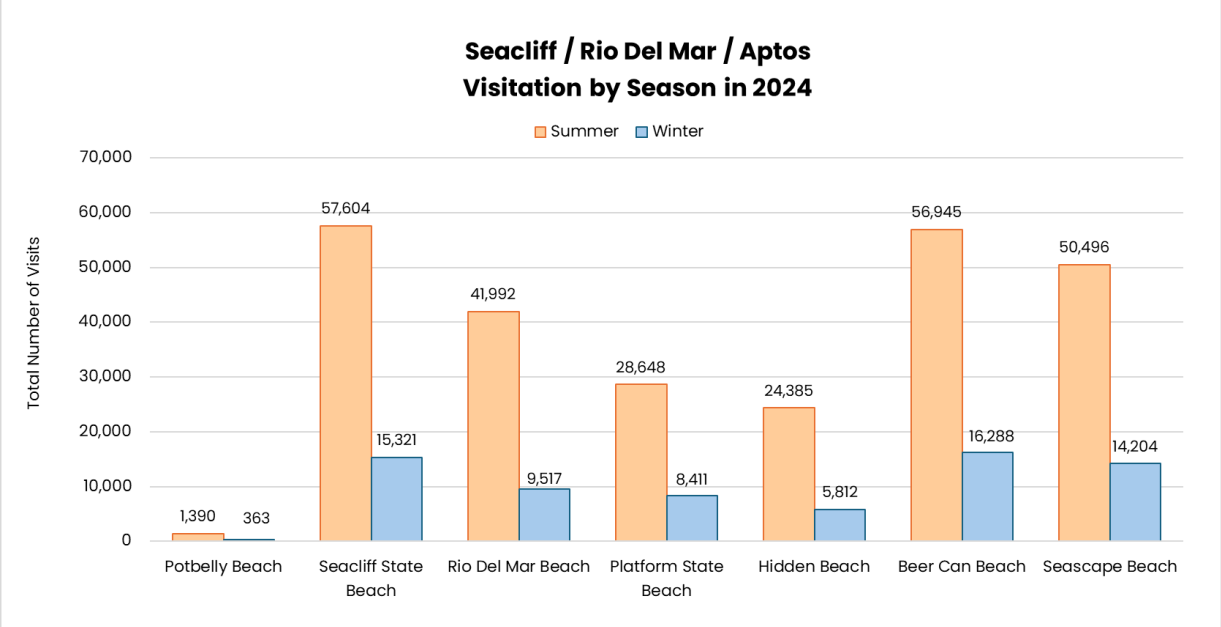


Figure 3-60. Visitation in Summer and Winter (2024)

Visitation data were not available for all beaches, especially for beaches with extensive residential development near the beach.

The visitation pattern of Seacliff / Rio del Mar / Aptos neighborhood reflects those found throughout the unincorporated Santa Cruz County coastline, and approximately 80% of all beach visits occur in the summer season (Figure 3-61). That the distribution of visits at Platform and Beer Can (Sumner) Beach skews more towards the shoulder seasons with fewer tourists suggests that these beaches are likely to be more often visited by locals rather than out-of-town visitors. More in-depth analysis of visitation trends would be required to confirm this, which is beyond the scope of this study.

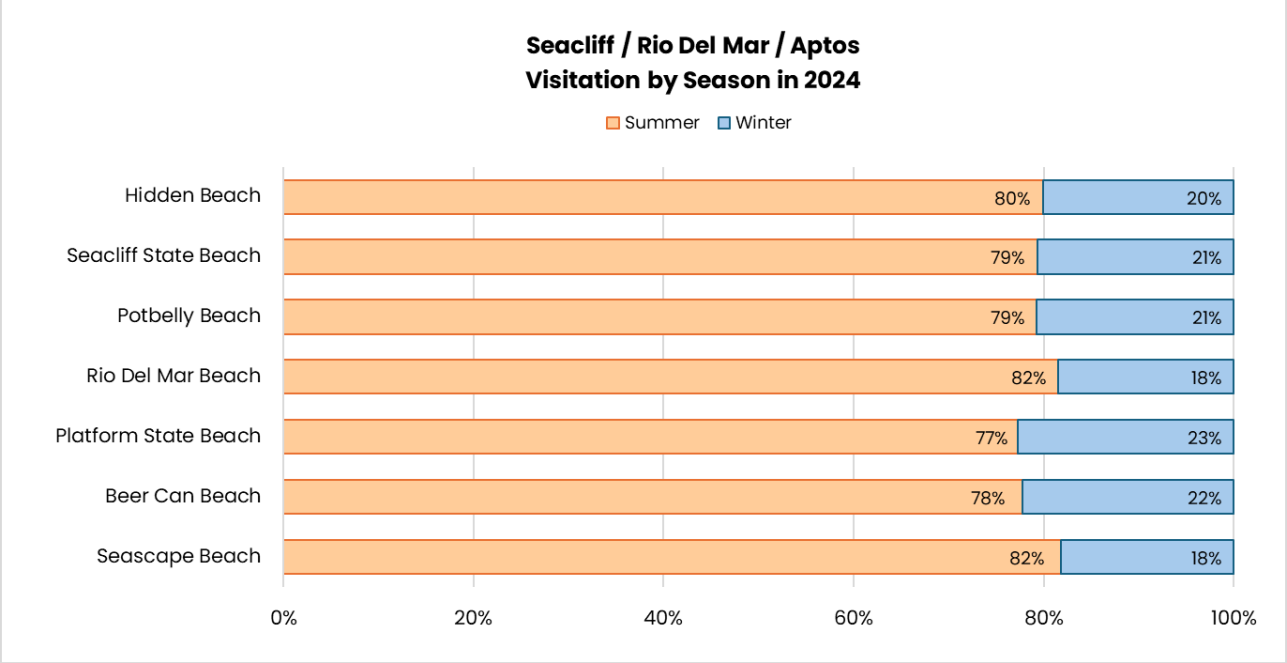


Figure 3-61. Distribution of Visitation in Summer and Winter (2024)

3.4.5 Coastal Processes and Hazards

3.4.5.1 Coastal Erosion

The Purisima Formation (comprising siltstone and sandstone) forms the sea cliffs from Santa Cruz to Rio del Mar, which then transitions to the Pleistocene Aromas Sand further southeast. This latter formation is predominantly composed of semi-consolidated aeolian and fluvial deposits, and although it can stand in steep cliffs protected by a beach, it erodes quickly when exposed to wave action and intense precipitation (Griggs and Johnston 1983).

Long-term cliff and bluff retreat, loss of beach width, and episodic storm-driven erosion regularly affect development in this neighborhood. Most recently, in January 2023, Seacliff State Beach experienced two severe storms with 25- to 35-ft waves that catastrophically damaged the park, leading to significant erosion and damage to the retaining walls, facilities, and removing half of the historic pier that connected with the Cement Ship (Figure 3-62). It also seriously damaged above-ground infrastructure such as restrooms and all the park's underground infrastructure, including campsite hookups (Moffatt & Nichol 2024).



Figure 3-62. Left: Seacliff State Beach, Exposed Retaining Wall Pilings following the 2023 Winter Storm Event. Right: Destruction of the Fishing Pier at Seacliff State Beach (Source: G. Griggs)

3.4.5.2 Coastal Wave Flooding

The Seacliff / Rio del Mar / Aptos neighborhood has the greatest exposure of structures, roadways, and utilities to coastal flooding of any of the unincorporated neighborhoods. This is due to the neighborhood having a significant amount of development directly behind the beach and in the low-lying floodplain adjacent to Aptos Creek.

The Rio del Mar Flats, located within the Aptos Creek floodplain, is particularly vulnerable to stormwater flooding and drainage issues, and storm wave events can cause overtopping along the Rio del Mar Esplanade. In addition to flooding, these storm events can deposit significant quantities of sand and other debris throughout the Esplanade, contributing to potential safety hazards and leading to significant cleanup post-storm event (Figure 3-63).



Figure 3-63. Left: Rio del Mar Flats during the December 11, 2014, Flood Event. The overall flooding was slightly less than a 2-yr event (Source: Kenneth A. Goettel & Associates Inc.) Right: Wave Overtopping and Debris along the Promenade at Rio del Mar during the 1982/1983 Winter. (Source: G. Griggs)

During large swell events and king tides, coastal waves will impact coastal homes, damaging structures and their foundations, walkways, and protective structures. Some of the most notable recent storm events occurred in the winters of 1977/1978, 1982/1983, 1997/1998, and 2022/2023. The 1977/1978 storm event led to the emplacement of much of the current riprap; however, the 1982/1983 event brought waves that overtopped these structures after scouring away the protective beach, and many homes sustained damage (Griggs and Johnson 1983). All these events saw significant damage and disruption to homes in this neighborhood as waves broke through the windows and doors and flooded homes, with several homes partially or fully dislodged from their foundations or collapsing (Figure 3-64).

These storm events also caused significant disruptions to the coastal road network. For example, access to Las Olas Drive, a strip of oceanfront development adjacent to Seacliff State Beach, was cut off for days during the 1982–1983 winter because the access road through Seacliff State Beach flooded and then was blocked by logs and debris (Figure 3-64).



Figure 3-64. Left: Las Olas Drive with Waves Overtopping the Road and Reaching the Homes in 1983 (Source: G. Griggs). Right: Wave Uprush during the Winter 2023

3.4.5.3 Coastal Armoring

Much of the neighborhood's shoreline is armored with a variety of seawalls, revetments, and other stabilization structures to protect residences, roads, and park facilities from chronic erosion and coastal flooding. In total, 3.3 miles of coastal armoring protect many residential and visitor-serving buildings from erosion and coastal flooding, with much of this development built on the back beach. In addition, flood control infrastructure is present along Aptos Creek, which flows onto Rio del Mar State Beach. Among the longest structures are a 1.1-mile retaining wall along Seacliff State Beach, portions of which have recently sustained damage, and a 0.7-mile seawall along the central portion of Beach Drive that was built following the 1978 winter storm event. Other areas are protected by a mix of revetments, bulkheads, and

seawalls. Within this neighborhood, 73% of the shoreline is armored,[12] and 96% of residential buildings are protected by coastal armor.

This neighborhood is also home to a unique living shoreline project that was launched in 2021 and consists of a driftwood core and sand dune, with native plants to help anchor the sand in place. This living shoreline is located near the Rio del Mar State Beach restroom and is a nature-based solution to help protect the State Park facilities from erosion while supporting natural processes and ecosystems (Figure 3-65). While this strategy is not considered a form of hard armoring, it served to protect the state park bathroom during the winter of 2023.

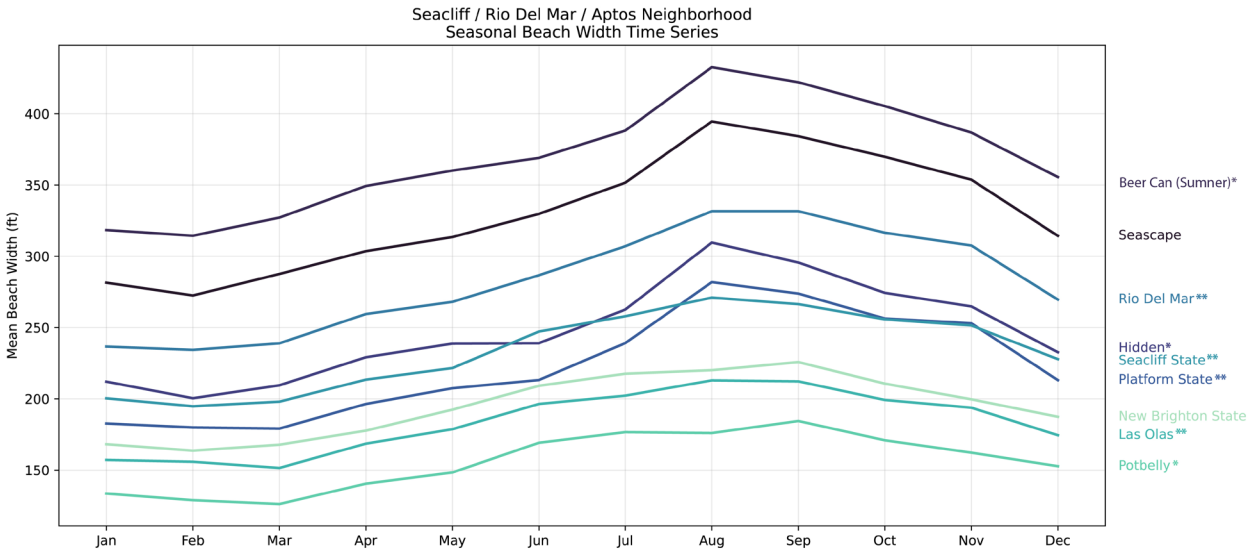


Figure 3-65. Rio del Mar Living Shoreline Project. Top Left: Driftwood Core of the Dune during Construction (Source: D. Revell). Top Right: Dune Grading during Construction (Source: D. Revell). Bottom: Established Dune with Newly Planted Vegetation (Source: M. Jamieson)

[12] Much of the State Park's protective seawall was damaged in the winter storms of 2023; however, at the time of this writing, the current status and future protection provided by this wall is not known. For the purposes of this study, the entire pre-storm damage extent of the wall was considered as armored.

3.4.5.4 Beach Width

Historical beach analysis of CoastSat data shows seasonal variability in beach widths. Figure 3-66 illustrates these seasonal patterns, showing average monthly beach widths over the 40-year record. Beaches south of Rio del Mar beach and Aptos Creek show more seasonal variability than beaches further to the north. On average, there is an approximate 75-ft difference between narrow winter beach widths and the wide summer beaches. The widest beaches occur near the creek mouths, with persistently wider beaches at Rio del Mar Beach near Aptos Creek, and Hidden Beach and Seascape near Bush Gulch. Development on the backshore reduces beach widths in this neighborhood, and beaches without development and armoring are about 100–125 ft wider.



*partially armored

** fully armored

Figure 3-66. Seasonal Beach Width Trends by Beach (average width by month across all records from 1984–2024)

Lighter colors appear further north, and darker colors appear further south. New Brighton State Beach is located outside of the study area, but is included for reference

Beach width trends show that from the mid-1980s to the present, the northern beaches have narrowed, while southern beaches have widened (Figure 3-67). The northwesternmost beaches, including Potbelly and Las Olas, are now narrow significantly in the winter, with recent records showing beaches reaching ~20 ft or less of beach width in the winter (Appendix E).

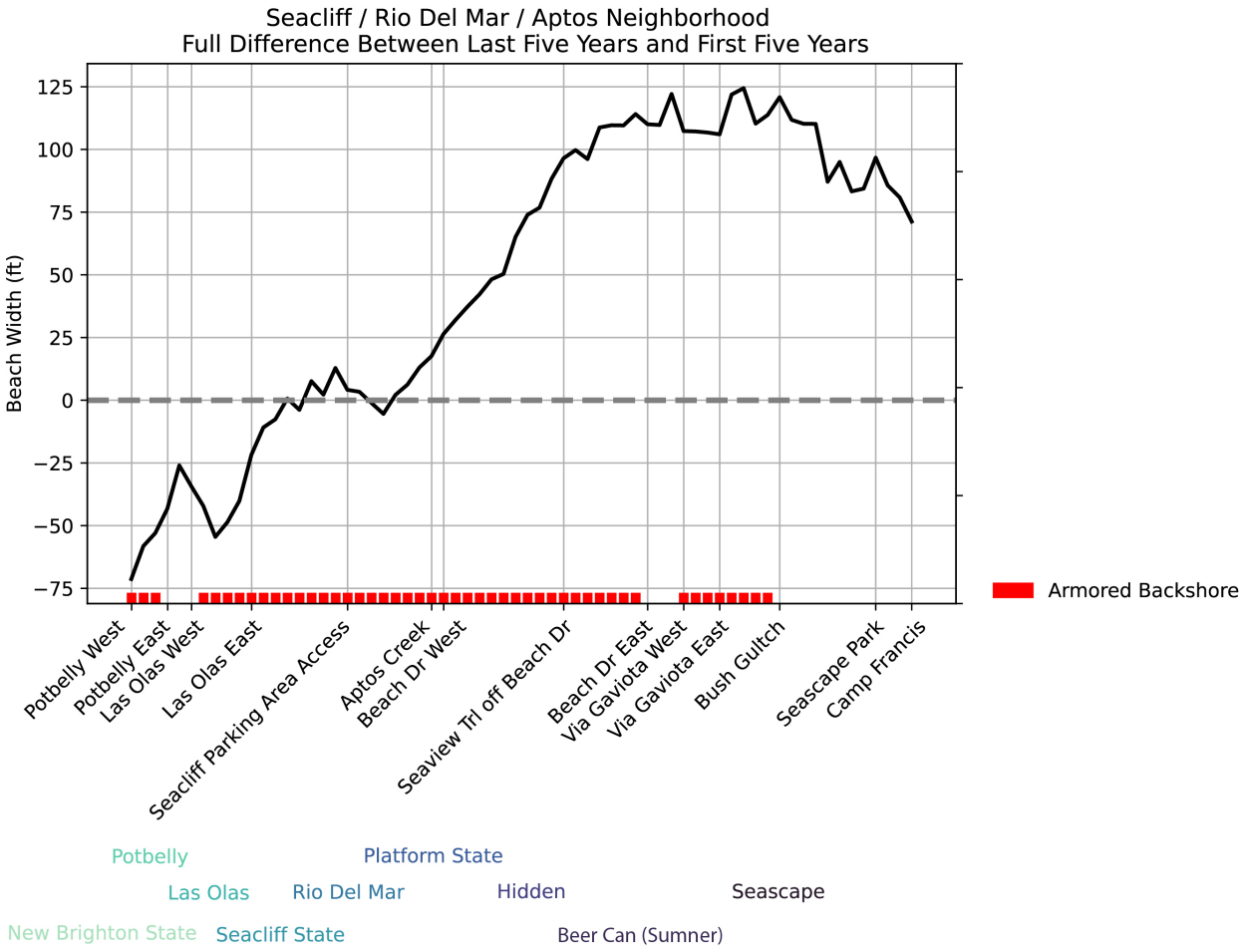


Figure 3-67. Alongshore Difference in Beach Width between the Time Periods of 1984–1989 and 2019–2024

Negative numbers indicate a net narrowing, and positive numbers indicate net widening. New Brighton State Beach is located outside of the study area but is included for reference.

3.4.6 Vulnerability with Sea Level Rise

3.4.6.1 Storm Recurrence and Sea Level Rise

With SLR, coastal wave flooding will reach higher flood elevations more frequently and cause greater depths of flooding. Figure 3-68 illustrates storm recurrence intervals and flood depths with SLR for the Seacliff / Rio del Mar / Aptos neighborhood. This analysis relies on storm wave modeling conducted by the Federal Emergency Management Agency (FEMA), which does not account for higher water levels associated with fluvial compound flooding within the Aptos Creek floodplain, nor does FEMA incorporate SLR into their modeling.

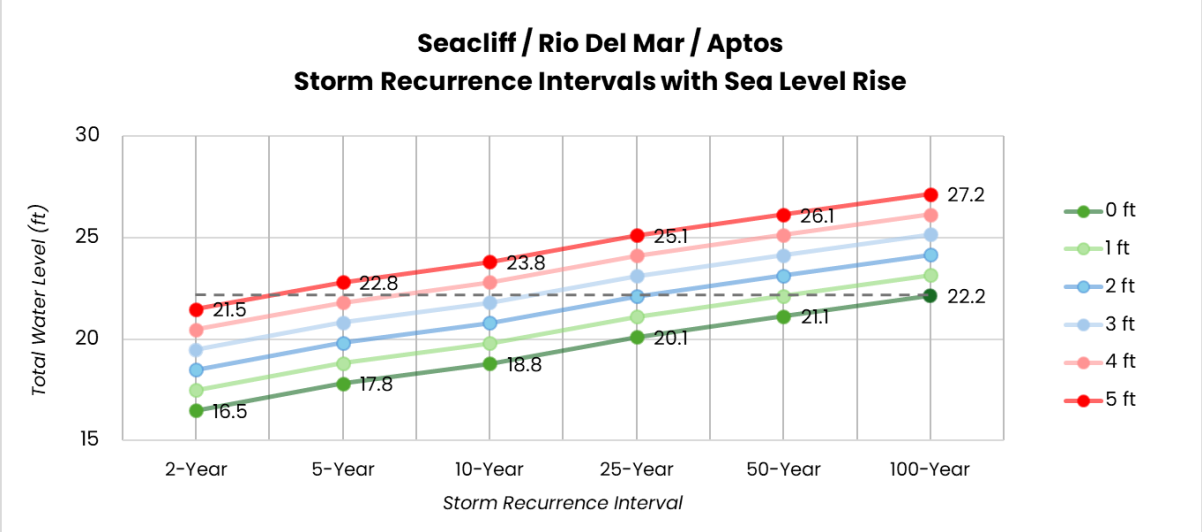


Figure 3-68. Average Storm Recurrence Intervals and Associated Total Water Levels (in ft) with SLR for all FEMA Transects in the Neighborhood

The dashed line represents the total water level associated with the current 100-yr storm.

Currently, a 100-yr storm (1% annual chance) produces an average total water level of about 22.2 ft. With 1 ft of SLR, that same flooding level would occur during a 50-yr storm (2% annual chance), effectively doubling how often it happens. With 2 ft of SLR, it would occur during a 25-year storm (4% annual chance), and with 3 ft, during a 10-year storm (10% annual chance).

Even smaller, more frequent storms will bring higher water levels over time. Under today's conditions, a 2-year storm event (50% annual chance) reaches about 16.5 ft. With 1 ft of SLR, that baseline increases to 17.5 ft, equivalent to what is now a 5-yr storm event (20% annual chance). At 2 ft of SLR, water levels rise to about 18.5 ft, similar to today's 10-yr storm event (10% annual chance).

3.4.6.2 Key Assets at Risk with SLR

As sea levels rise, the Seacliff / Rio del Mar / Aptos neighborhood will face increasing exposure to coastal hazards, including storm wave flooding, erosion, and accelerated beach loss. These impacts will affect a wide range of community assets, from low-lying residential areas and park facilities to beach access infrastructure, recreational beaches, and the Aptos Creek Lagoon ecosystem.

Land Use and Structures

Figure 3-69 summarizes the number of structures exposed to coastal hazards under increasing SLR, presents the associated cost ranges for those impacts, and provides a comparative view of potential damages by hazard type. It highlights how exposure to coastal wave flooding is

currently high, and the number of exposed structures does not increase much with SLR, exposing 449 structures today and rising slightly to just 477 structures by 5 ft of SLR. However, as coastal wave flooding water levels increase, storm wave damage will escalate. With armoring in place, by **2 ft of SLR**, the coastal development in this neighborhood is projected to experience cumulative damages of $160M to $372M due to storm wave damages. This assumes that coastal structures are continually repaired and rebuilt following a damaging storm event. **By 3 ft of SLR**, a 10-yr storm reaches the same water level as today's 100-yr storm, and by this SLR horizon, without significant adaptation measures in place, all the low-lying coastal development will be damaged faster than it can be repaired. By 3 ft of SLR, assuming no armoring in place, the damages and losses to property and structures could amount to $1.98B. **By 5 ft of SLR**, assuming no armoring is in place, this rises to $2.56B.

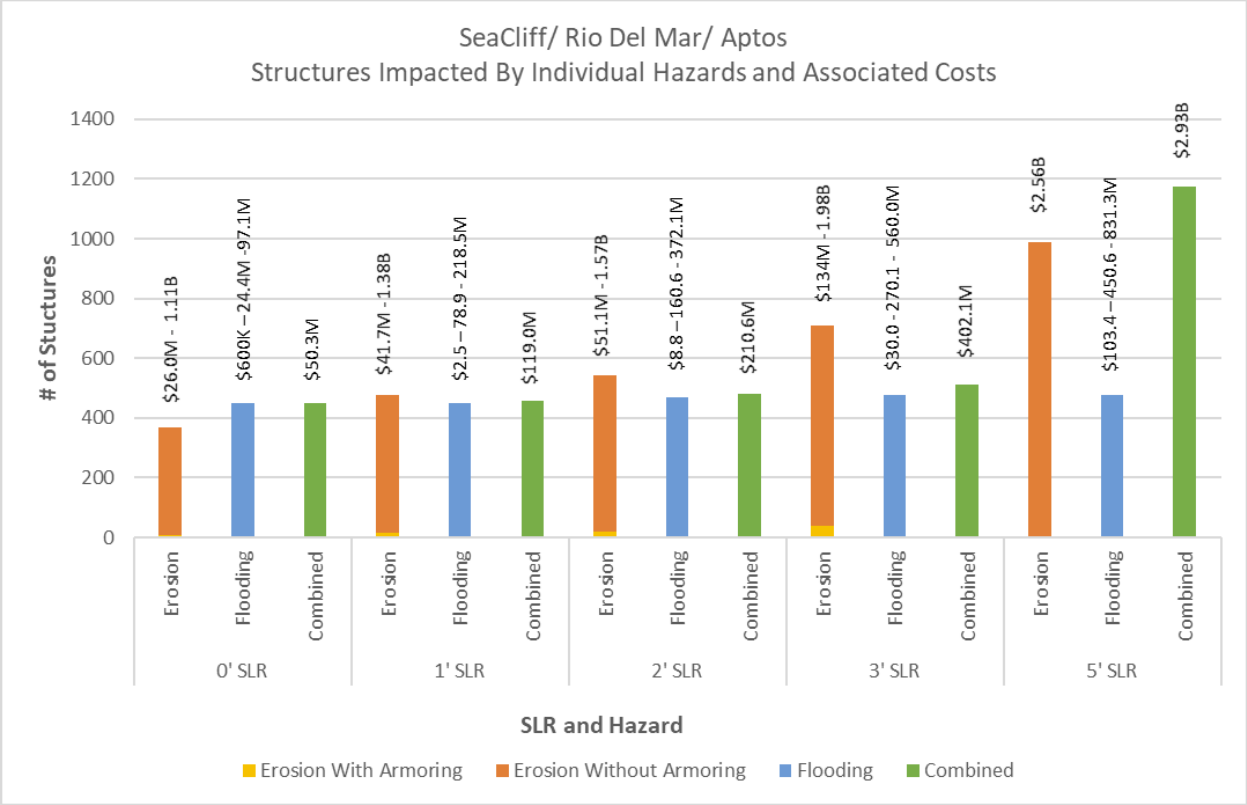


Figure 3-69. Seacliff / Rio del Mar / Aptos Number of Structures Experiencing Impacts from Coastal Hazards and Associated Costs under Different SLR Scenarios

Costs associated with coastal erosion include the permanent loss of land value and structures. Costs associated with flooding include temporary damages to structures and contents. The combined category includes both but removes flood damages to unarmored structures lost to erosion in prior horizons.

With SLR, and without adaptation measures and assuming armor stays in place, beach widths will narrow, and the northernmost beaches will be the first to disappear. **By 1 ft of SLR**, there will be no beach left at Potbelly Beach and Las Olas Beach in the winter, which will lead to additional scouring, wave attack, and increasing maintenance requirements for existing coastal armoring. **By 2 ft of SLR**, all beaches from Potbelly to Platform State Beach will disappear in the winter, further threatening the viability of the coastal armoring and low-lying development in this entire area. This vulnerable coastal armoring and development are currently preventing wave action from reaching the toe of the cliffs, reducing cliff erosion, and indirectly protecting the cliff-top development. If the low-lying development on the beach is removed, erosion rates along these cliffs are expected to increase and expose more cliff-top development. Due to the soft and erodible nature of these cliffs and bluffs, approximately 600 cliff-top structures in Seacliff and Aptos may be exposed to coastal erosion by 5 ft of SLR. This includes many structures not just adjacent to the blufftop edge, but potentially multiple rows of homes from the cliff-top edge.

Figure 3-70 illustrates the probability that a structure will experience damage due to wave exposure or coastal erosion with SLR. This assumes a more risk-averse scenario and identified all structures with the potential to be impacted during a 500-year storm event and assumes coastal armoring is in place through 3 ft of SLR (Appendix D). **Currently**, the only properties in the very high probability of impact are in the low-lying area of Rio del Mar Flats and are exposed to a combination of flood hazards related to stormwater flooding, storm wave overtopping, and potential spillover of Aptos Creek. The oceanfront structures at Potbelly, Las Olas, Beach Island, and Seacliff State Beach are categorized as a high probability of impact, and the remaining beachfront development along Beach Drive and Via Gaviota is categorized as a medium to low probability of impact. All development at the top of the cliffs is categorized as either low, very low, or no probability of impact.

By **2 ft of SLR**, there is a significant increase in exposure to the beachfront development and the development in Rio del Mar Flats. Two hundred forty-five structures are in the very high probability of impact category, and 153 are in the high category. The only beachfront development that remains in the medium category is at Via Gaviota. By **5 ft of SLR**, 680 structures, including all the low-lying beachfront development, as well as development adjacent to the bluff top edge, are categorized as very high probability. The remaining 434 structures are all categorized between very low to medium probability of impact.

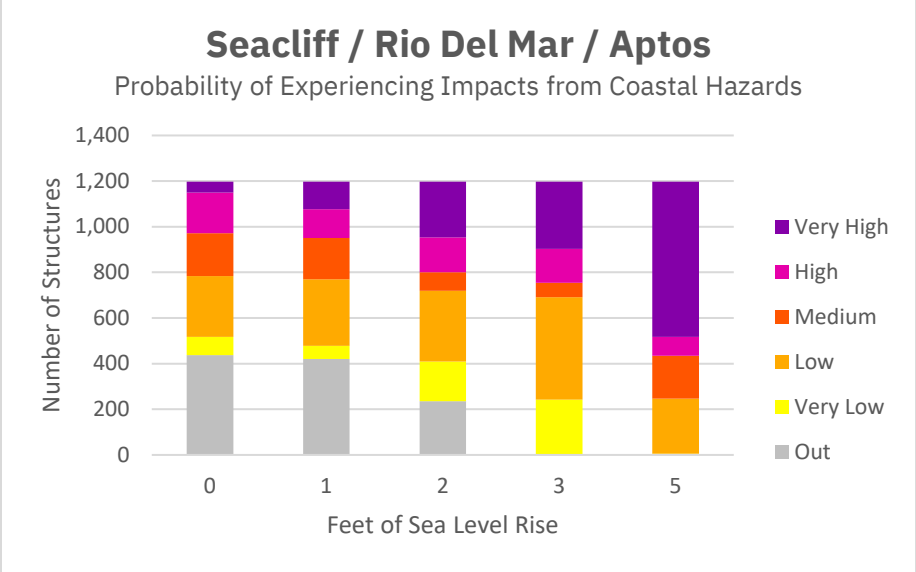


Figure 3-70. Probability of Structures Experiencing Impacts from Coastal Hazards by SLR Horizon

Probabilities combine exposure to both coastal flood and erosion hazards. Flood probabilities correspond to the following: Very High = 20% or greater annual chance, High = 10%–20% annual chance, Med = 5%–10% annual chance, Low = 1%–5% annual chance, Very Low = 0.2%–1% annual chance. Probability of erosion is related to the length of time a structure is within the erosion hazard zone, as well as the armoring condition of the backshore. See Appendix D for more details.

Roads

This neighborhood area is currently vulnerable to storm-driven wave flooding, with much of the Rio del Mar Flats subject to inundation during large storm events. The Esplanade, State Park Drive, Beach Drive, Los Olas Drive, and roadways within the Rio del Mar Flats already experience flooding and disruptions during major storms.

Although much of the area is currently protected from coastal erosion by armoring, by 5 ft of SLR and in the absence of armoring, erosion could extend into the cliff-top neighborhoods and expose roadways, including Seacliff Drive, Coates Drive, Kingsbury Drive, Seaview Drive, and Bay View Drive.

Wastewater Stormwater, and Water Supply Infrastructure

Critical infrastructure and utilities are protected by coastal armoring, including five wastewater pump stations located at 22 Potbelly Beach Road (Potbelly Pump Station), 201 State Park Drive (A1 Pump Station), Marina Avenue (Aptos Esplanade Pump Station), the beach restroom at the end of Aptos Beach Drive (Rio del Mar State Beach Bathroom Pump Station), and Beach Drive at Seacliff State Beach (A3 Pump Station). While protected by armoring, they are still

exposed to wave-driven flooding. In the absence of coastal armoring, these pump stations, along with three additional stations at 101 Mar Vista Drive (Mar Vista Pump Station), 1046 Malibu Road (Via Palo Alto Pump Station), and 770 Cliff Drive (Hidden Beach Pump Station), would be exposed to coastal erosion if the armoring were not in place (Figure 3-71). So long as the coastline remains armored, water mains along Las Olas Drive, Beach Drive, and other coastal areas will not be exposed to coastal erosion, but impacts associated with storm wave flooding are expected to escalate with SLR.

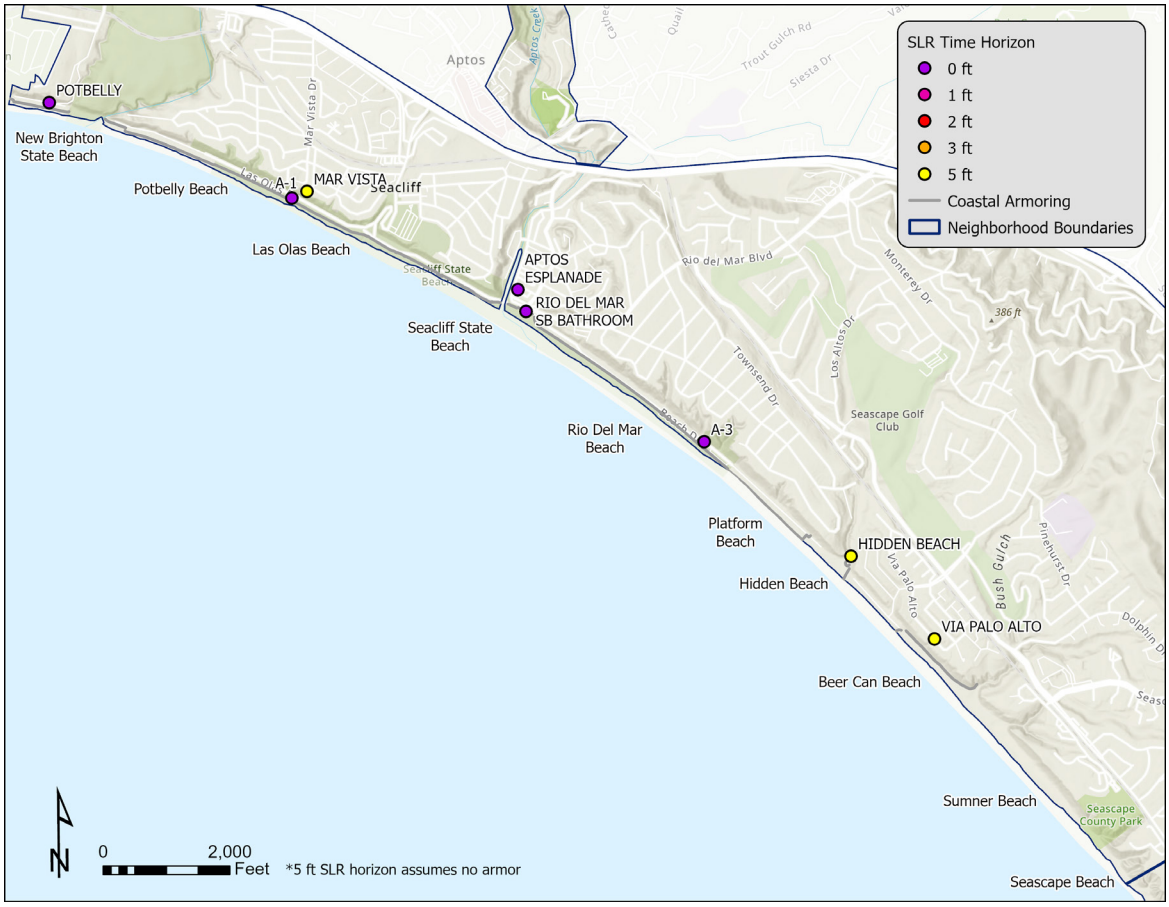


Figure 3-71. Seacliff /Rio del Mar / Aptos Wastewater Pump Stations at Risk with SLR.

Results shown assume that armoring is in place through 3 ft of SLR, and by 5 ft of SLR, armoring is no longer in place.

Table 3-10. Seacliff/Rio del Mar/ Aptos wastewater pump stations at risk with SLR

Wastewater Infrastructure	SLR (ft)				
	0	1	2	3	5
Potbelly Pump Station	●	●	●	●	●
A1 Pump Station	●	●	●	●	●
Mar Vista Pump Station	●	●	●	●	●
Aptos Esplanade Pump Station	●	●	●	●	●
Rio del Mar SB Bathroom Pump Station	●	●	●	●	●
A3 Pump Station	●	●	●	●	●
Hidden Beach Pump Station	●	●	●	●	●
Via Palo Alto Pump Station	●	●	●	●	●

● = safe ● = at risk from flooding or erosion

In addition to storm wave flooding and erosion, emergent groundwater also has the potential to impact back-beach utilities with SLR. A study by Moffatt & Nichol (2024) found that the general groundwater elevation at Seacliff and New Brighton State Beach is around +18 ft NAVD88, and the groundwater elevation at the base of the cliff at Seacliff Beach is generally at +12 feet NAVD88 [North America Vertical Datum of 1988]. Moffatt & Nichol (2024) also observed that in some areas of Las Olas Drive, the groundwater elevation is at the elevation of the roadway, and groundwater seeps are sometimes visible. However, the study concluded that groundwater rise driven by SLR is not anticipated to significantly impact below-grade utilities more so than coastal hazards exacerbated by SLR, such as wave run-up, beach scour, and inundation due to SLR.

Beaches

Average winter beach widths in the Seacliff / Rio del Mar / Aptos neighborhood decline sharply with SLR, from roughly 220 ft today to under 100 ft with just 1 ft of SLR. In the west end of the neighborhood, winter beaches are projected to disappear as early as 1 ft of SLR. By 2 ft of SLR, winter beach widths throughout the area are reduced to approximately 10 ft, and summer beaches are reduced to less than 50 ft (Figure 3-72). By this horizon, there is no beach along any of the developed sections of coastline. However, the beach development and armoring consume an average of 125 ft in beach width, and these projections assume that these features stay in place. With development not on the beach, by 2 ft of SLR, summer beaches will remain south of Rio del Mar. By 3 ft of SLR, nearly all summer and winter beach is lost for this entire stretch of coastline (Figure 3-72 and Table 3-11).

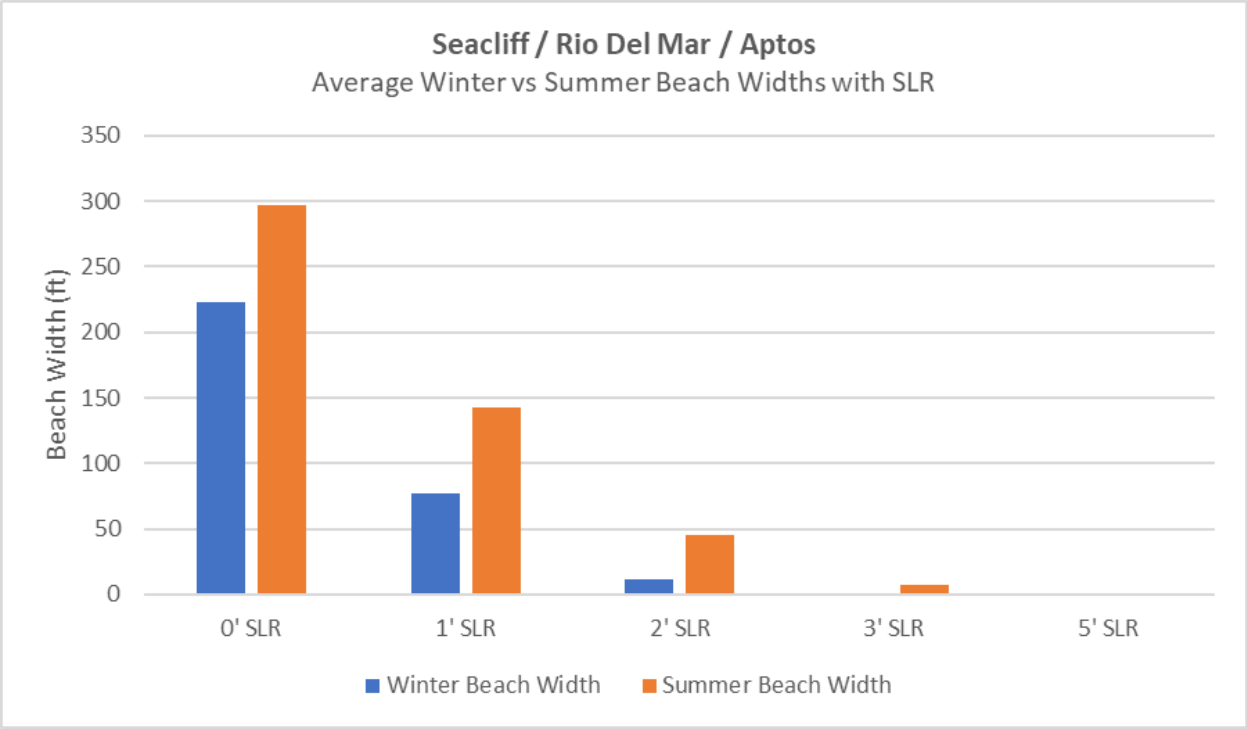


Figure 3-72. Seacliff /Rio del Mar /Aptos Summer and Winter Beach Widths with SLR

Table 3-11. Seacliff / Rio del Mar / Aptos average winter beach width projections with SLR

Beaches	SLR (ft)				
	0	1	2	3	5
Potbelly Beach *	🟡	🟤	🟤	🟤	🟤
Las Olas Beach *	🟢	🟤	🟤	🟤	🟤
Seacliff State Beach **	🟢	🟡	🟤	🟤	🟤
Rio del Mar Beach **	🟢	🟡	🔴	🟤	🟤
Platform State Beach **	🟢	🟡	🟤	🟤	🟤
Hidden Beach (Via Gaviota) *	🟢	🟡	🟡	🟤	🟤
Beer Can Beach (Sumner Beach) *	🟢	🟢	🟡	🔴	🟤
Seascape Beach	🟢	🟢	🔴	🟤	🟤

🟢 = 100+ ft, 🟡 = 25–100 ft, 🔴 = <25 ft, 🟤 = no beach

* = partially armored
** = fully armored

3.4.6.3 Risk Summary

The Seacliff / Rio del Mar / Aptos neighborhood is one of the more densely developed segments of the county's coastline, with a high concentration of residential development, roadways, critical utilities, and recreational infrastructure located on the back of the beach and at the top of the coastal cliffs. The utilities that support this development, including wastewater pump stations and conveyance infrastructure, are highly sensitive as the allowable service interruption time is limited, and failure could lead to serious consequences such as a sewage spill. Low-lying areas, including the Rio del Mar Flats, are already vulnerable to flooding under current conditions, particularly during large storm events and high tides. Extensive coastal armoring currently provides protection to many cliff-backed areas, reducing erosion exposure at present and under lower SLR scenarios, but also constraining the natural ability of beaches and the backshore to migrate inland. Key findings by time horizon are summarized below.

Seacliff / Rio del Mar / Aptos: Near Term (0–1 ft of SLR). By 1 ft of SLR:



Four hundred forty-nine structures are within the 100-yr flood hazard area, and seven structures are exposed to coastal cliff erosion, assuming armoring is in place.

Seven hundred sixty structures are within a coastal, riverine, and/or erosion hazard area, assuming a more risk-averse scenario, and 414 are categorized as having a medium to very high probability of impact.

In Rio del Mar Flats, 246 commercial and residential buildings are vulnerable to flooding due to a combination of storm wave overtopping, stormwater, and fluvial flooding.

Along the beachfront, more than 250 structures are protected by the 2.9 miles of existing seawall; however, they are vulnerable to storm wave flooding and wave overtopping.

Given the largely armored coastline and that many beachfront homes are elevated, damage estimates related to flooding could vary from $2.5M in calmer conditions up to $218M in stormier conditions.[13]

With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $119M.

[13] Calm conditions are represented as multiple small storms (5-yr recurrence or less) over a 20-yr window, and stormier conditions represent multiple large storms over a 20-yr window (one 100-yr, one 25-yr, and multiple smaller storms).



Coastal roadways including Potbelly Beach Road, Las Olas Drive, State Park Drive, Rio del Mar Esplanade, and Beach Drive are vulnerable to coastal storm wave overtopping and flooding.



Wastewater pump stations protected by coastal armoring (Potbelly, A1, Aptos Esplanade, Rio del Mar SB Bathroom, and A3) are already exposed to wave-driven flooding during high tides and storms, increasing operational and spill risk.



Storm wave flooding exposes parking lots and park facilities at Seacliff and Rio del Mar State beaches, including gazebos, restrooms, and picnic areas. Western beaches, including Potbelly, Las Olas, and portions of Seacliff State Beach, are projected to be lost with 1 ft of SLR.



Increased tidal backwatering at Aptos Creek leads to more frequent flooding near the creek mouth, altered salinity and habitat conditions, and a greater risk of compound flooding during storm events.

Seacliff / Rio del Mar / Aptos: Mid Term (1–3 ft of SLR). By 3 ft of SLR:



Four hundred seventy-seven structures are within the 100-yr flood hazard area, and 40 structures are exposed to coastal cliff erosion, assuming armoring is in place.

A total of 1,198 structures are within a coastal, riverine, and/or erosion hazard area, assuming a more risk-averse hazard scenario, and 507 are categorized as having medium to very high probability of impact categories.

In Rio del Mar Flats, the majority of the community will experience regular high tide flooding.

The homes at Via Gaviota may experience coastal wave overtopping.

Along the beachfront, with narrowing beaches and increases in wave exposure, the requirements to maintain the 2.9 miles of seawall will be challenging.

Assuming armoring is in place, damage estimates related to flooding could vary from $30M in calmer conditions up to $560M in stormier conditions.[14] Many coastal properties may be damaged faster than they can be repaired. With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $402M.



Storm wave overtopping and flooding expand along coastal roadways, with Via Gaviota beginning to experience wave-driven flooding during storm events.



At the Rio del Mar Flats, higher groundwater levels could result in more inflow and infiltration into the wastewater collection system, as well as corrosion issues to the electrical infrastructure.

Water mains along Las Olas Drive, Beach Drive, and other armored coastal corridors remain largely protected from erosion but are increasingly exposed to flooding.

Flooding over manhole tops could lead to increased infiltration as well as scouring/damage due to wave action.

The wastewater system could experience overflows and backflow, as well as reduced conveyance and increased pumping requirements.

Low-lying infrastructure will experience maintenance and repair challenges due to higher groundwater levels and surface inundation.



State Park facilities are projected to experience chronic flooding. Average summer beach widths narrow to approximately 17 ft, with beaches remaining only in southeastern areas that are currently unarmored and not backed by development. This substantially reduced recreational capacity along the beaches in this neighborhood that support approximately 330,000 annual visits.

[14] Calm conditions are represented as multiple small storms (5-yr recurrence or less) over a 20-yr window, and stormier conditions represent multiple large storms over a 20-yr window (one 100-yr, one 25-yr, and multiple smaller storms).



Continued increases in tidal backwatering at Aptos Creek lead to more frequent and prolonged flooding and ongoing salinity change.

Seacliff / Rio del Mar / Aptos: Long Term (3–5 ft SLR). By 5ft of SLR:



Four hundred seventy-seven structures are within the 100-yr flood hazard area, and 987 structures are exposed to coastal cliff erosion.

A total of 1,198 structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse hazard scenario, and 952 are categorized as having medium to very high probability of impact.

Rio del Mar Flats and beachfront communities will experience chronic flooding.

A middle estimate for cumulative damages and losses from flooding and erosion is projected to be $2.9B. This includes substantial damages and losses to properties above the cliff in Seacliff, Aptos, and Seascape.

Damage estimates related to flooding could vary from $30M in calmer conditions up to $560M in stormier conditions.[15]

With coastal armoring in place through 3 ft of SLR, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $402M.



All back-beach coastal roadways will experience chronic flooding and exposure to coastal erosion. Many cliff top roadways, including Seacliff Drive, Coates Drive, Rio del Mar Boulevard, Kingsbury Drive, and others, will be exposed to coastal cliff erosion.



All back-beach utilities will experience exposure to wave runup, beach scour, and tidal inundation, and this critical wastewater and water supply infrastructure faces a high risk of failure and service disruption. The Mar Vista, Hidden Beach, and Via Palo Alto Pump Stations may be exposed to coastal erosion.

[15] Calm conditions are represented as multiple small storms over a 20-yr window, and stormier conditions represent multiple large storms over a 20-yr window.



Beaches are fully lost, and coastal erosion exposes the cliff-top State Park parking lot at Seacliff State Park.



Persistent tidal backwatering and lagoon expansion result in chronic flooding near the Aptos Creek mouth.

3.4.7 Key Adaptation Strategies for Consideration

Based on the exposure and vulnerability findings described above, the following list summarizes potential adaptation strategies for the Seacliff / Rio del Mar /Aptos neighborhood that will be further evaluated. The County owns Hidden Beach County Park, Dolphin and Sumner County Beach (Beer Can Beach), and multiple shore trails and coastal access locations.

Near-Term

- Planning and Alignment
  - State parks
  - Coastal property owners
  - Coastal resource advocates
- Nature-Based Solutions
  - Dune creation and restoration
  - Cliff and bluff planting and management of stormwater and access
- Stormwater Management at Rio del Mar Flats
- Sand Management

Mid-Term

- Protection
  - Raise armoring
- Nourishment

Long-Term

- Managed Retreat
  - Relocation or retreat of beachfront and upland development.

Seacliff / Rio Del Mar / Aptos - Coastal Hazard Areas: 0 ft SLR with Existing Armoring

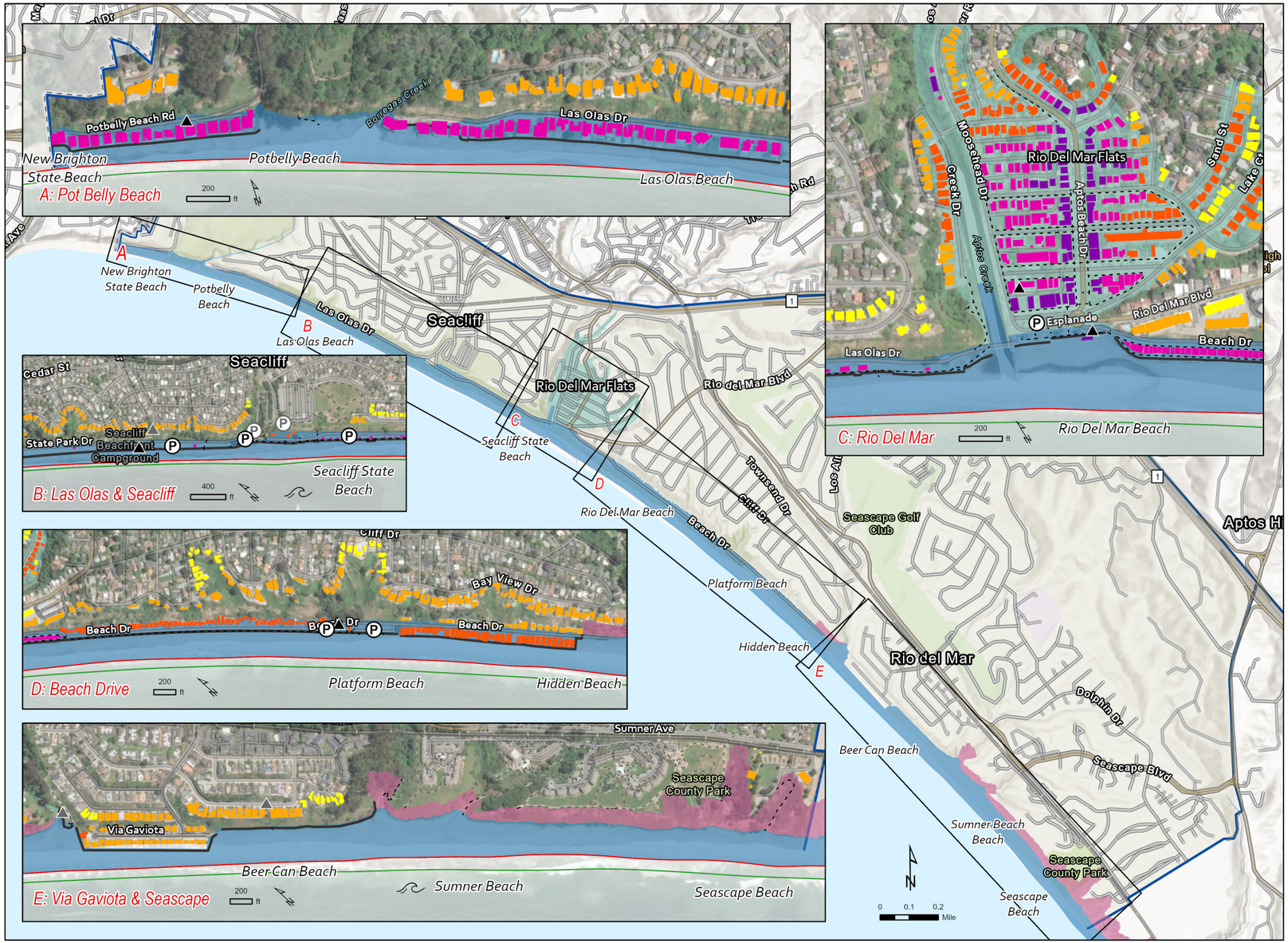
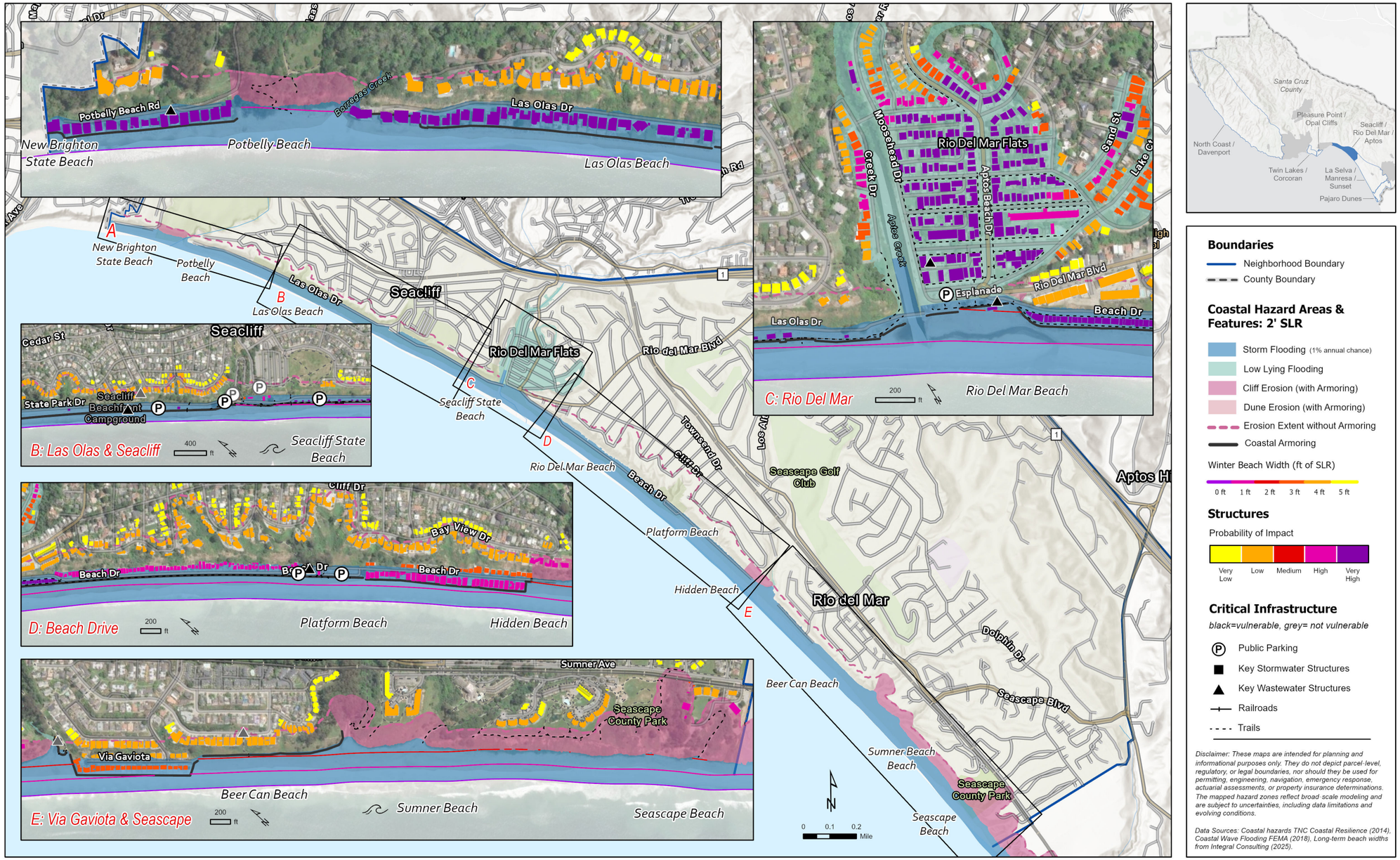


Figure 3-73. Seacliff / Rio del Mar / Aptos SLR Vulnerability Map—0 ft of SLR with Existing Armoring

Seacliff / Rio Del Mar / Aptos - Coastal Hazard Areas: 2 ft SLR with Existing Armoring



Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 2' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (with Armoring)
- Dune Erosion (with Armoring)
- Erosion Extent without Armoring
- Coastal Armoring

Winter Beach Width (ft of SLR)
0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Structures
Probability of Impact
Very Low | Low | Medium | High | Very High

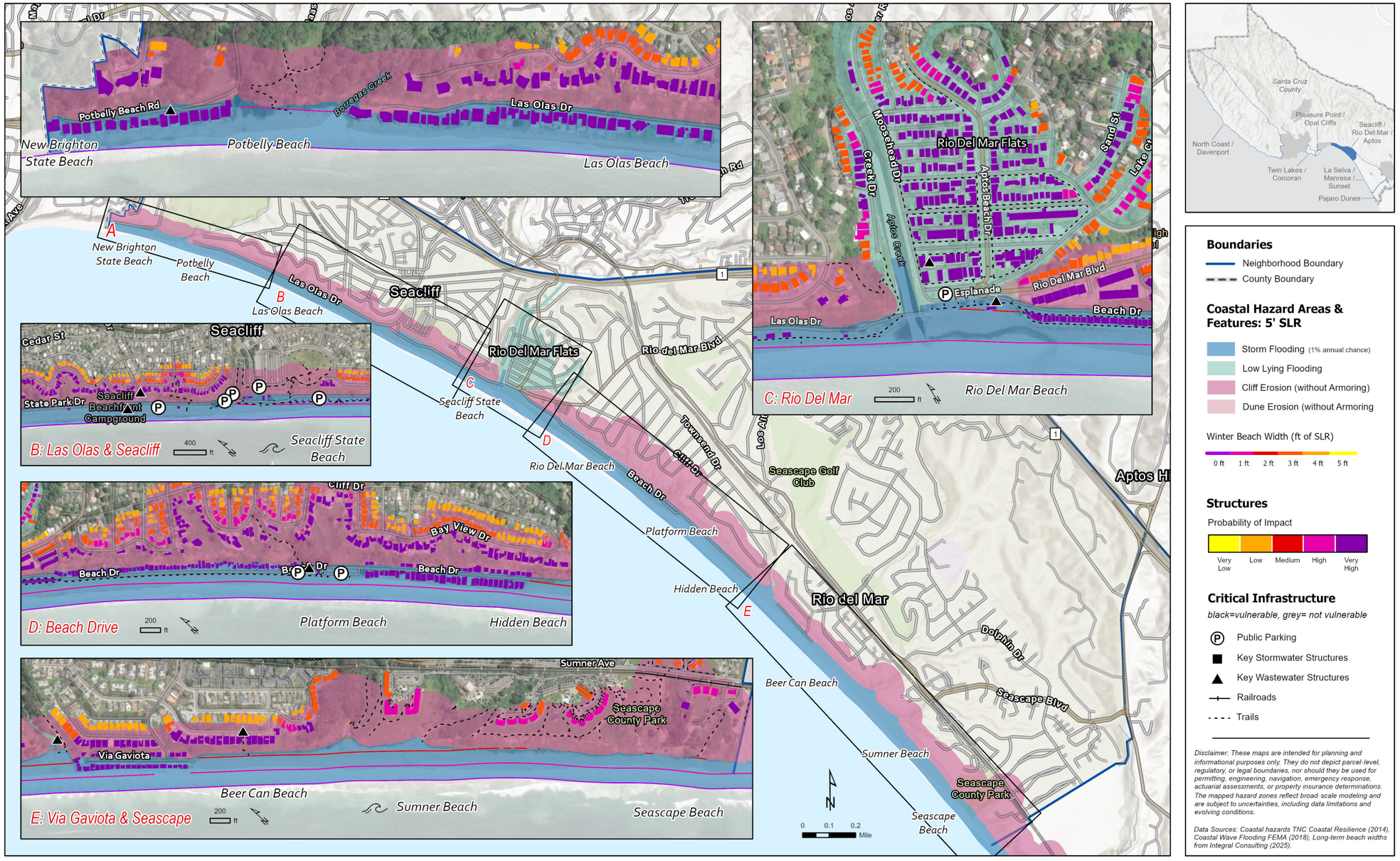
Critical Infrastructure
black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-74. Seacliff / Rio del Mar / Aptos SLR Vulnerability Map—0 ft of SLR with Existing Armoring

Seacliff / Rio Del Mar / Aptos - Coastal Hazard Areas: 5 ft SLR without Existing Armoring



Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 5' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (without Armoring)
- Dune Erosion (without Armoring

Winter Beach Width (ft of SLR)

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Structures

Probability of Impact

Very Low | Low | Medium | High | Very High

Critical Infrastructure

black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad-scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-75. Seacliff / Rio del Mar / Aptos SLR Vulnerability Map—5 ft of SLR without Existing Armoring

3.5 LA SELVA / MANRESA / SUNSET

3.5.1 Overview

The La Selva Beach, Manresa, and Sunset area of unincorporated Santa Cruz County extends south of Seascape to the Pajaro Dunes and encompasses just over 5 miles of coastline. It is characterized by broad sandy beaches backed by extensive dune systems and coastal bluffs. These dunes are active, meaning they are connected to beach sand sources and will periodically undergo erosion from wave action, followed by subsequent recovery. The shoreline is relatively open and natural compared to the developed portions of the county, with wide beach areas that support both recreation and habitat. The area includes two state parks—Manresa State Beach (Main and Upland) and Sunset State Beach—and several small residential communities, including the rural service district communities of La Selva Beach, Sand Dollar Beach, and Port Watsonville (Figure 3-76).



Figure 3-76. Left: Looking South Towards Sand Dollar Beach and Manresa State Beach (Source: Vrbo.com). Right: Sunset State Beach Parking Area (Source: State Parks)

3.5.2 Community Characteristics

This region is primarily rural and recreational in nature, with residential development concentrated in the La Selva Beach community. La Selva Beach is a small, unincorporated residential community with a mix of permanent residents, retirees, and vacation homes. The neighborhood retains a rural, open-space character, with strong ties to both agriculture and coastal recreation. Beaches in this area tend to see higher use among the south county communities and non-native English speakers. Within the neighborhood boundary, less than 1% of the population is designated as a disadvantaged community (California State Water Resources Control Board 2020). The average CalEnviroScreen score places it in the 32nd percentile statewide for cumulative pollution burden and population vulnerability. This

indicates a low to moderate cumulative pollution burden and population vulnerability (OEHHA 2021).

3.5.3 Infrastructure and Development

Development is limited to residential neighborhoods at La Selva Beach, Sand Dollar Lane, Port Watsonville, and park facilities at Manresa and Sunset State Beaches. The community of La Selva Beach sits atop the coastal cliffs, consisting primarily of single-family homes and small neighborhood businesses. Access to the area is provided by San Andreas Road, which runs parallel to the coast, connecting local neighborhoods and state parks. Infrastructure consists mainly of small parking lots, beach access stairways, campgrounds, and restroom facilities associated with the state beaches. There are also several wastewater pump stations located near the coast. Between these residential communities are agricultural lands, which extend inland from the cliff. There is minimal coastal armoring in this neighborhood, with some smaller seawalls and revetments, and limited erosion control measures on the dunes and bluffs.

Key assets and infrastructure in the coastal study area include:

- Santa Cruz Branch Rail Line
- Manresa State Beach parking lot
- Wastewater pump stations serve La Selva Beach and Sand Dollar Beach.

3.5.4 Recreation and Coastal Resources

The La Selva / Manresa / Sunset neighborhood is home to beaches and dune systems that provide valuable habitat space to support species such as the western snowy plover and native dune vegetation. These beaches and dune systems also provide habitat connectivity to adjacent agricultural and upland areas. In addition to its diverse and valuable ecological services, this neighborhood's beaches and dunes provide community members and visitors with outdoor recreational opportunities such as surfing, fishing, camping, hiking, and beachgoing. A unique feature of this neighborhood is the state beaches that provide access to scenic open spaces, wide beaches, and coastal bluffs and dunes.

With the third most estimated beach visits of all neighborhood areas of unincorporated Santa Cruz County, the La Selva / Manresa / Sunset neighborhood hosted an estimated 191,000 visits in the year 2024. Of these total visits, 92% were drawn in by Manresa State Beach (73%) and Sunset State Beach (19%) (Figure 3-77 and Figure 3-78).

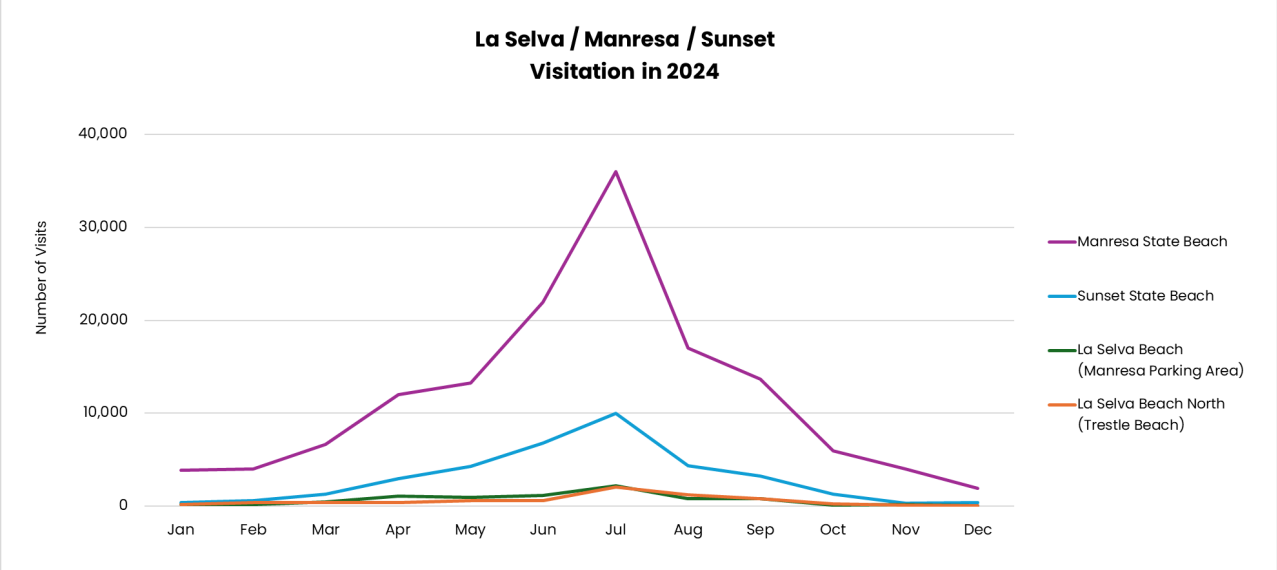


Figure 3-77. Seasonal Beach Visitation (2024)

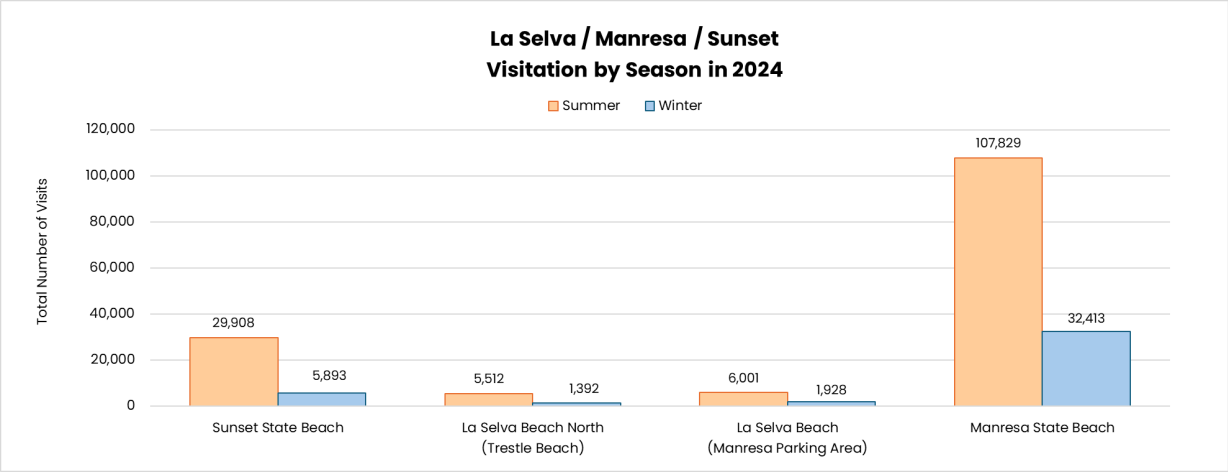


Figure 3-78. Visitation Numbers in Summer and Winter (2024)

The La Selva / Manresa / Sunset neighborhood hosts, on average, 78% of all visits within the neighborhood during the summer season. This trend aligns with the unincorporated Santa Cruz County neighborhood beach visitation trends (Figure 3-79).

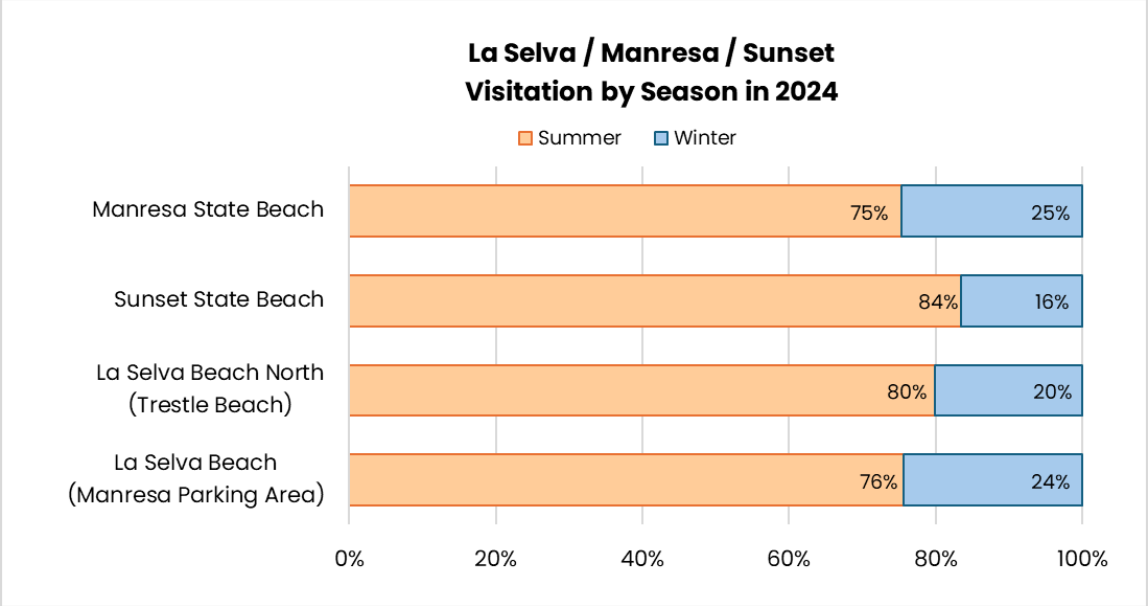


Figure 3-79. Distribution of Beach Visitation between Summer and Winter (2024)

3.5.5 Coastal Processes and Hazards

3.5.5.1 Coastal Erosion and Flooding

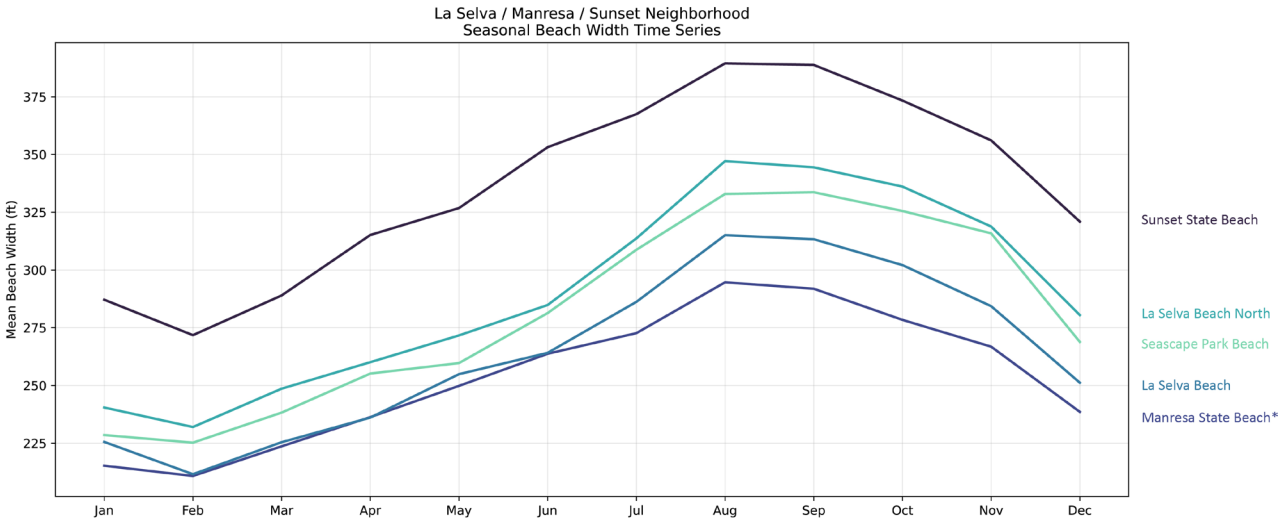
The shoreline here is characterized by dynamic sandy beaches and dune systems that routinely migrate inland, leading to the loss of dune volume and gradual shoreline retreat over time. During large storm events, high surf can overtop the foredune in low-lying sections, resulting in localized flooding of beach access paths, parking areas, and portions of the back beach. Storm wave run-up has also contributed to erosional dune scarping and temporary closures of beach access points. While development in this area is generally set back from the cliffs, the continued erosion of dunes and cliffs will reduce the natural buffer that protects upland development.

3.5.5.2 Coastal Armoring

Unlike other parts of the county, this stretch of coastline has limited shoreline armoring, and much of the neighborhood retains a natural character. Localized efforts to stabilize the shoreline have been taken along some pre-coastal act (pre-1972) structures, as well as around access points and stormwater drainage areas. Only 3% of the shoreline is armored, and 16% of structures have coastal armoring.

3.5.5.3 Beach Widths

Historical beach analysis of CoastSat data shows seasonal variability in beach widths. Figure 3-80 illustrates these seasonal patterns, showing average monthly beach widths over the 40-year record. On average, there is an approximate 100-ft difference between narrow winter beach widths and the wide summer beaches (Figure 3-80). Similar to the eastern beaches of the adjacent Seacliff / Rio del Mar / Aptos neighborhood, historical beach width data indicate that beaches within this neighborhood have experienced a net accretionary trend; however, some beaches, especially near Manresa State Beach parking lot and Sunset Beach campground have seen a very gradual narrowing (Figure 3-81).



*partially armored
** fully armored

Figure 3-80. Seasonal Beach Width Trends by Beach (average width by month across all records from 1984–2024)

Lighter colors appear further north, and darker colors appear further south.

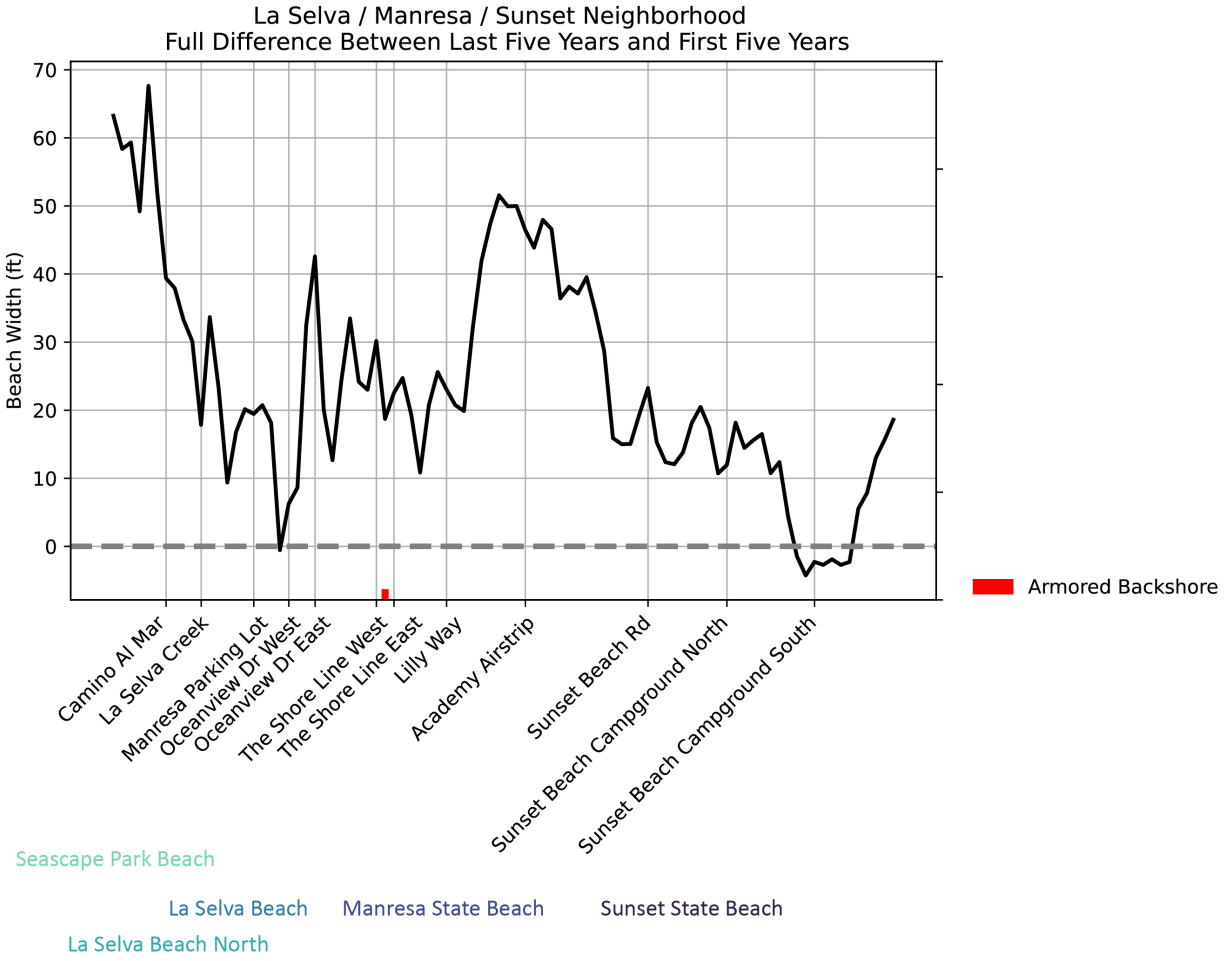


Figure 3-81. Difference in Beach Width between the Time Periods of 1984–1989 and 2019–2024

Negative numbers indicate a net narrowing, and positive numbers indicate a net widening.

The beaches and dunes in this neighborhood are highly dynamic, with wind-driven sand movement causing periodic burial of access infrastructure. Field observations have shown that seasonal beach scouring during winter storms reduces beach width and can lead to damage to stairways and fencing at the state park facilities.

3.5.6 Vulnerability with Sea Level Rise

3.5.6.1 Storm Recurrence and Sea Level Rise

With SLR, coastal wave flooding will reach higher flood elevations more frequently and cause greater depths of flooding. Figure 3-82 illustrates storm recurrence intervals and flood depths with SLR for the La Selva /Manresa / Sunset neighborhood.

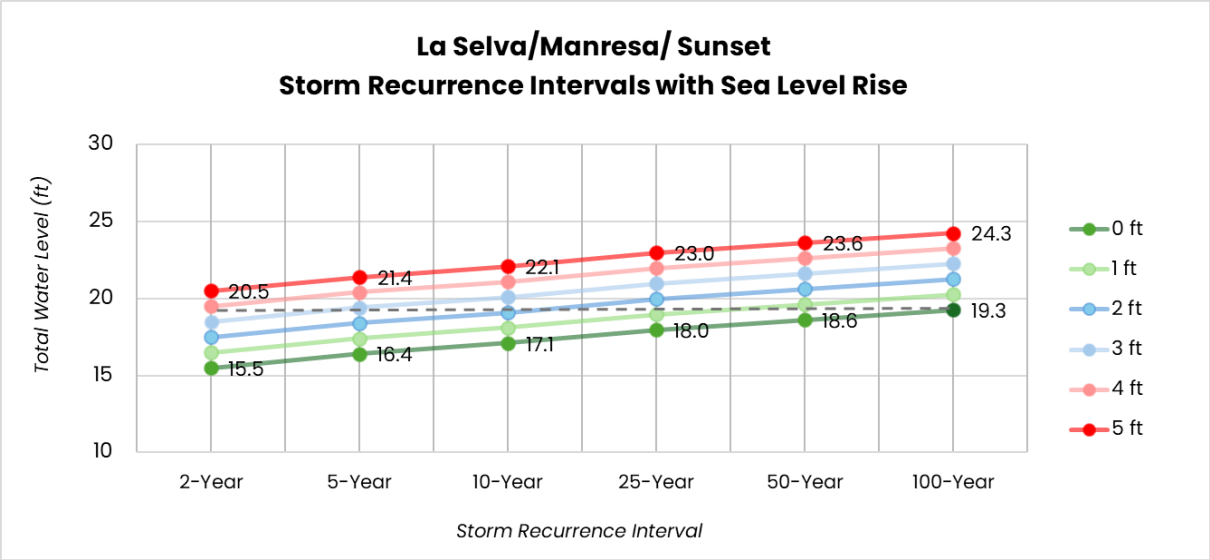


Figure 3-82. Average Storm Recurrence Intervals and Associated Total Water Levels (in ft) with SLR for all FEMA Transects in the Neighborhood.

The dashed line represents the total water level associated with the current 100-yr storm.

Currently, a 100-year storm produces an average total water level of about 19.3 ft. With 1 ft of SLR, that same flooding level would occur during a 50-year storm, effectively doubling how often it happens. With 2 ft of SLR, it would occur during a 25-year storm, and with 3 ft, during a 10-year storm.

Even smaller, more frequent storms will also bring higher water levels over time. Under today's conditions, a typical 2-yr storm event (50% annual chance) will reach about 15.5 ft. With 1 ft of SLR, that baseline increases to 16.5 ft, equivalent to what is now a 5-yr storm event (20% annual chance). At 2 ft of SLR, water levels rise to about 17.5 ft, similar to today's 10-yr storm event (10% annual chance).

3.5.6.2 Key Assets at Risk with SLR

As sea levels rise, the La Selva, Manresa, and Sunset neighborhood will face increasing exposure to coastal hazards, including sustained beach narrowing and coastal cliff and dune erosion. These hazards threaten residential communities, agricultural lands, park facilities, beach access infrastructure, and the area's recreational beaches.

Land Use and Structures

Figure 3-83 summarizes the number of structures exposed to coastal hazards under increasing SLR, presents the associated cost ranges for those impacts, and provides a comparative view of potential damages by hazard type.

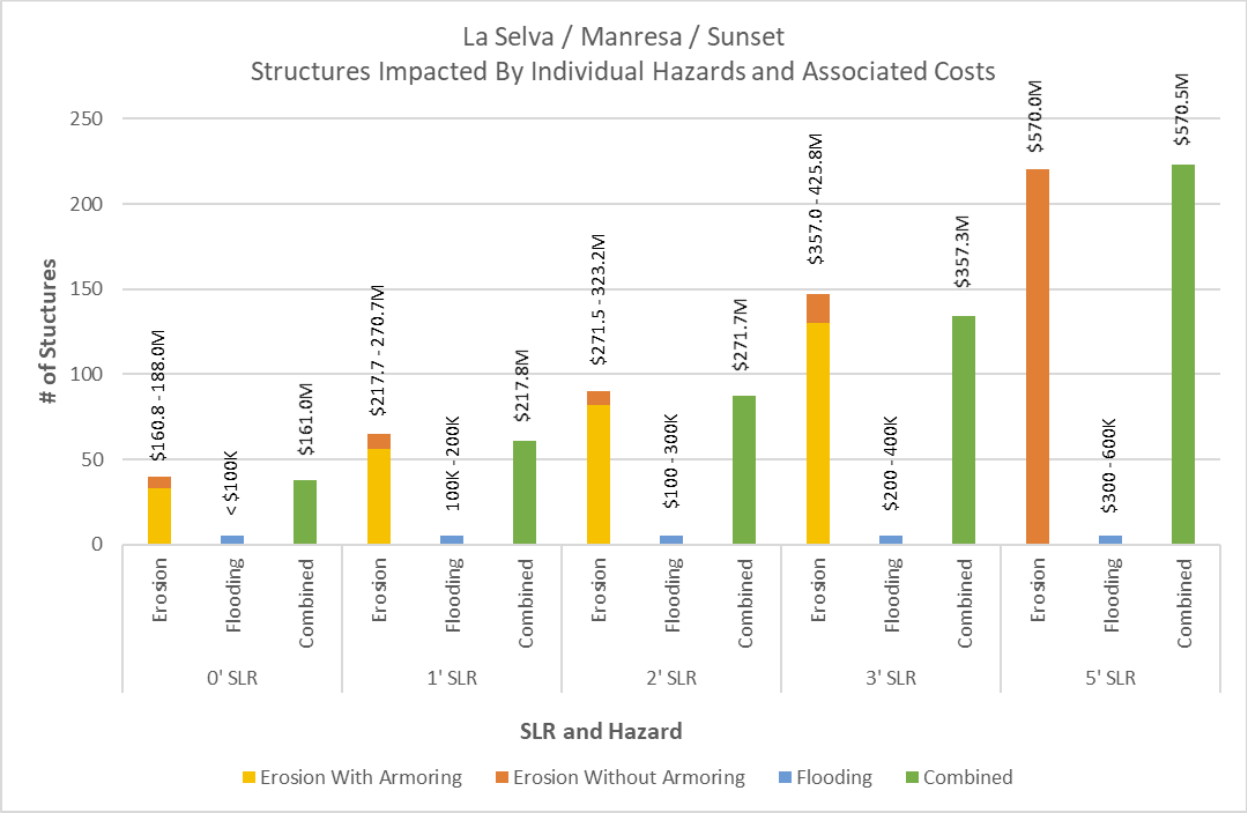


Figure 3-83. La Selva / Manresa / Sunset Number of Structures Experiencing Impacts from Coastal Hazards and Associated Costs under Different SLR Scenarios

Costs associated with coastal erosion include the permanent loss of land value and structures. Costs associated with flooding include temporary damage to structures and contents. The combined category includes both but removes flood damages to unarmored structures lost to erosion in prior horizons.

Cliff and dune erosion is the dominant hazard projected to impact structures in the La Selva / Manresa / Sunset neighborhood, and that risk increases sharply with higher SLR. Given the limited armoring in this neighborhood, the with- and without-armoring scenarios are very similar. There is minimal low-lying development in this area, aside from some development at Sunset State Beach, and as a result, storm wave flooding exposes relatively few structures across all scenarios.

Between 0 and 2 ft of SLR, structural impacts increase gradually, with moderate erosion-related exposure. By 3 ft of SLR, the number of structures impacted rises, and associated permanent loss of land and damages to structures escalate into the hundreds of millions (Figure 3-83).

Figure 3-84 illustrates the probability that a structure will experience damage due to wave exposure or coastal erosion with SLR. This assumes a more risk-averse scenario and identified all structures with the potential to be impacted during a 500-year storm event and assumes coastal armoring is in place through 3 ft of SLR (see Appendix D). **Currently**, the structures with the highest probability of impact are the beachfront townhomes located along Oceanview Drive (Place de Mer) just south of La Selva Beach, at Sand Dollar Beach, and the homes located within proximity to the bluff top edge in Port Watsonville. By **2 ft of SLR**, the unarmored townhomes at Oceanview Drive and Port Watsonville move into a very high probability of impact from coastal erosion, and many of the surrounding homes in this area are categorized as having a low to medium probability of impact. By **5 ft of SLR**, 92 structures have a very high probability of impact, and 131 range from low to high probability of impact depending on their proximity to the coastal cliffs.

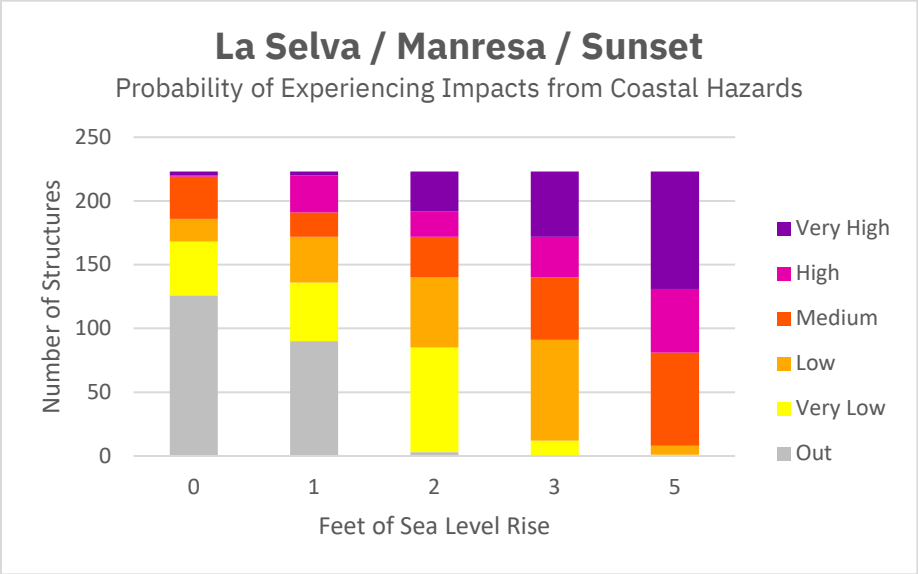


Figure 3-84. Probability of Structures Experiencing Impacts from Coastal Hazards by SLR Horizon

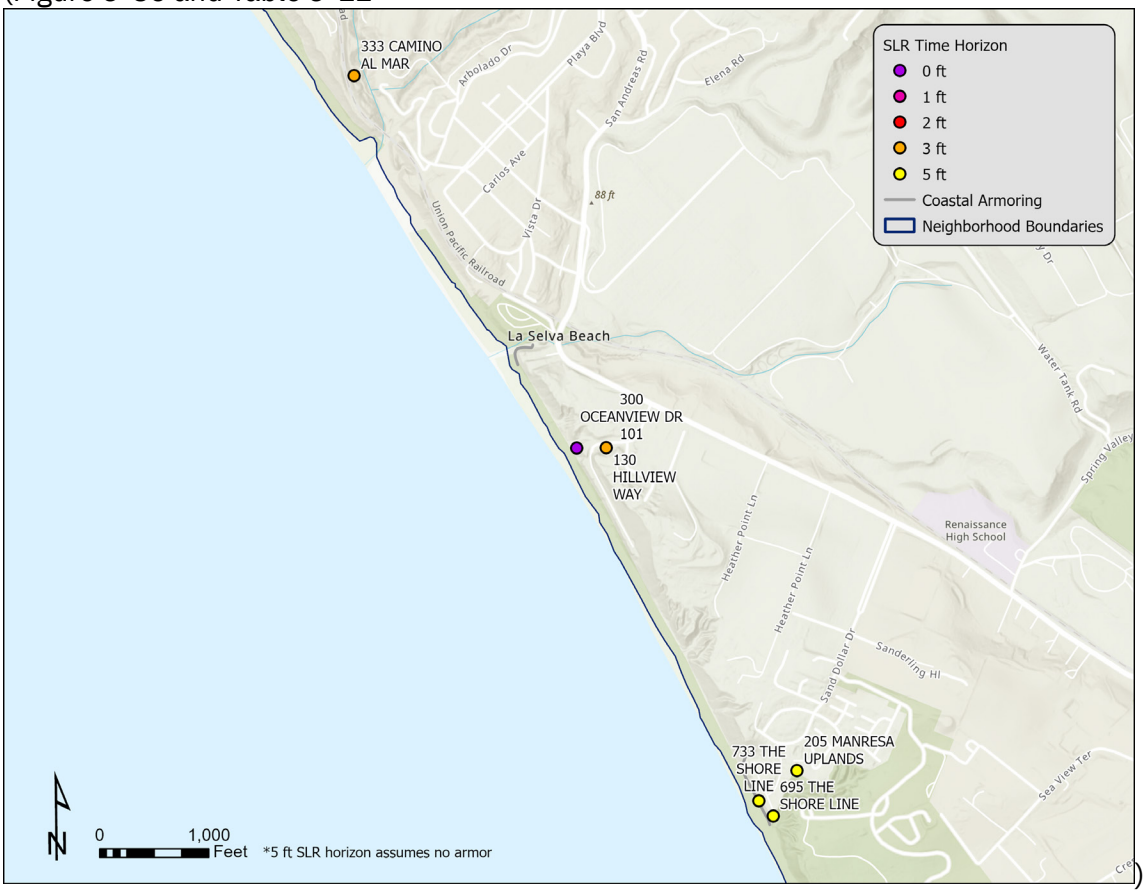
Roads and Railroad

Segments of the rail line north of the Manresa Main Beach parking lot are currently exposed to coastal erosion, and overall vulnerability to this critical infrastructure is expected to increase with ongoing shoreline retreat and rising sea levels.

For roadways, coastal erosion primarily exposes small residential streets. Oceanview Drive south of La Selva Beach and parts of Sunset Drive are currently exposed, and by 3 ft of SLR, erosion could extend farther inland and impact Vista Drive, Hillview Way, The Shore Line, and Sand Dollar Lane.

Wastewater, Stormwater, and Water Supply Infrastructure

The wastewater pump station servicing Place de Mer at 300 Oceanview Drive is currently exposed to coastal erosion, and the nearby pump station located at 130 Hillview Way is projected to be exposed by 3 ft of SLR. In La Selva Beach, a pump station located at 333 Camino Al Mar is also projected to be exposed to coastal erosion by 3 ft of SLR. Three pump stations, currently behind coastal armoring, located at 695 and 733 The Shore Line at Sand Dollar Beach, and 205 Manresa Uplands, may become exposed to erosion at 5 ft of SLR (Figure 3-85 and Table 3-12



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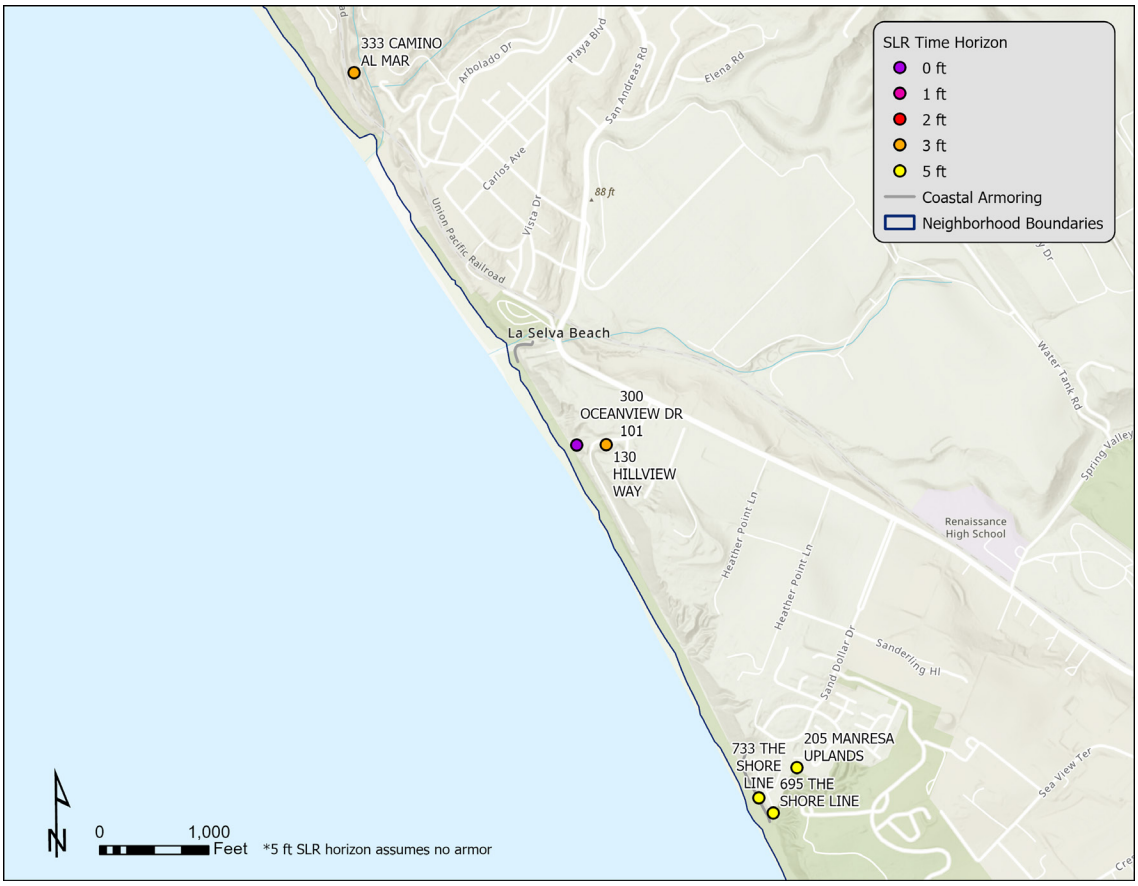


Figure 3-85. La Selva / Manresa / Sunset Wastewater Infrastructure at Risk with SLR

Results shown assume armoring is in place through 3 ft of SLR, and by 5 ft of SLR, armoring is no longer in place.

Table 3-12. La Selva / Manresa / Sunset wastewater infrastructure at risk with SLR

Wastewater Infrastructure	SLR (ft)				
	0	1	2	3	5
333 Camino Al Mar	🟢	🟢	🟢	🔴	🔴
300 Oceanview Drive	🔴	🔴	🔴	🔴	🔴
130 Hillview Way	🟢	🟢	🟢	🔴	🔴
695 The Shore Line	🟢	🟢	🟢	🟢	🔴
733 The Shore Line	🟢	🟢	🟢	🟢	🔴
205 Manresa Uplands	🟢	🟢	🟢	🟢	🔴

🟢 = safe, 🔴 = at risk from flooding or erosion

Several segments of water main lines within the neighborhood are currently exposed to coastal erosion, including segments located adjacent to the Southern Pacific Railroad corridor and Oceanview Drive in Place de Mer. Most other main water segments in this neighborhood are not projected to become exposed to erosion until after 3 ft of SLR.

Beaches

Average winter beach widths in the La Selva / Manresa / Sunset neighborhood decline with SLR. **Currently**, winter beaches average around 240 ft, while summer beaches are wider at about 340 ft. By **1 ft of SLR**, winter widths drop by more than half, to just over 120 ft, while summer widths decline to roughly 218 ft. By **2 ft of SLR**, winter beach width is reduced to about 25 ft, leaving only narrow strips of beach across the neighborhood, and summer widths fall to around 100 ft. By **3 ft of SLR**, winter beaches are no longer present except at Sunset State Beach, and summer beaches narrow to 30 ft. **By 5 ft of SLR**, both winter and summer beaches are effectively lost, indicating near-total disappearance of dry beach area in this neighborhood (Figure 3-86 and Table 3-13).

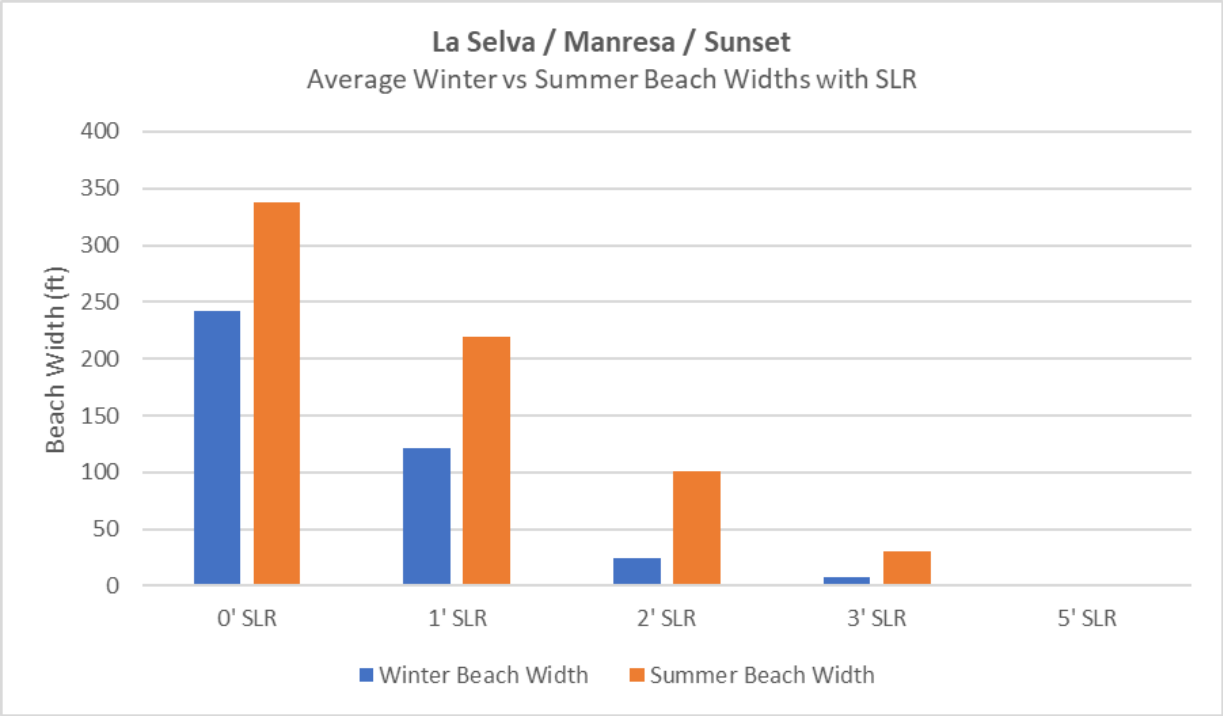


Figure 3-86. La Selva / Manresa / Sunset Summer and Winter Beach Widths with SLR

Table 3-13. La Selva / Manresa / Sunset winter beach loss locations

Beaches	SLR (ft)				
	0	1	2	3	5
Seascape Park Beach	●	●	●	●	●
La Selva Beach North (Trestle Beach)	●	●	●	●	●
La Selva Beach (Manresa Parking Area)	●	●	●	●	●
Manresa State Beach *	●	●	●	●	●
Sunset State Beach	●	●	●	●	●

● = 100+ ft, ● = 25–100 ft, ● = <25 ft, ● = no beach

* = partially armored
** = fully armored

Coastal Access

Coastal access in the La Selva / Manresa / Sunset neighborhood becomes increasingly impacted by SLR, primarily due to erosion. Access stairs and ramps at Manresa Main Beach are

already exposed to erosion and wave impacts at their base, and the adjacent parking lot becomes exposed to erosion by approximately 1–2 ft of SLR. Parking at the end of Manresa Beach Road begins to be impacted as early as 2 ft of SLR.

Because this neighborhood is less developed and includes large areas of open space, much of the coastal access is provided by trails that retain some capacity for retreat or realignment as conditions change. Even so, beach access trails from Manresa Beach Road, the Manresa Uplands Campground, Sunset State Beach campground, and others become progressively more exposed to erosion between current conditions and 5 ft of SLR. In addition, parking areas along Sunset Drive are already vulnerable to flooding under current conditions, with impacts expected to worsen as sea levels rise.

Table 3-14. La Selva / Manresa / Sunset impacts to coastal access with SLR

Beaches	SLR (ft)				
	0	1	2	3	5
Sunset Drive Parking	🟢	🟡	🔴	🔴	🔴
Manresa Main Beach Parking and Access	🟢	🟡	🟡	🔴	🔴
Manresa Upland Beach Access Parking	🟢	🟢	🟡	🟡	🔴
Sunset State Beach Campground Trails	🟢	🟢	🟡	🟡	🔴

🟢 = accessible, 🟡 = at risk from flooding, erosion, and beach loss, 🔴 = no longer accessible

3.5.6.3 Risk Summary

The La Selva / Manresa / Sunset neighborhood remains one of the least developed segments of the county's coastline. The combination of wide beaches, extensive dune systems, and minimal armoring provides natural resilience but also leaves public access infrastructure highly exposed to coastal erosion. Because armoring is minimal, there is an opportunity to allow the backshore to transgress with SLR and beaches to migrate inland. In addition, many of the structures in this neighborhood are located on larger rural lots and may have space on the same parcel to be relocated further inland, affording some adaptive capacity. Key findings by time horizon are summarized below.

La Selva / Manresa / Sunset: Near Term (0–1 ft of SLR). By 1 ft of SLR:	
	Five structures are within the 100-yr flood hazard area, and 33 structures are exposed to coastal cliff and erosion, assuming armoring is in place. Ninety-seven structures are within a coastal, riverine, and/or erosion hazard area, assuming a more risk-averse hazard scenario, and 37 are categorized as having medium to very high probability of impact. With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $217M. This is higher than other neighborhoods in the county and is a result of exposure to coastal erosion and the largely unarmored coastline.
	Localized erosion exposes Oceanview Drive south of La Selva Beach.
	The wastewater pump station at 300 Oceanview Drive (Place de Mer) is exposed to coastal erosion, and several water main segments are also vulnerable, including those adjacent to the Southern Pacific Railroad corridor and along Oceanview Drive in Place de Mer.
	Dune fencing and trails are already periodically buried or washed out during winter storms, increasing maintenance demands for State Parks. With 1 ft of SLR, beach widths are projected to decline by approximately half, state park buildings at Sunset State Beach become vulnerable to storm wave flooding, and localized erosion exposes parking lots at Manresa and Sunset State Beaches.
	Dune habitats experience increased erosion and storm disturbance, with localized loss of vegetation and reduced habitat stability.

La Selva / Manresa / Sunset: Mid Term (1–3 ft of SLR). By 3 ft of SLR:



Five structures are still within the 100-yr flood hazard area, and 134 structures are exposed to coastal cliff and erosion, assuming armoring is in place.

Two hundred twenty-three structures are within a coastal, riverine, and/or erosion hazard area, assuming a more risk-averse hazard scenario, and 132 are categorized as having medium to very high probability of impact.

With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $357M. This is largely due to coastal erosion.



The Santa Cruz Branch Rail Line, which runs close to Manresa Beach, is vulnerable to coastal erosion, while portions of San Andreas Road south of La Selva Beach are exposed to coastal erosion and may also experience flooding during extreme tides or heavy rainfall events.



Additional wastewater pump stations become exposed to erosion, including the station at 130 Hillview Way and the La Selva Beach pump station at 333 Camino Al Mar, increasing the vulnerability of wastewater infrastructure in low-lying coastal areas. While most water main lines remain protected, erosion exposure begins to expand in vulnerable coastal corridors.



Average summer beach widths narrow to approximately 22 ft, with beaches likely remaining only between La Selva and Sunset Beach. Reduced beach width limits recreational capacity along this neighborhood's beaches, which support approximately 191,000 annual visits. Cliff and dune retreat threatens State Park facilities, including campgrounds, restrooms, and parking areas, requiring relocation or redesign to remain functional.



Portions of Sunset State Beach and Manresa State Beach will experience chronic loss of foredunes.

La Selva / Manresa / Sunset: Long Term (3–5 ft of SLR). By 5 ft of SLR:



Five structures are still within the 100-yr flood hazard area, and 220 structures are exposed to coastal cliff and erosion.

Two hundred twenty-three structures are within a coastal, riverine, and/or erosion hazard area, assuming a more risk-averse hazard scenario, and 215 are categorized as having medium to very high probability of impact.

With coastal armoring in place through 3 ft of SLR, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $571M. This is largely due to coastal erosion.



Multiple residential roads are threatened by erosion, requiring retreat or realignment.



Wastewater pump stations currently protected by coastal armoring, located at 695 and 733 The Shore Line (Sand Dollar Beach) and 205 Manresa Uplands, are projected to become exposed to erosion by 5 ft of SLR if armoring does not remain in place. Many segments of the neighborhood water line become vulnerable to erosion, substantially increasing the risk of service disruption.



Both winter and summer beaches are effectively lost, resulting in a near-complete loss of dry beach recreation. Parking, access trails, and campground connections at Manresa and Sunset State Beaches are no longer reliably functional due to erosion and flooding, substantially limiting public coastal access despite some opportunities for access retreat.



While dune migration remains feasible in some areas and can be supported through management actions, SLR will lead to substantial dune habitat loss, with chronic erosion and inundation limiting dune formation, persistence, and habitat value in more constrained locations.

3.5.7 Key Adaptation Strategies for Consideration

Based on the exposure and vulnerability findings described above, the following list summarizes potential adaptation strategies for the La Selva / Manresa / Sunset neighborhood that will be further evaluated.

Near-Term

- Planning and Alignment
  - State parks
- Nature-Based Solutions
  - Dune and bluff restoration
  - Living shorelines

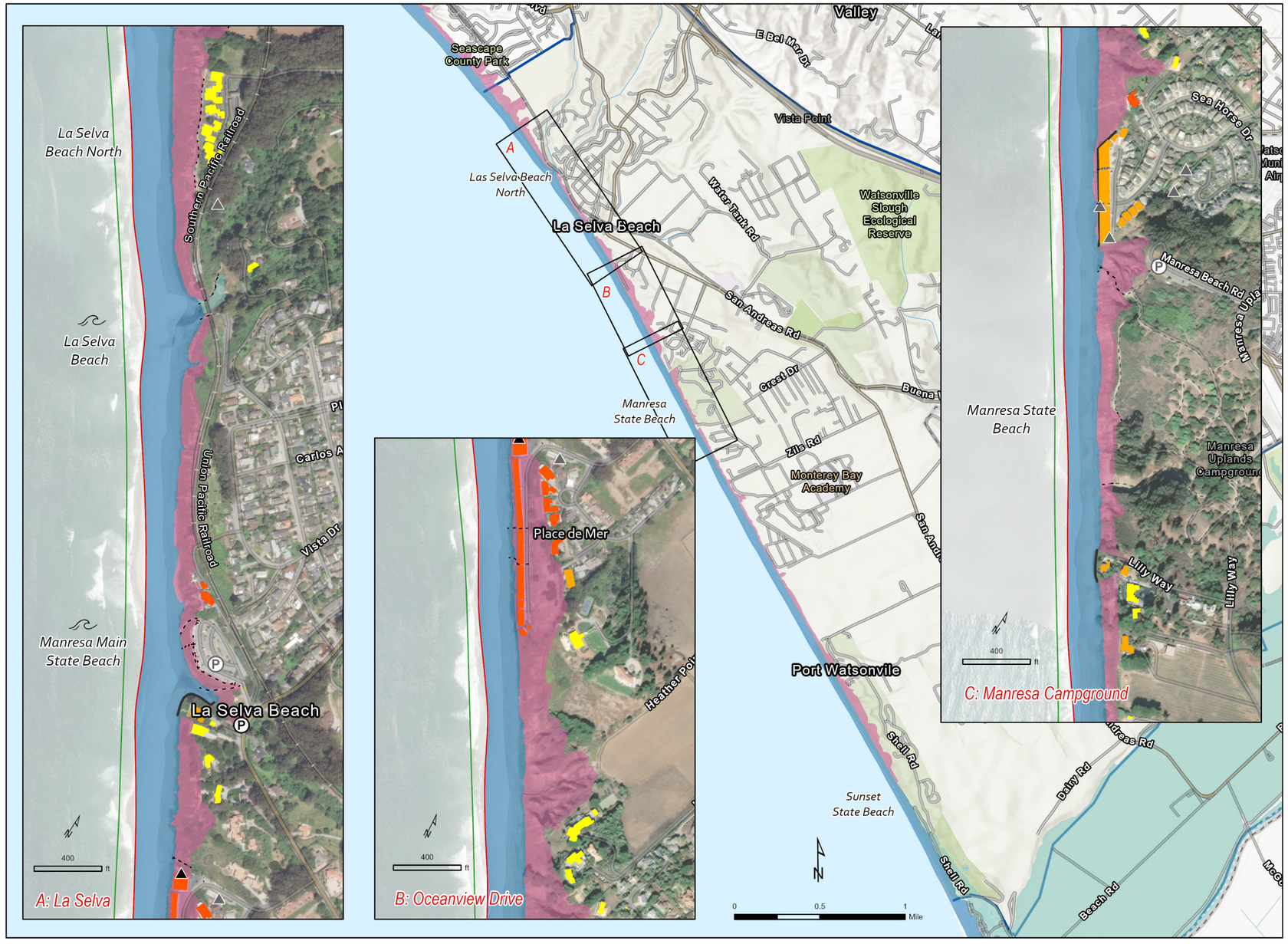
Mid-Term

- Protection
  - Armoring at critical, hard-to-relocate locations such as at San Andreas Road and the Branch Railroad

Long-Term

- Managed Retreat
  - Relocation of cliff-top development.

La Selva / Manresa / Sunset - Coastal Hazard Areas: 0 ft SLR with Existing Armoring





Boundaries
- Neighborhood Boundary
- County Boundary

Coastal Hazard Areas & Features: 0' SLR
- Storm Flooding (1% annual chance)
- Low Lying Flooding
- Cliff Erosion (with Armoring)
- Dune Erosion (with Armoring
- Coastal Armoring

Beach Width (Existing Seasonal Average)
- Summer
- Winter

Structures

Probability of Impact

Very Low | Low | Medium | High | Very High

Critical Infrastructure

black=vulnerable, grey= not vulnerable
- Public Parking
- Key Stormwater Structures
- Key Wastewater Structures
- Railroads
- Trails

Disclaimer: These maps are intended for planning and informational purposes only. They do not depict parcel-level, regulatory, or legal boundaries, nor should they be used for permitting, engineering, navigation, emergency response, actuarial assessments, or property insurance determinations. The mapped hazard zones reflect broad scale modeling and are subject to uncertainties, including data limitations and evolving conditions.

Data Sources: Coastal hazards TNC Coastal Resilience (2014), Coastal Wave Flooding FEMA (2018), Long-term beach widths from Integral Consulting (2025).

Figure 3-87. La Selva / Manresa / Sunset SLR Vulnerability Map—0 ft of SLR with Existing Armoring

La Selva / Manresa / Sunset - Coastal Hazard Areas: 2 ft SLR with Existing Armoring

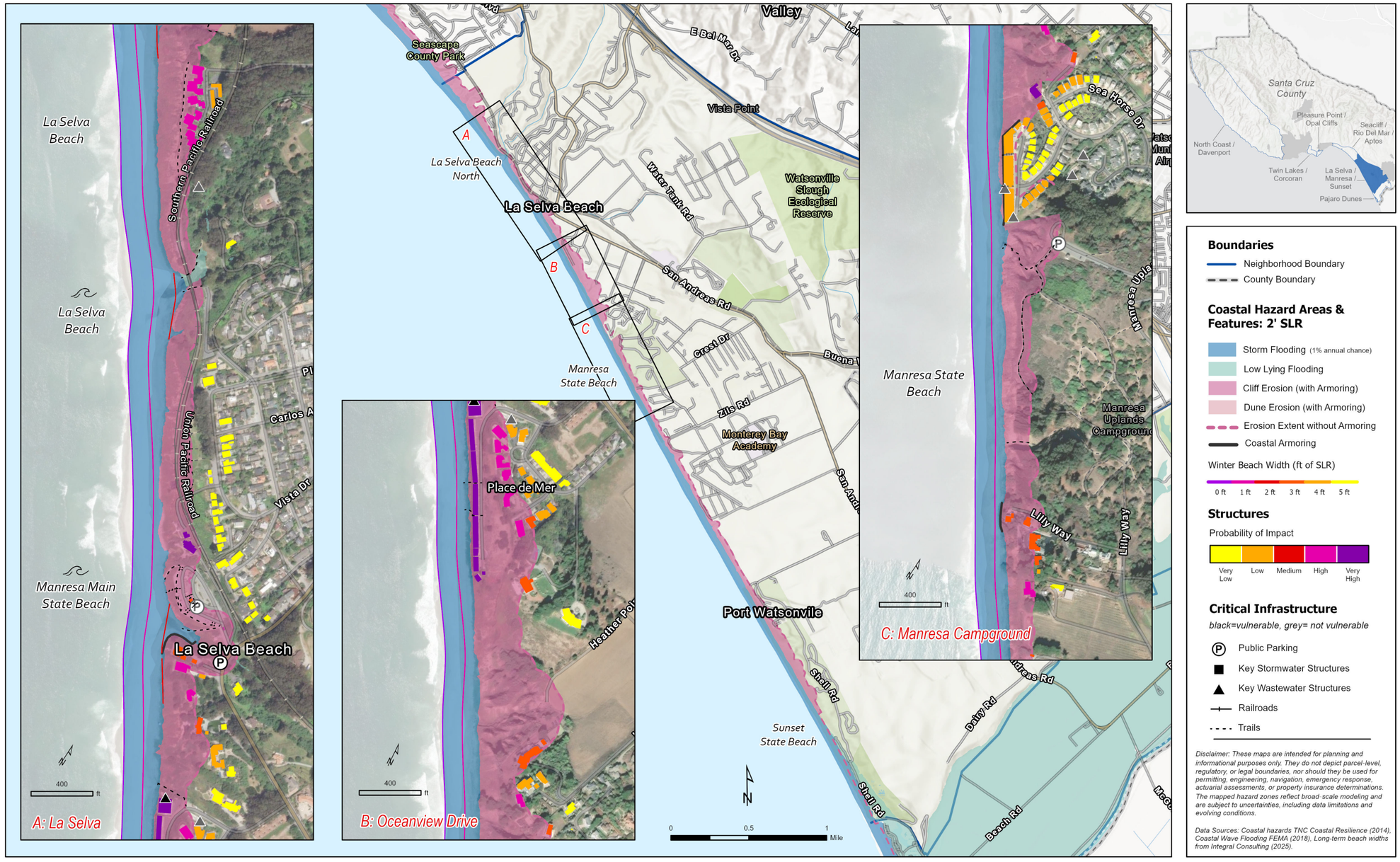


Figure 3-88. La Selva / Manresa / Sunset SLR Vulnerability Map—2 ft of SLR with Existing Armoring

La Selva / Manresa / Sunset - Coastal Hazard Areas: 5 ft SLR without Existing Armoring

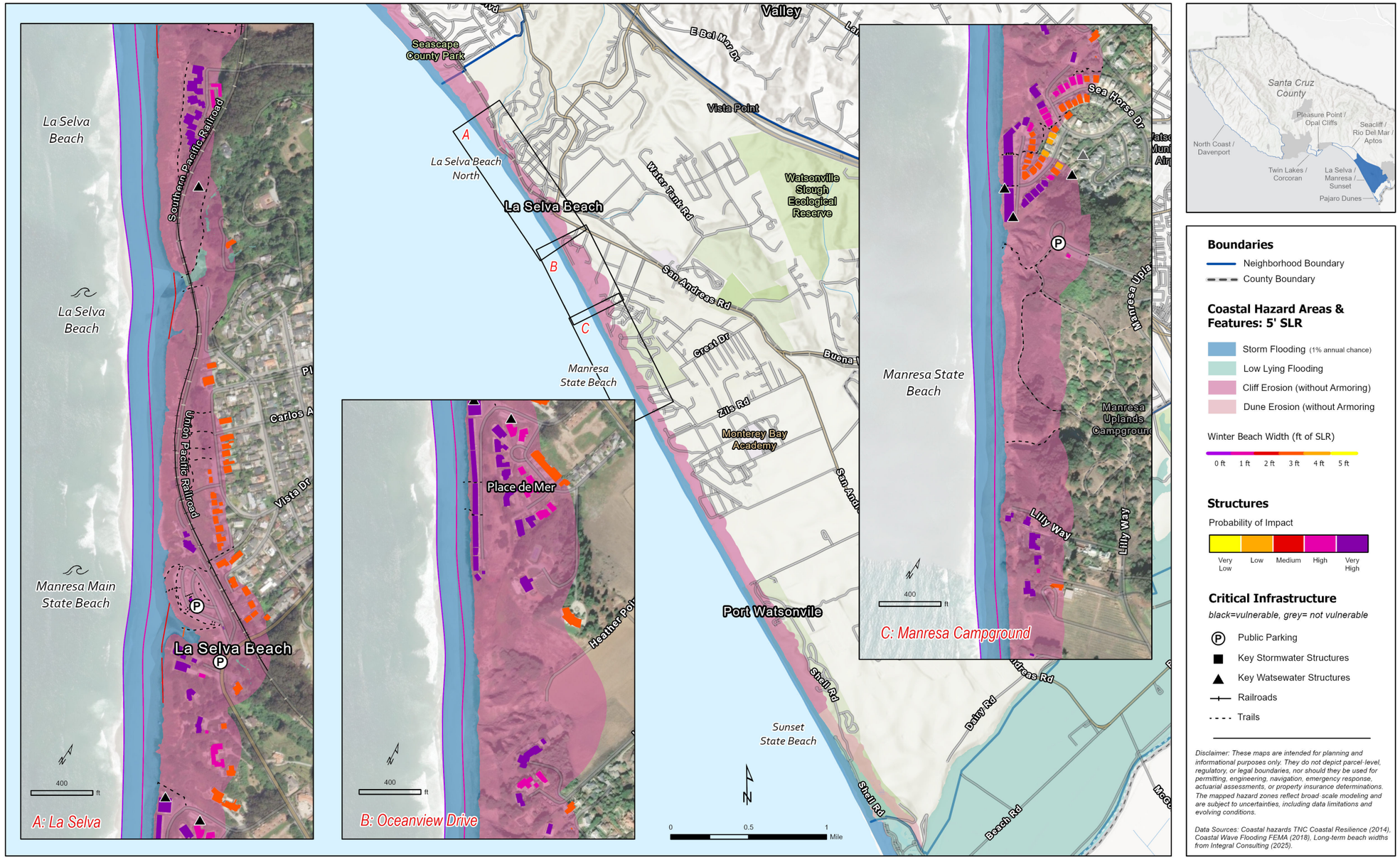


Figure 3-89. La Selva / Manresa / Sunset SLR Vulnerability Map—5 ft of SLR without Existing Armoring

3.6 PAJARO DUNES / PAJARO VALLEY

3.6.1 Overview

The Pajaro Dunes / Pajaro Valley neighborhood occupies the southernmost stretch of Santa Cruz County's coastline, directly bordering Monterey County along the Pajaro River, and encompasses just over 2 miles of coast. This largely rural area includes the Pajaro Dunes—a master-planned coastal community built in the late 1960s and 1970s on a low-lying dune complex—and agricultural lands of the lower Pajaro Valley (Figure 3-90). The coastline is characterized by a broad sandy barrier beach backed by dunes and the Pajaro River estuary, forming a highly dynamic shoreline where shifting dunes provide both habitat value and natural flood protection. The City of Watsonville Wastewater Treatment Plant lies within the broader study area; however, because it falls under the jurisdiction of the City of Watsonville and would warrant its own site-specific vulnerability assessment, its vulnerabilities are discussed only at a high level.



Figure 3-90. Mouth of the Pajaro River (Source: Left: Tripadvisor, Right: Tarmo Hannula via Good Times Santa Cruz)

3.6.2 Community Characteristics

The Pajaro Dunes is primarily a vacation community, with a mix of short-term rentals and second homes, with a smaller group of year-round residents. The community has a distinct identity as a private, visitor-oriented coastal enclave. Beyond the dunes, the lower Pajaro Valley supports extensive agricultural production and farmworker housing. Within the neighborhood boundary, 99% of the neighborhood is designated as a disadvantaged community (California State Water Resources Control Board 2020). The average CalEnviroScreen score places the entire census tract in the 59th percentile statewide for cumulative pollution burden and population vulnerability. This indicates a moderate to high cumulative pollution burden and population vulnerability (OEHHA 2021). There is a distinct socioeconomic and demographic divide between the more affluent Pajaro Dunes and the more socially vulnerable communities of the lower Pajaro Valley; thus, the area impacted by coastal hazards likely has a lower level of pollution burden and population vulnerability.

3.6.3 Infrastructure and Development

Key infrastructure in the Pajaro Dunes / Pajaro Valley neighborhood centers on the Pajaro Dunes, which consists of condominiums, townhouses, single-family homes, and resort facilities situated immediately behind the foredunes on the coastal terrace. The community includes private roads, recreational amenities, and coastal access paths that are managed by a homeowners' association, and fire services are provided by the Pajaro Dunes Fire Station 42. Vehicular access is limited by private gates that connect to West Beach Road, which further connects to San Andreas Road and Highway 1.

Inland of the Pajaro Dunes, the neighborhood is largely agricultural lands between the Pajaro River and Watsonville Slough levee systems. There are approximately 15,000 acres of agricultural land in the lower Pajaro Valley that lie below 10 ft in elevation, making the farmland and associated development highly vulnerable to SLR, closed lagoon, riverine, and compound flooding.

Critical infrastructure, including the Pajaro River levees, are currently undergoing major reconstruction to address failure risk including the USACE levee widening project inland of Hwy 1 and the USACE and Pajaro Regional Flood Management Agency's project to improve levees along the Pajaro River and Corralitos and Salsipuedes creeks. The City of Watsonville Wastewater Treatment Plant is located just behind the levee, and is currently exposed to coastal and riverine flood hazards. Stormwater infrastructure within the Pajaro Dunes is limited, relying primarily on percolation of surface runoff with minimal pumping capacity during heavy rainfall events, further contributing to localized ponded flooding during intense rainfall events. Stormwater infrastructure near Beach Road at the Watsonville Slough consists of a coastal outfall with a flap gate to prevent tidal backflow, along with a pump to convey stormwater when gravity drainage is limited. Together, these features reduce flooding in this low-lying area during high tides and storm events.

In 2010, the City of Watsonville completed its upgrade of the wastewater treatment plant to include tertiary treatment for water reuse and to protect against seawater intrusion. Part of this effort included a recycled water facility and supply system (purple pipes), which provides a supplemental irrigation supply to the lower Pajaro Valley.

Key assets and infrastructure in the coastal study area include:

- Pajaro Dunes Fire Station 42
- Pajaro Dunes community buildings
- Wastewater pump stations
- Flood control structures and pump stations
- City of Watsonville Wastewater Treatment Plant
- Palm Beach coastal access parking and trails.

3.6.4 Recreation and Coastal Resources

The Pajaro Dunes / Pajaro Valley neighborhood contains a diverse set of coastal ecosystems, including Pajaro Dunes Beach, extensive dune systems, the Pajaro River estuary, and the Watsonville Slough network, which consists of six interconnected freshwater sloughs. Together, these habitats support migratory birds and several sensitive species, such as the western snowy plover and California red-legged frog, and provide significant ecological and recreational value. The Pajaro River and its estuary also serve as pathways for floodwaters during major storm events.

Recreational opportunities primarily include beachgoing, birdwatching, and active recreation along the Pajaro River Levee Trail. Palm Beach State Park, located at the end of W. Beach Road, is popular with visitors from the south county and Watsonville, making it an important location for providing equitable access to coastal recreation. The beaches along the Pajaro Dunes are also popular; however, public access is limited due to limited access and to the gated roads. The Pajaro Dunes / Pajaro Valley neighborhood hosted an estimated 61,000 visits in the year 2024, with about 50,000 (81%) of these drawn in by Palm Beach State Park. The remaining 19% of visits are drawn in from the Pajaro Dunes beaches (Figure 3-91 and Figure 3-92).

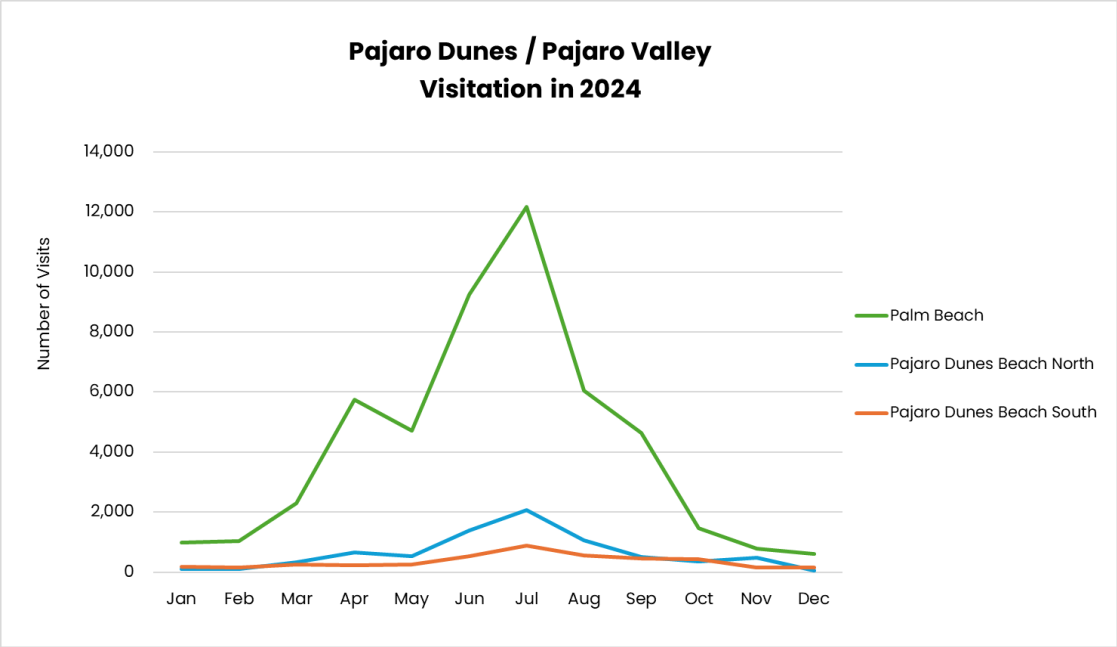


Figure 3-91. Seasonal Beach Visitation (2024) by Beach

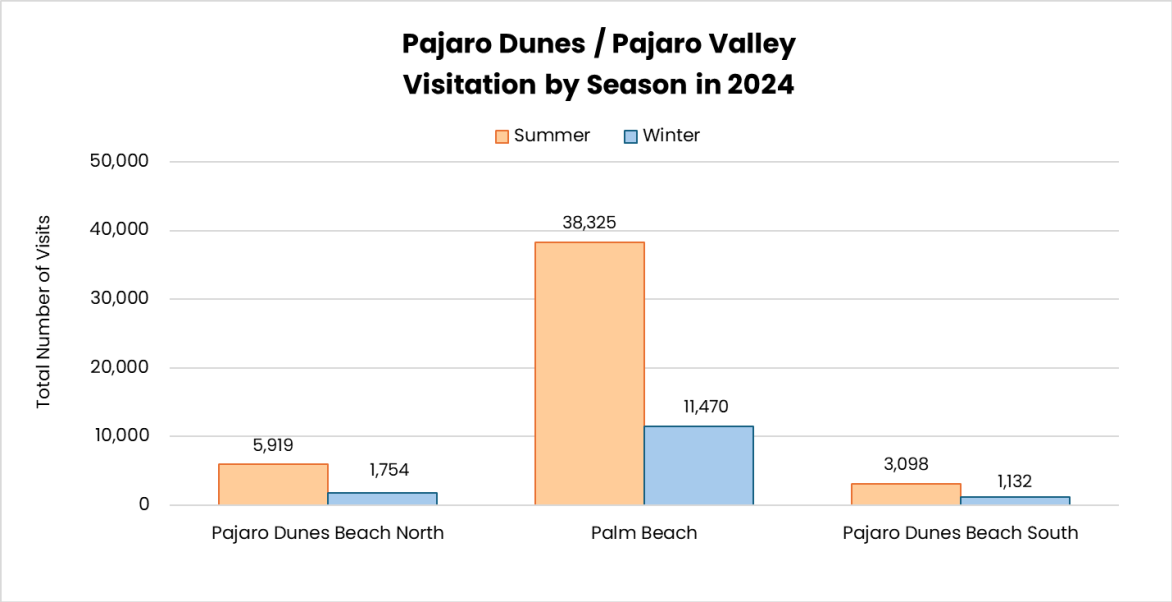


Figure 3-92. Beach Visitation between Summer and Winter (2024)

Of the estimated 61,000 beach visits in 2024, on average, about 76% occurred during the summer season (Figure 3-93).

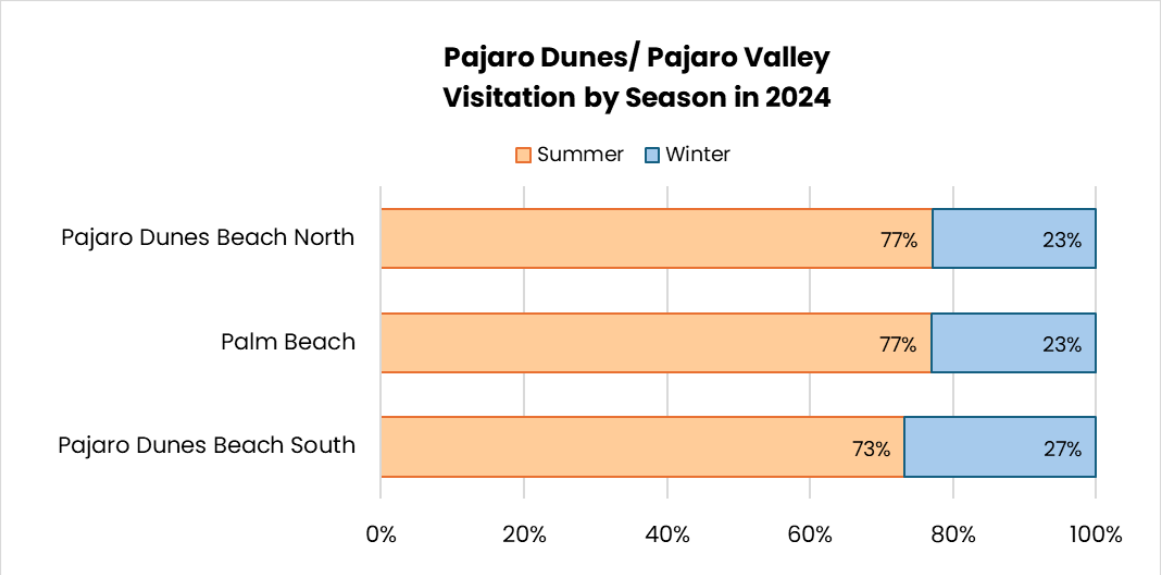


Figure 3-93. Distribution of Beach Visitation between Summer and Winter (2024)

3.6.5 Coastal Processes and Hazards

3.6.5.1 Coastal Erosion

The Pajaro Dunes area is a young dune field that extends several miles north of the mouth of the Pajaro River, and consists of a series of closely spaced, parabolic dunes that are generally less than 20 ft high. The shoreline is highly sensitive to both coastal erosion and wave flooding due to its low elevation and its location at the mouth of the Pajaro River. As a harbinger of potential future hazard exposure, in 1969, before the Pajaro Dunes was completely built out, storm waves struck the dune, and 12 of the oceanfront lots were severely eroded (Griggs and Johnson 1983). Less than 10 years later, the 1978 winter storm further cut into the dunes. This storm led to significant dune retreat, threatening at least 17 houses and 25 condominium units, causing the original riprap to settle into the sand as much as 10 to 15 ft vertically and moving the structure seaward. At the end of that storm season, a massive riprap seawall was placed along the entire seaward frontage of this development. Since the 1980s, winter storms have frequently eroded the foredunes, sometimes exposing property foundations and necessitating repairs to the structures and coastal armoring.

3.6.5.2 Coastal Flooding

These low-lying areas are subject to compound flooding driven by coastal storm surge, river flow, and lagoon overtopping and barrier beach-related flooding. Within the lower Pajaro Valley, there is a long record of historical flood events, including the January 1995 flood event, the March 2023 flood event and the river levee breach.

The Pajaro Dunes area is supported by a combination of stormwater and flood-control infrastructure, including the Pajaro River levee system, tide gates along the Watsonville Slough that regulate drainage into the river and prevent tidal backflow, and a network of slough channels and agricultural drainage ditches throughout the valley.

3.6.5.3 Coastal Armoring

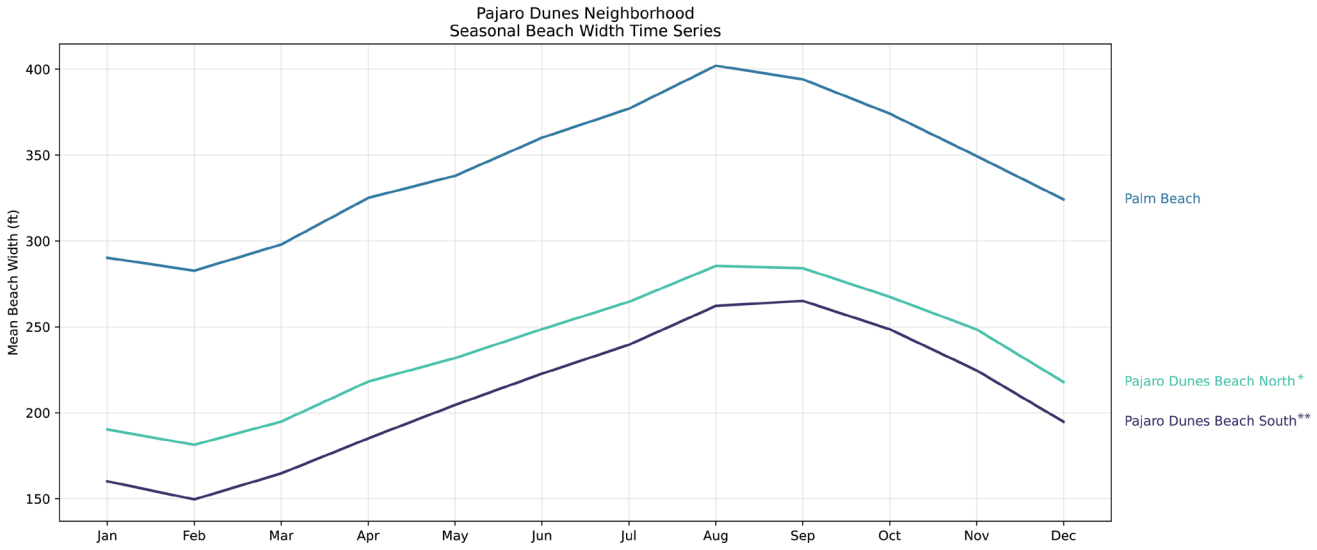
The entirety of the Pajaro Dunes community is protected by riprap, engineered dunes, and a steel bulkhead at the river mouth, all maintained through the Pajaro Dunes Geologic Hazard Abatement District.[16] This coastal armor represents the longest contiguous revetment in Santa Cruz County and one of the longest in California. Along undeveloped areas of this neighborhood, such as at Palm Beach State Park, the dune system provides the primary natural

[16] Formed in 1998 to manage and repair the coastal armoring, the Geologic Hazard Abatement District includes two zones: one responsible for the rock revetment seawall and one for the sheet-pile river wall. These systems were designed to limit damage from a 30-yr coastal storm event.

line of coastal defense. Approximately 73% of the shoreline and 69% of structures are protected by coastal armoring.

3.6.5.4 Beach Widths

Interannual beach width trends in this neighborhood show variability by as much as 140 ft, with the narrowest beaches occurring along the developed portions of the coastline (Figure 3-94).



*partially armored

** fully armored

Figure 3-94. Seasonal Beach Width Trends by Beach (average width by month across all records from 1984–2024)

Lighter colors appear further north, and darker colors appear further south.

All of the beaches in the north of the neighborhood have shown a gradual long-term widening of 20–40 ft since the early 1980s. In the south, beach width data indicate a moderate reduction by approximately 10 ft (Figure 3-95).

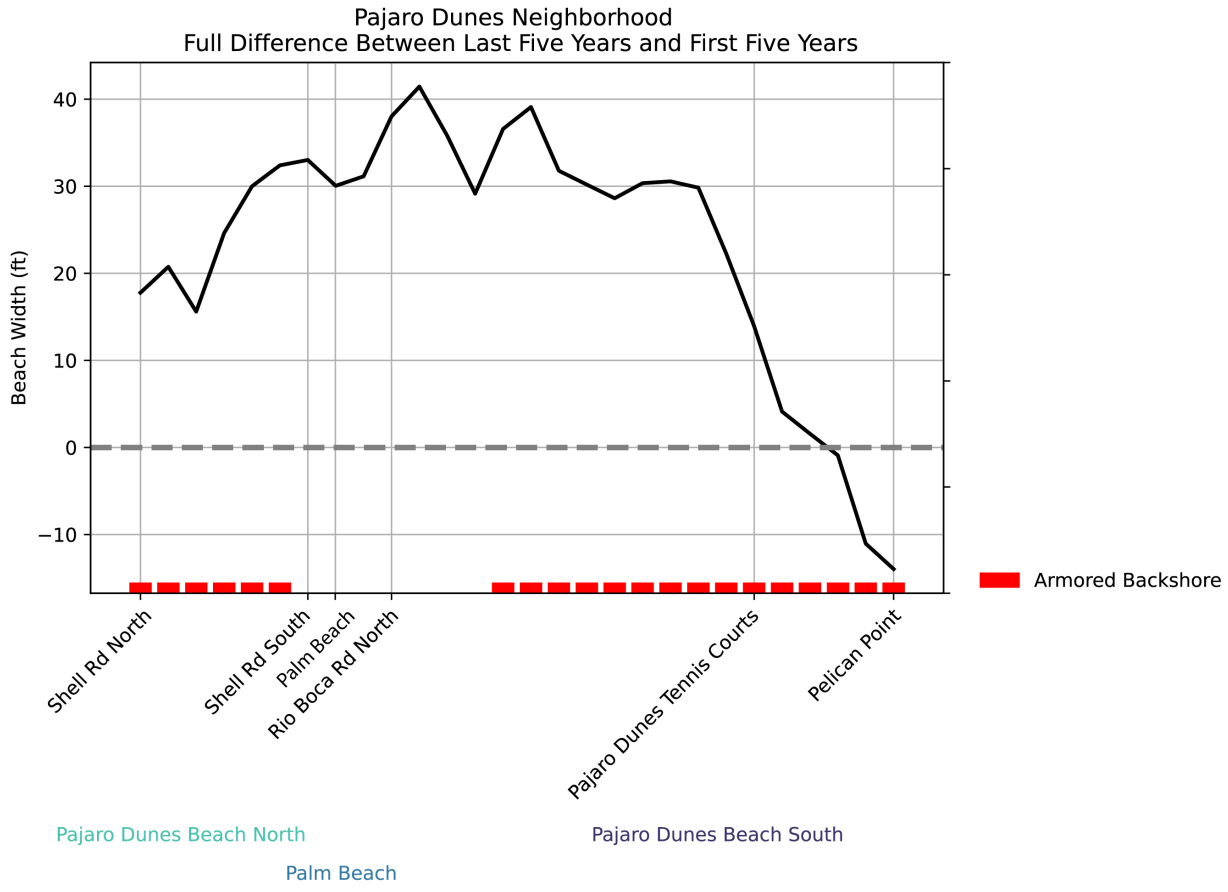


Figure 3-95. Alongshore Difference in Beach Width between the Time Periods of 1984–1989 to 2019–2024

Negative numbers indicate a net narrowing, and positive numbers indicate a net widening.

3.6.6 Vulnerability with Sea Level Rise

3.6.6.1 Storm Recurrence and Sea Level Rise

With SLR, coastal flooding elevations will reach more severe flood elevations more frequently and will produce greater depths of flooding. Figure 3-96 below illustrates storm recurrence intervals and flood depths with SLR for the Pajaro Dunes / Pajaro Valley neighborhood.

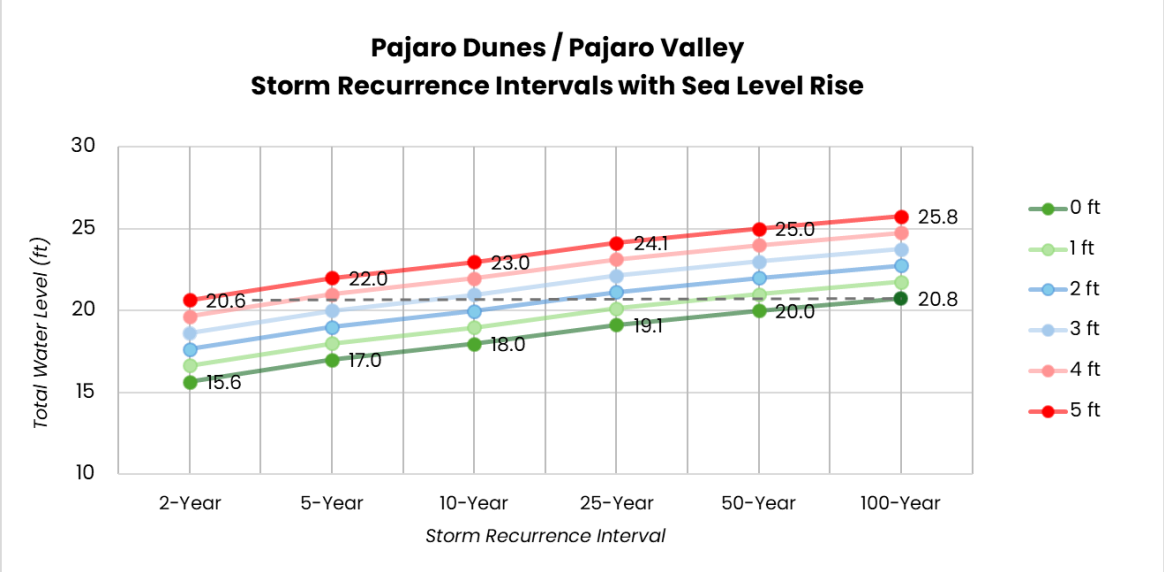


Figure 3-96. Average Storm Recurrence Intervals and Associated Total Water Levels (in ft) with SLR for all FEMA Transects in the Neighborhood

The dashed line represents the total water level associated with the current 100-yr storm. These data only account for coastal wave flooding and do not account for compound and riverine flood events.

Currently, a 100-yr storm (1% annual chance) produces an average total water level of about 20.8 ft. With 1 ft of SLR, that same flooding level would occur during a 50-yr storm (2% annual chance), effectively doubling how often this flooding intensity occurs. With 2 ft of SLR, it would occur during a 25-yr storm (4% annual chance), and with 3 ft, during a 10-year storm (10% annual chance).

Even smaller, more frequent storms will bring higher water levels over time. Under today's conditions, a 2-yr storm event (50% annual chance) will typically reach about 15.6 ft. With 1 ft of SLR, a 2-yr storm (50% annual chance) event baseline increases to 16.6 ft, equivalent to what is now a 5-yr storm (20% annual chance). At 2 ft of SLR, a 2-year storm event's water levels rise to 17.6 ft, similar to today's 10-yr event (10% annual chance).

3.6.6.2 Key Assets at Risk with SLR

As sea levels rise, the Pajaro Dunes / Pajaro Valley neighborhood will face increasing exposure to coastal and riverine hazards, including storm-driven flooding, dune erosion, beach loss, and overtopping of the Pajaro River levee system. These hazards threaten the Pajaro Dunes, critical access roads, agricultural lands, and emergency response infrastructure.

Land Use and Structures

Figure 3-97 summarizes the number of structures exposed to coastal hazards under increasing SLR, presents the associated cost ranges for those impacts, and provides a comparative view of potential damages by hazard type.

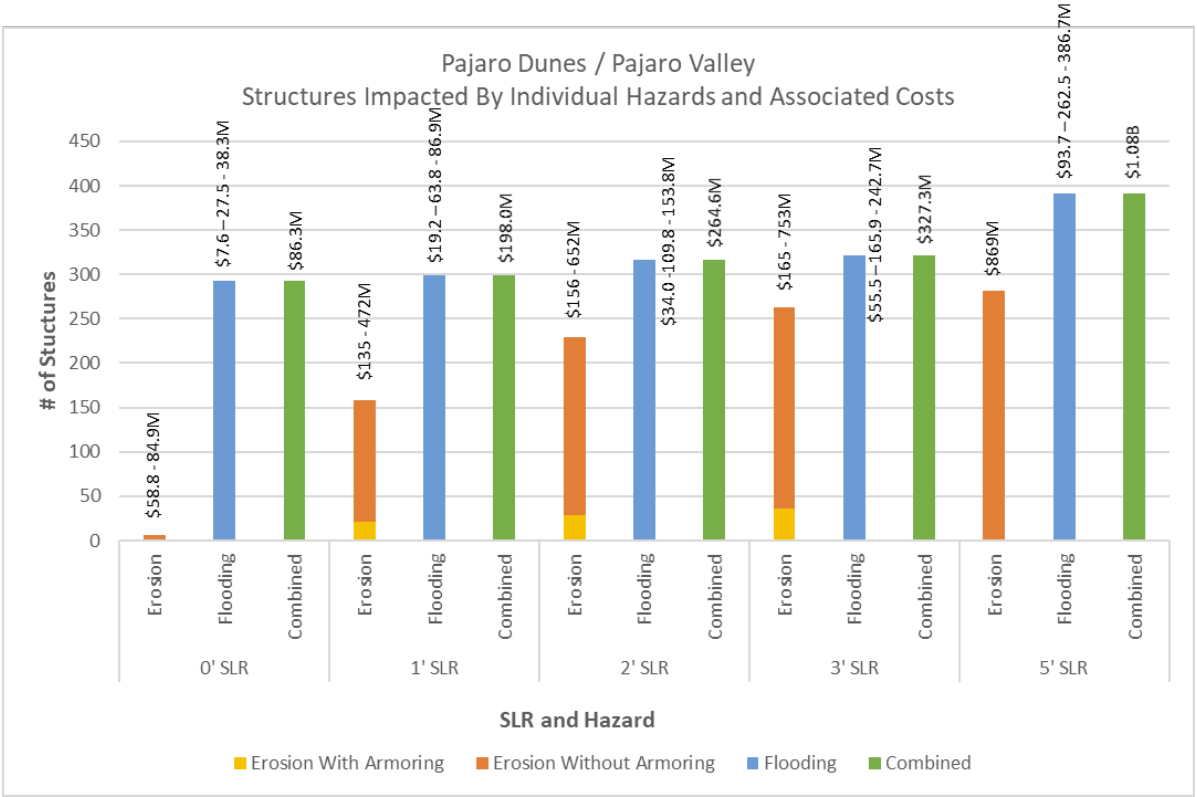


Figure 3-97. Pajaro Dunes / Pajaro Valley Number of Structures Experiencing Impacts from Coastal Hazards and Associated Costs under Different SLR Scenarios

Costs associated with coastal erosion include the permanent loss of land value and structures. Costs associated with flooding include temporary damage to structures and contents. The combined category includes both but removes flood damages to unarmored structures lost to erosion in prior horizons.

In the neighborhood, the entirety of the lower Pajaro Valley is currently flood prone, exposing almost 300 structures today. Damages to these structures are variable and based on projected depths of flooding, and are projected from $27.5M as a middle estimate to $38.3M as a high estimate. **Between 0 and 3 ft of SLR,** the number of structures in the lower Pajaro Valley exposed to flooding is not projected to increase substantially; however, depths of flooding are projected to increase, and cumulative damages are projected to be $55M to $242M. By **5 ft of SLR**, this study assumed the coastal armoring would no longer be in place, but the Pajaro River

levees would remain. A cumulative high-end estimate of damages associated with flooding by this horizon is estimated to be $386.7M.

Coastal erosion currently exposes very few structures, and armoring plays a major role in keeping these numbers low. However, without armoring, coastal erosion becomes a significant hazard. Currently, with armoring in place, $58.8M in property and structures is exposed to dune erosion, and $84.9M is exposed without armoring. By **2 ft of SLR**, $156M is exposed with armoring in place, and $652M is exposed without armoring in place. By **5 ft of SLR**, this number rises to $869M, assuming armoring is no longer in place. By **5 ft of SLR**, coastal flooding and coastal erosion hazards threaten nearly 400 structures, with a projected cumulative damage and losses to land and structures equal to $1.1B.

Figure 3-98 illustrates the probability that a structure will experience damage due to wave exposure or coastal erosion with SLR. This assumes a more risk-averse scenario and identified all structures with the potential to be impacted during a 500-year storm event and assumes coastal armoring is in place through 3 ft of SLR (Appendix D). **Currently**, most structures in Pajaro Dunes that are protected by coastal armoring are categorized as having a low probability of impact. At the southern end of the neighborhood, the condos in the Pelican Point development near the mouth of the Pajaro River are categorized as having a medium probability of impact due to their heightened exposure to a confluence of coastal wave and riverine flood hazards. Some of the very low-lying structures at the back of the dune complex have a very high probability of impact due to their location near the Watsonville Slough and exposure to both riverine and barrier beach flooding. Structures in the lower Pajaro Valley have varying probabilities of impact, with structures closer to the ocean generally having a very high probability and structures closer to Watsonville having a medium or low probability of impact. **By 2 ft of SLR**, many of the structures within the Pajaro Dunes move to a medium probability of impact. This encompasses all the first row of oceanfront homes. **By 5 ft of SLR**, most of the structures in the neighborhood are categorized as having a high or very high probability of impact.

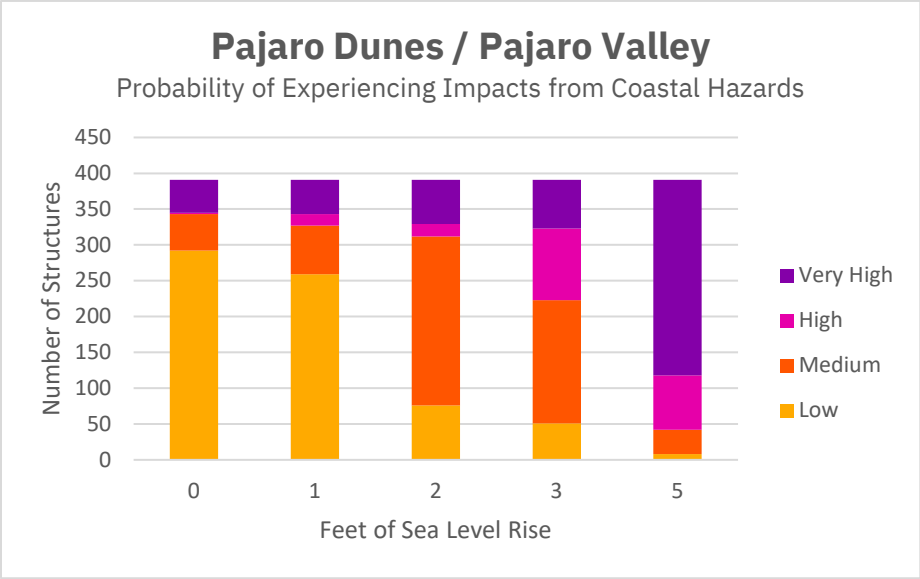


Figure 3-98. Probability of Structures Experiencing Impacts from Coastal Hazards by SLR Horizon

Probabilities combine exposure to both coastal flood and erosion hazards. Flood probabilities correspond to the following: Very High = 20% or greater annual chance, High = 10%–20% annual chance, Med = 5%–10% annual chance, Low = 1%–5% annual chance, Very Low = 0.2%–1% annual chance. Probability of erosion is related to the length of time a structure is within the erosion hazard zone, as well as the armoring condition of the backshore. See Appendix D for more details.

Roads and Railroad

Much of the Pajaro Dunes is currently vulnerable to low-lying flooding, including access roads such as Beach Road and Shell Road, as well as internal community roads like Rio Boca Road/River Road, and Shearwater Lane.

Wastewater, Stormwater, and Water Infrastructure

Several wastewater pump stations, one located near the Pajaro Dunes entrance office just south of Beach Road along Rio Boca Road, and another near the intersection of Rio Boca Road and Puffin Lane, are vulnerable to low-lying flooding under current conditions.

The Watsonville Slough pump systems along Shell Road, which function to lower water levels in the slough, will have reduced opportunities for gravity drainage with SLR, causing the flap gate to remain closed more often. This will increase reliance on the stormwater pump and elevate flood risk during large storm events, power outages, or pump failure.

In 2018, Environmental Science Associates (ESA) conducted a site-specific vulnerability assessment of the infrastructure at Pajaro Dunes. For this study, ESA determined critical flooding thresholds in mean sea level (MSL) for a range of assets and infrastructure in the community. Vulnerable infrastructure included pump stations, electrical and telephone boxes, roads, and numerous Pajaro Dune's community buildings, including Dunes Hall, Cypress House, the Lagoon House (dining and meeting rooms), and the Gatehouses. Also vulnerable are several drinking water wells and a booster station off Shell Road, and two sewage pump stations, one off River Road, and one off of Shell Road. All of these infrastructures are only vulnerable during severe flood events now; however, vulnerabilities will increase with SLR. Some of those critical elevations (in MSL) can be found below.[17]

KEY FINDINGS FROM THE PAJARO DUNES AND LAGOON FLOOD VULNERABILITY ASSESSMENT. ESA (2018)

1. +4 ft MSL, the lower areas of the residential development begin to flood. This largely consists of open space within the development, but also include the Cypress House community building.
2. At +5.0 ft MSL the W. Beach Street shoulder experiences flooding, impacting access to the community.
3. At +5.5 to +5.8 ft MSL, Shell Road and W. Beach Road begin to flood. This can cut off vehicle access to the community.
4. At +6 ft MSL, a sewer pump station and sewer manholes throughout the community are exposed to flooding. This can result in raw sewage spills into Watsonville Slough.

Beaches

Average winter beach widths in the Pajaro Dunes / Pajaro Valley neighborhood decline with SLR. **Currently**, winter beaches average around 200 ft, while summer beaches are wider at about 300 ft. By **1 ft of SLR**, winter widths drop to 100 ft, while summer widths decline to roughly 210 ft. By **2 ft of SLR**, winter beach width is reduced to about 20 ft, leaving only narrow strips of beach across the neighborhood, and summer widths fall to around 120 ft. By **3 ft of**

[17] For reference, the highest observed tide at the Monterey Tide Gauge was 5.05 ft above MSL on January 27, 1983. Mean higher-high water is 2.51 ft above MSL.

SLR, winter beaches are only present at Palm Beach, and summer beaches narrow to 30 ft. **By 5 ft of SLR**, both winter and summer beaches are effectively lost (Figure 3-99).

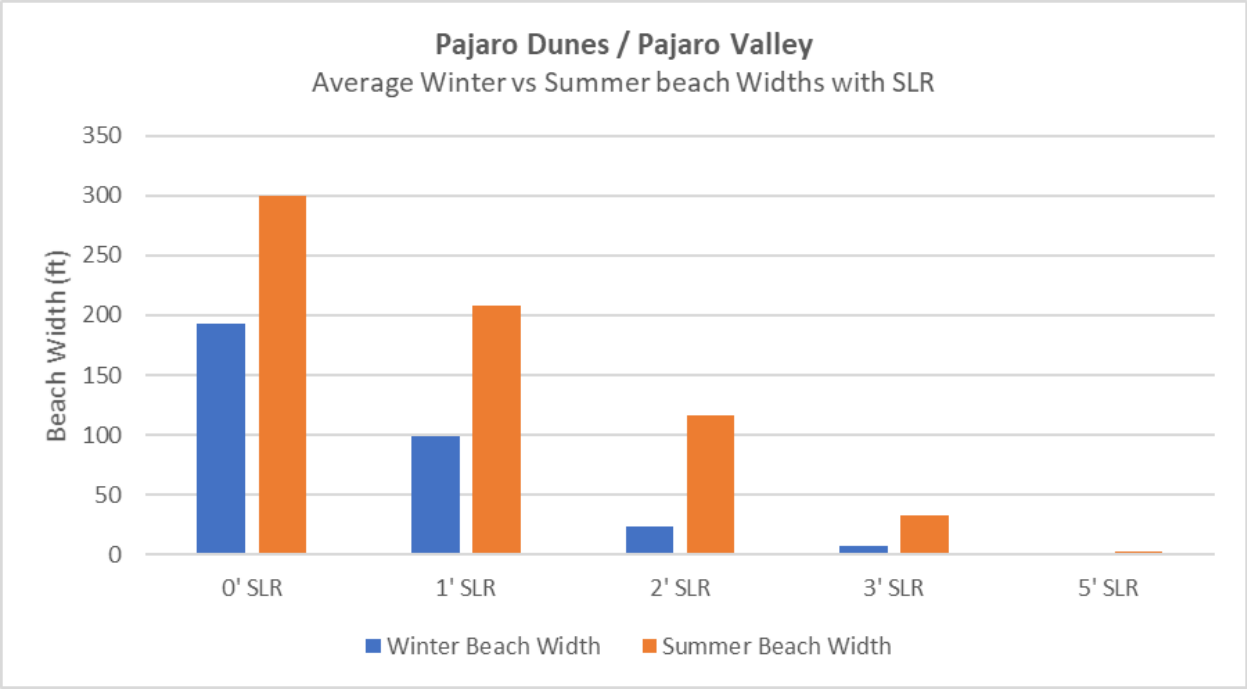


Figure 3-99. Pajaro Dunes / Pajaro Valley Summer and Winter Beach Widths with SLR

Table 3-15. Pajaro Dunes / Pajaro Valley winter beach loss locations

	SLR (ft)				
Beaches	0	1	2	3	5
Pajaro Dunes Beach North *	●	●	●	●	●
Palm Beach	●	●	●	●	●
Pajaro Dunes Beach South **	●	●	●	●	●

● = 100+ ft, ● = 25-100 ft, ● = <25 ft, ● = no beach

* = partially armored
** = fully armored

Coastal Access

The primary public access point in this neighborhood, Palm Beach, is vulnerable to flooding due to its low elevation, proximity to the shoreline and slough system, and reliance on a single access road. Even under near-term conditions (0–1 ft SLR), storm wave run-up, high tides, and

combined coastal and fluvial influences are likely to cause episodic flooding of the Beach Road parking area and lower portions of the access trail, reducing reliability during winter storms. Under mid-term SLR (1–3 ft SLR), flooding becomes more frequent and prolonged, with periodic loss of usable parking. By the long term (3–5 ft SLR), chronic flooding and erosion are likely to render the parking area and beach access trail unreliable or nonfunctional without significant elevation, relocation, or redesign, substantially limiting public access to Palm Beach.

3.6.6.3 Risk Summary

The Pajaro Dunes / Pajaro Valley neighborhood is characterized by an extensive concentration of residential and resort development and inland agricultural lands that are highly vulnerable to coastal and riverine flooding. While the dunes provide a degree of natural protection, the area's limited access roads' reliance on the Pajaro River levee system creates significant sensitives to coastal hazards and combined coastal–fluvial flooding. In addition, unlike in more modern coastal development, most of the structures in the Pajaro Dunes are built on conventional concrete foundations, rather than on elevated pilings, making them more susceptible to flooding.

As discussed in the community characteristic section, the lower Pajaro Valley area is characterized as a disadvantaged community. Disadvantaged communities are more sensitive to the impacts of SLR as they may have difficulty securing flood insurance, and have less adaptive capacity to recover or adapt to hazards. These communities also have intrinsic sensitivities, including linguistic isolation, that can make communication of emergency services and the ability to evacuate to safe areas more challenging. Consideration of these populations should be included in the development of adaptation strategies and emergency response plans. Key findings by time horizon are summarized below.

Pajaro Dunes / Pajaro Valley: Near Term (0–1 ft of SLR). By 1 ft of SLR:



Two hundred ninety-three structures are within the 100-yr flood hazard area. This includes all oceanfront homes.

Three hundred ninety-one structures are within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse scenario, and 99 structures are categorized as having medium to very high probability of experiencing impacts.

Flooding is a regular occurrence on agricultural fields. This land has recently been in strawberry and mixed vegetable production; however, with SLR, these fields will become poor performing. There are currently plans for the purchase and restoration of these fields.

Homes at the Pajaro Dunes are protected from dune erosion so long as armoring is in place. However, many critical facilities and infrastructure are located at lower elevations and vulnerable to flooding including a fire station, three wastewater pump stations, and an electrical transformer.

Given the largely armored coastline, damage estimates related to flooding could vary from $7.6M in calmer conditions to $38.8M in stormier conditions.[18]

With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $198M. This represents land losses associated with dune erosion (~70%) and damages associated with flooding (~30%).



Tidal inundation and flooding are a regular occurrence on access roads such as Beach Ranch Road within the lower Pajaro Valley, as it is poorly drained and lies at a lower elevation. These hazards will inhibit traffic flow, block access, and endanger road users and pedestrians.



The Watsonville Slough pump along Shell Road already experiences flooding during high tides and storms and may become overworked with SLR, increasing inland flooding risk. In Pajaro Dunes, flooding exposure affects wastewater infrastructure and Pacific Gas and Electric junction boxes, increasing the risk of sewage spills and corrosion.



Winter beach widths are reduced by approximately half, from about 200 to 100 ft, while summer beach widths remain wider but are still reduced, from about 300 to 200 ft. Public access at Palm Beach is vulnerable to flooding.



Wetland resources in the lower Pajaro Valley will be vulnerable to saltwater intrusion. Flooding of marsh areas of the lagoon in the spring and summer could adversely affect nesting and foraging waterfowl (W33b ESA Report).

[18] Calm conditions are represented as multiple small storms (5-yr recurrence or less) over a 20-yr window, and stormier conditions represent multiple large storms over a 20-yr window (one 100-yr, one 25-yr, and multiple smaller storms).

Pajaro Dunes / Pajaro Valley: Mid Term (1–3 ft of SLR). By 3 ft of SLR:



Three hundred twenty-one structures are within the 100-yr flood hazard area, and 36 structures are exposed to coastal dune and erosion assuming armoring is in place.

Three hundred ninety-one structures are still within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse scenario and assuming armoring is not in place, and 340 structures are categorized as having medium to very high probability of impact.

Most structures in the Pajaro Dunes are categorized as having medium to very high probability of impact.

Beaches will narrow and disappear in the winter. This will increase the maintenance requirements of coastal armoring. If these requirements are not met, armoring may no longer be effective and storm wave hazards will lead to undermining of building foundations.

In the Pajaro Dunes, many structures will not be viable to rebuild due to repeated flood exposure issues combined with exposure to dune erosion.

Barrier beach closures at the mouth of the Pajaro River could be more impactful, and lead to significant and more consequential inland flooding.

Floodwaters are more likely to circumvent or overtop inland agriculture berms and levies and back up water along the Watsonville Slough and flood low-lying areas in the Pajaro Dunes.

Low-lying structures in the Pajaro Dunes, including the Fire Station, will be exposed to regular flooding.

With coastal armoring in place, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $327.3M. This represents an even distribution between land losses associated with dune erosion (~50%) and damages associated with flooding (~50%).



Access to the Pajaro Dunes along W. Beach Road, Shell Drive, and River Road (Rio Boca Road) will be increasingly disrupted by flooding. Regular tidal inundation could lead to failure due to saturation of unbound roadway materials.



Slough gate malfunction along the Watsonville Slough may increase significantly, which could have cascading impacts up and downstream of the gates. Higher groundwater levels could result in more inflow and infiltration into the wastewater collection system, as well as corrosion issues to electrical infrastructure.

Buried pipes may experience increased buoyancy forces and deterioration of facility components.

Water supply pipes may be exposed to inundation and infiltration, resulting in backflow and contamination.

Exposure of the wastewater treatment plant to flooding could impact wastewater quality, treatment needs, and the recycled water program.



Beaches will no longer be present along the armored and developed portions of the coastline, reducing recreational capacity along this neighborhood's beaches. Flooding at the Palm Beach access becomes more frequent and prolonged, with periodic loss of usable parking.



Wetland resources in the lower Pajaro Valley experience continued saltwater intrusion, leading to ongoing stress and shifts in wetland habitat conditions.

Pajaro Dunes / Pajaro Valley: Long Term (3–5 ft of SLR). By 5 ft of SLR:



Three hundred ninety-one structures are within the 100-yr flood hazard area, and 282 structures are exposed to coastal dune and erosion.

Three hundred ninety-one structures are still within a coastal, riverine, and/or erosion hazard area assuming a more risk-averse scenario and assuming armoring is not in place, and 383 structures are categorized as having medium to very high probability of impact.

The Pajaro Dunes, which includes approximately 270 structures, is exposed to a combination of hazards including dune erosion, storm wave flooding, fluvial flooding, barrier beach lagoon flooding, rising tides, and rising groundwater levels, significantly threatening the viability of the community.

	With coastal armoring in place through 3 ft of SLR, a middle estimate for cumulative damages and losses from flooding and erosion is projected to be $1.08B. Large portions of the Lower Pajaro Valley, currently under agricultural production, will become a tidally influenced system.
	Access to Palm Beach State Beach via Beach Road and access to and from the Pajaro Dunes via Beach Road, Rio Boca Road, Shell Drive, and River Road may be permanently underwater, affecting both public recreation and residential access.
	Chronic flooding and elevated groundwater compromise slough gates and pump systems, resulting in persistent drainage failures and flooding, along with ongoing inflow, corrosion, and service disruption to wastewater and electrical infrastructure.
	Beach access is highly constrained, with a loss of usable beach areas, which support approximately 61,000 annual visits. Chronic flooding and erosion at Palm Beach are likely to render the parking area and beach access trail unreliable or nonfunctional without significant elevation, relocation, or redesign.
	Chronic saltwater intrusion and sustained inundation result in substantial loss of freshwater wetland function, with many areas transitioning to brackish or tidally dominated systems.

3.6.7 Key Adaptation Strategies for Consideration

Based on the exposure and vulnerability findings described above, the following list summarizes potential adaptation strategies for the Pajaro Dunes/Pajaro Valley neighborhood that will be further evaluated.

Near-Term

- Planning and Alignment
  - State Parks
  - Pajaro Dunes Geologic Hazard Abatement District

  - Land trusts
  - City of Watsonville
- Nature-Based Solutions
  - Living shorelines
- Sand Management
- Accommodation
  - Stormwater infrastructure improvements (including floodproofing, upgrades, and/or relocation)
  - Raising the most vulnerable infrastructure and utilities
- Green and gray solutions that balance the protection of agricultural lands, habitat, and groundwater resources

Mid-Term

- Protection
  - Installation of groin near the northern end of the mouth of the Pajaro River
  - Raising of the riprap at the Pajaro Dunes
  - Ecotone slope enhancement
- Accommodation
  - Raise critical infrastructure and vulnerable community buildings
- Managed Retreat
  - Conversion of low-performing agricultural land to wetlands

Long-Term

- Managed Retreat
  - Retreat or relocation of the low-lying flood-prone development
  - Retreat development on the active dunes prone to coastal erosion.

Pajaro Dunes / Pajaro Valley - Coastal Hazard Areas: 0 ft SLR with Existing Armoring

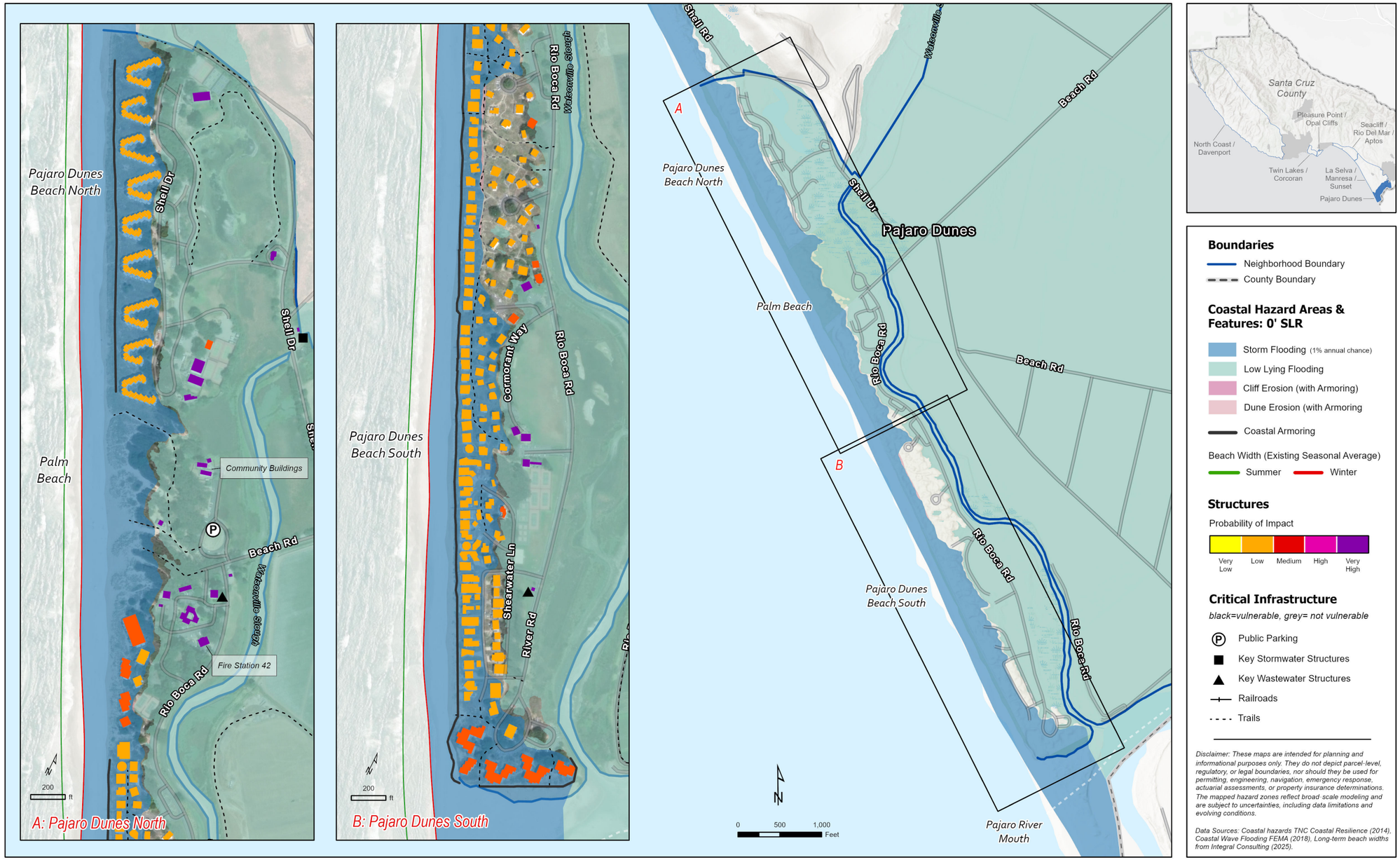


Figure 3-100. Pajaro Dunes / Pajaro Valley SLR Vulnerability Map—0 ft of SLR with Existing Armoring

Pajaro Dunes / Pajaro Valley - Coastal Hazard Areas: 2 ft SLR with Existing Armoring

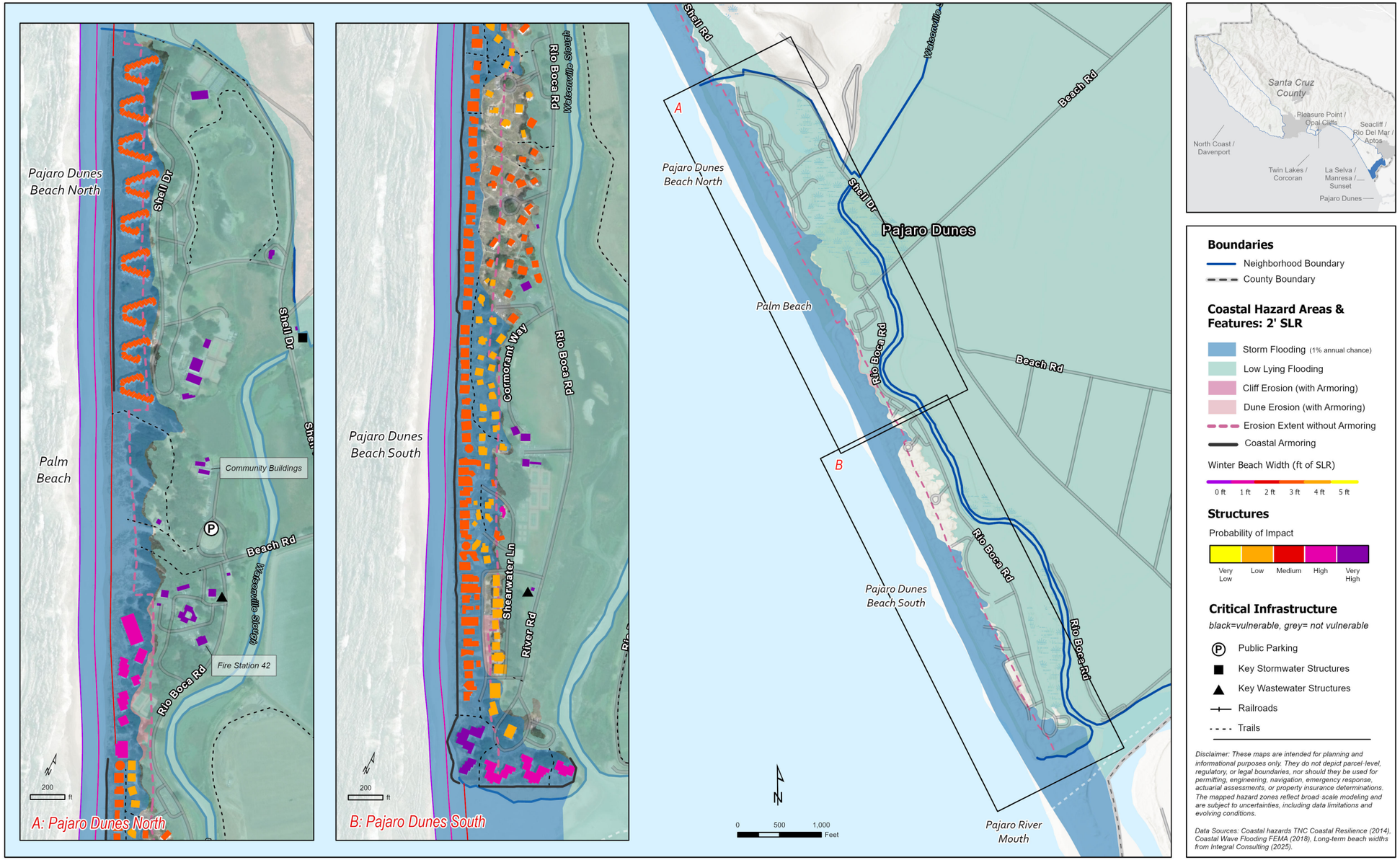


Figure 3-101. Pajaro Dunes / Pajaro Valley SLR Vulnerability Map—5 ft of SLR with Existing Armoring

Pajaro Dunes / Pajaro Valley - Coastal Hazard Areas: 5 ft SLR without Existing Armoring

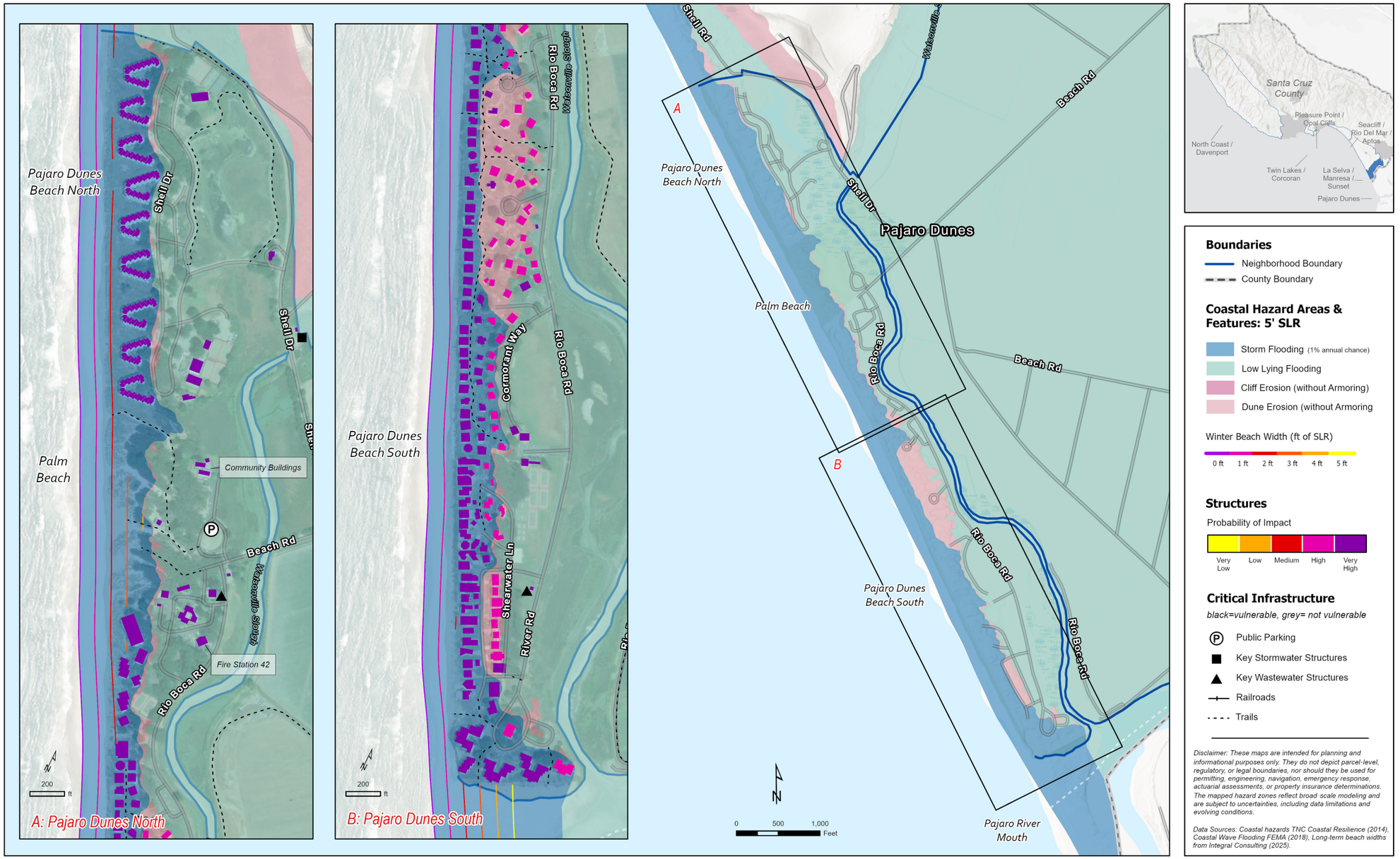


Figure 3-102. Pajaro Dunes / Pajaro Valley SLR Vulnerability Map—5 ft of SLR without Existing Armoring

3.7 COUNTYWIDE VULNERABILITY ASSESSMENT SUMMARY

Assets and infrastructure throughout Santa Cruz County are projected to be at risk from SLR. The primary near-term threat is storm-driven wave flooding to low-lying beachfront development. Without adaptation, in the mid-term, much of the development on the county's beachfront will face a dual threat of the loss of a protective winter beach and increased storm-wave attack associated with higher water levels. This will lead to greater coastal armoring maintenance demands, and could make beachfront development unviable, as structures and their supporting infrastructure are damaged faster than they can be repaired. This will continue to intensify with rising sea levels, and clifftop asset sand infrastructure will also experience an increased threat if beachfront development and armoring are no longer present.

By 2 ft of SLR, if beachfront development remains and coastal armoring fixes the backshore position, many beaches along the county coastline will no longer have dry sandy beach in the winter, and very narrow beaches in the summer. Between 2 and 3 ft of SLR, many of the county's surf spots will be rarely surfable or functionally extinct. Coastal access points may be affected prior to the loss of the surf breaks themselves, particularly within the Pleasure Point / Opal Cliffs neighborhood.

This section provides a broad overview of the entire county's SLR risk summaries, including land use, infrastructure, and coastal recreation, as well as short comparisons between each of the neighborhoods.

3.7.1 Land Use, Structures, and Infrastructure Risk Summary

This section provides an overview of countywide exposure to coastal hazards including coastal flooding and erosion. This section is divided into three sections, structural exposure, which include buildings and their contents, land area exposure, which includes all terrestrial land area, and a combined structures and land area exposure overview. For structures, exposure and estimates of damages are reported for both coastal flooding and coastal erosion. For land area, only exposure related to coastal erosion is reported. Although short-duration wave action and flooding can cause significant impacts to land, these impacts are generally considered temporary, and no direct damages are reported. The conversion of land uses associated with repeated flooding or tidal inundation are not included in this analysis.

3.7.1.1 Structural Exposure

Structures Exposed to Coastal Hazards

Currently, more than 1,500 structures in unincorporated Santa Cruz County are exposed to coastal hazards. **By 3 ft of SLR**, the number of structures exposed increases to more than 2,200, and the probability of exposure to structures increases substantially, with more than

half in the medium to very high probability categories. **By 5 ft of SLR**, more than half of all coastal structures, or ~1,200 structures, will be in a very high probability of impact to coastal hazards categories (Figure 3-103).

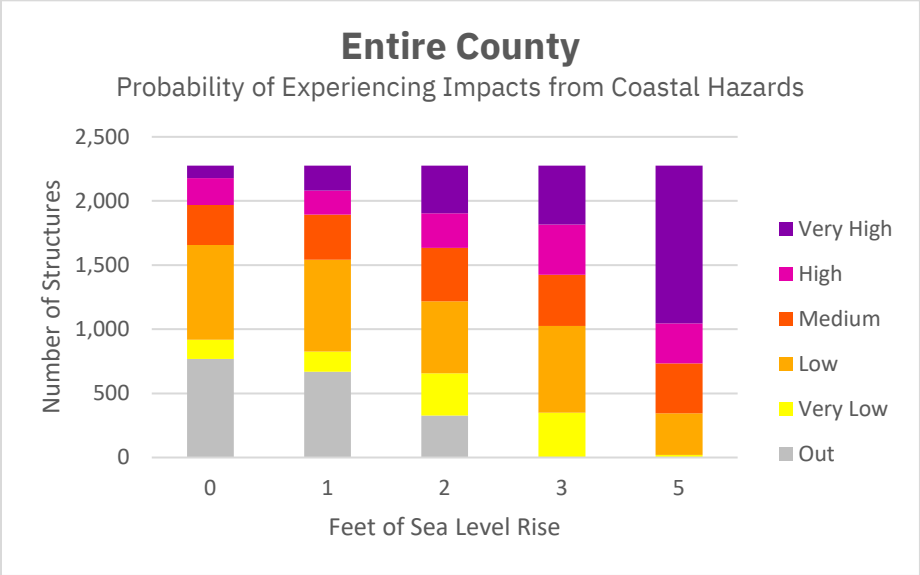


Figure 3-103. Probability of Structures Experiencing Impacts from Coastal Hazards by SLR Horizon

Probabilities combine exposure to both coastal flood and erosion hazards. Flood probabilities correspond to the following: Very High = 20% or greater annual chance, High = 10%–20% annual chance, Med = 5%–10% annual chance, Low = 1%–5% annual chance, Very Low = 0.2%–1% annual chance. Probability of erosion is related to the length of time a structure is within the erosion hazard zone, as well as the armoring condition of the backshore. See Appendix D for more details.

Structures Exposed to Flooding

Currently, 903 structures are exposed to a 100-yr storm, and potential damages due to flooding over a 20-yr window range from a middle estimate of $24M to $100M (with a middle estimate of $64M), to a high estimate of $100M to $155M. **By 3 ft of SLR**, the number of structures exposed to a 100-yr storm only increases slightly to 993. Assuming all existing structures remain in place, potential cumulative damages by this time period due to flooding range from a middle estimate of $216M to $676M (with a middle estimate of $502M), to a high estimate or $676M to $910M. **By 5 ft of SLR**, 1,129 structures are exposed to a 100-yr storm, and assuming all existing structures remain in place, potential cumulative damages due to flooding by this time period range from a middle estimate of $414M to $1.0B (with a middle estimate of $809M), to a high estimate or $1.0B to $1.38 B (Figure 3-104). Beyond 3 ft of SLR, many low-lying structures may experience damages faster than they can be repaired resulting

in their permanent removal, and as a result, the damage projections due to flooding by 5 ft of SLR may be an overestimation.

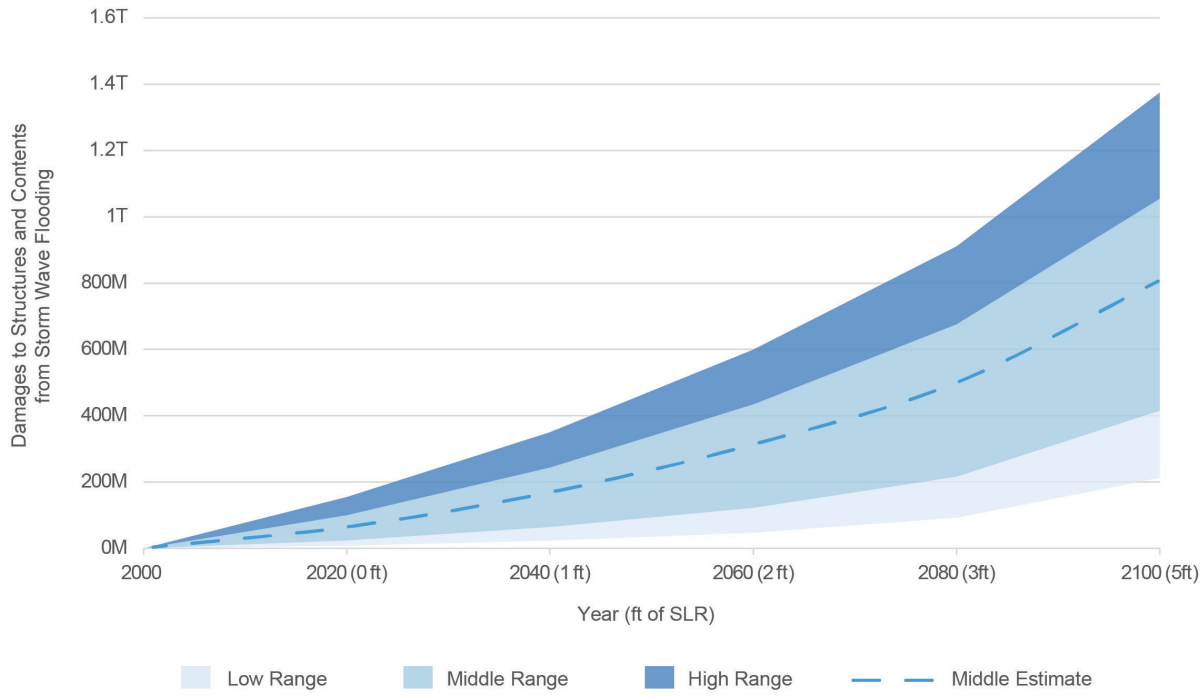


Figure 3-104. A Range of Projected Costs Associated with Damages to Structures and Contents due to Flooding

Flooding impacts are from storm wave and lagoon/low-lying flooding in the coastal zone. SLR horizons are based on an Ocean Protection Council intermediate–high scenario, assuming a baseline year of 2000. Damage estimates are based on depth damage curves that are further discussed in Appendix D. The low range assumes calm conditions and is associated with multiple small storms (5-yr recurrence or less) over a 20-yr window. The middle range assumes average conditions and is associated with one 25-yr storm and multiple smaller storms over a 20-yr window. High range assumes stormier conditions and represents multiple large storms over a 20-yr window (one 100-yr, one 25-yr, and multiple smaller storms). The limits of the high and low-end range are highly improbable. For instance, the top of the high-end range represents five 100-yr, five-25 yr, and multiple smaller storms over a 100- year timeframe. For purposes of this study, this higher and low range can be seen as covering some of the uncertainty in the flood depth-to-damage curves. All projections assume no adaptation strategies are adopted, and that existing structures are continually rebuilt in-kind.

Structures Exposed to Coastal Erosion

Currently, with existing armoring in place, 51 structures are exposed to coastal erosion; however, without armoring, 489 structures are exposed (Figure 3-105). Most of the exposed and unarmored structures are in the La Selva / Manresa / Sunset neighborhood, and most of the protected structures are located along the beachfront of the Seacliff / Rio del Mar / Aptos neighborhood. Currently, with armoring in place, $96M in structural value is exposed to coastal erosion. Without armoring, $490M in structural value is exposed (implying a protection value of $394M) (Figure 3-106).

Across the entire unincorporated County, most of the exposed structures are residential, and the Seacliff / Rio del Mar / Aptos is the only neighborhood where institutionally zoned buildings are currently exposed to erosion, with Camp St. Francis at risk (Figure 3-107).

By 2 ft of SLR, with armoring in place, an additional 109 additional structures are exposed to coastal erosion for a total of 160 structures. Without armoring, 1,054 structures are exposed (Figure 3-105). This represents $212M in cumulative structural losses with armoring in place and $1.04B in structural losses without armoring (implying a protection value of $828M in cumulative structure value) (Figure 3-106).

By 5 ft of SLR, assuming coastal armoring is no longer in place, 1,892 structures, representing $1.7B in cumulative value, are exposed to coastal erosion (Figure 3-105 and Figure 3-106).

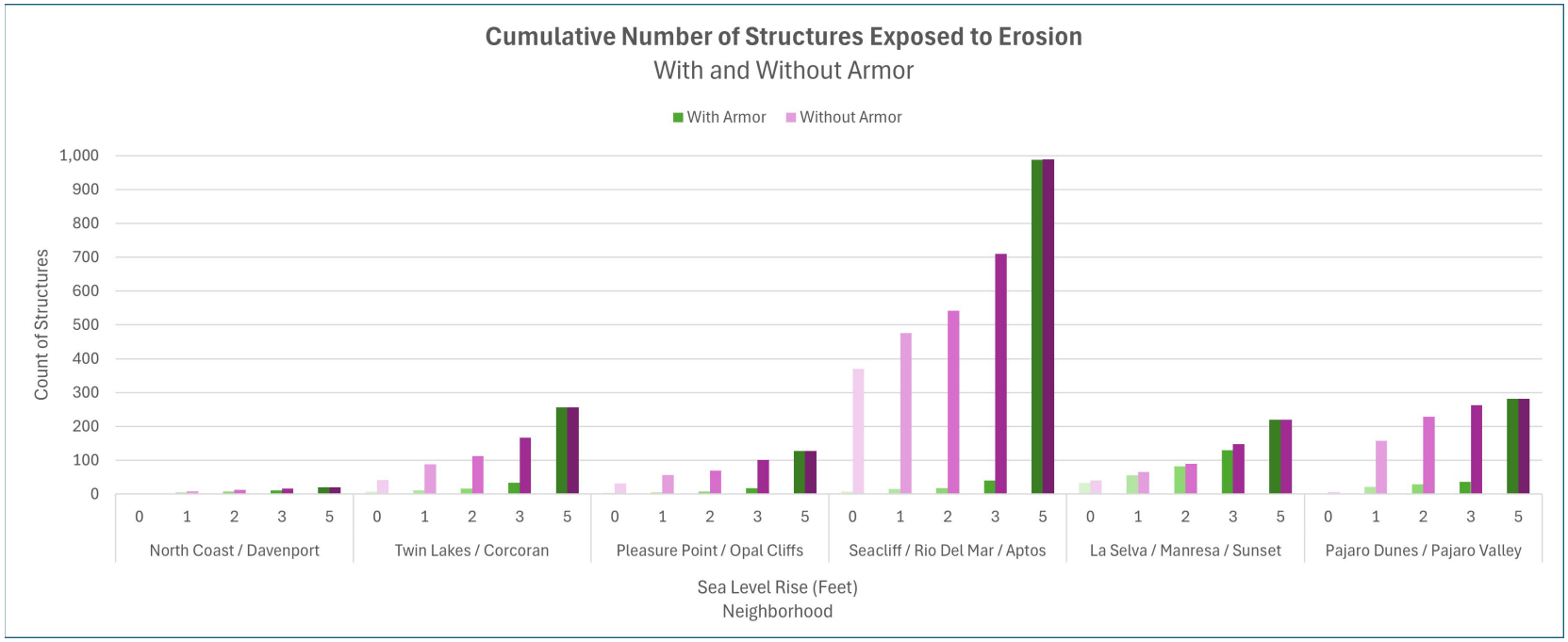


Figure 3-105. Cumulative Number of Structures Exposed to Erosion, With and Without Armor, by Neighborhood and SLR Scenario

A no-coastal-armoring assumption was made for 5 ft of SLR.

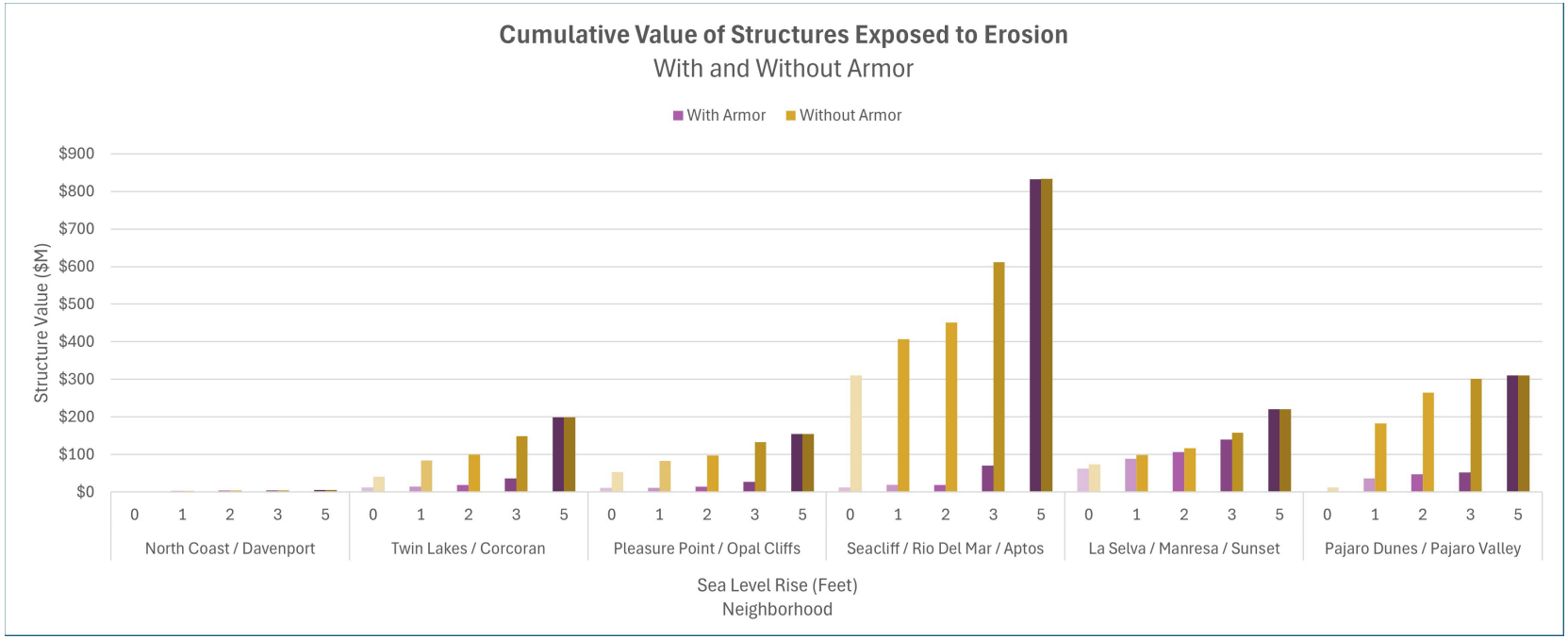


Figure 3-106. Cumulative Value of Structures Exposed to Coastal Erosion, With and Without Armoring, by Neighborhood and SLR Scenario

A no-coastal-armoring assumption was made for 5 ft of SLR. Damages include the value of the structure and omit content values or any associated economic impacts. Structural values are based on 2024 market rates and were determined based on real estate data from CoreLogic. Values are in 2024 dollars.

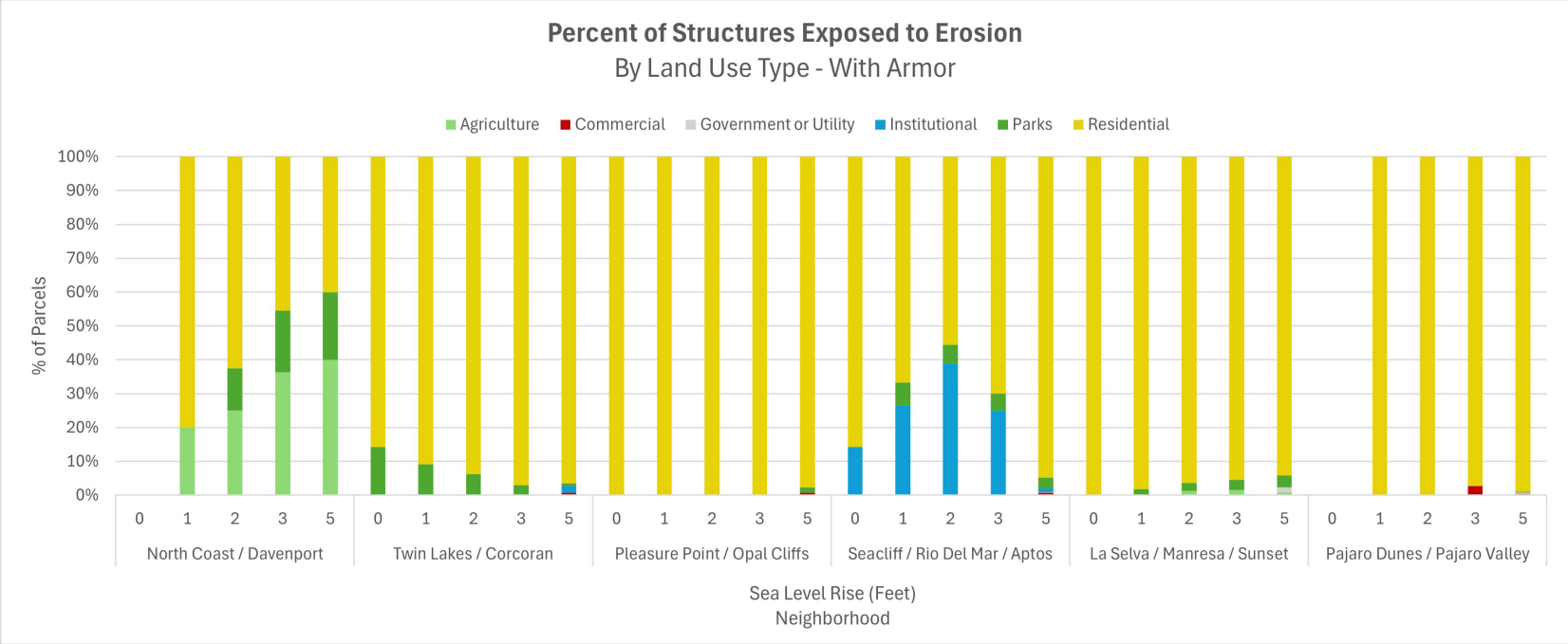


Figure 3-107. Structures Exposed to Coastal Erosion by Land Use Type, With Armor, by Neighborhood and SLR Scenario

The 5 ft SLR horizon assumes armoring is no longer in place.

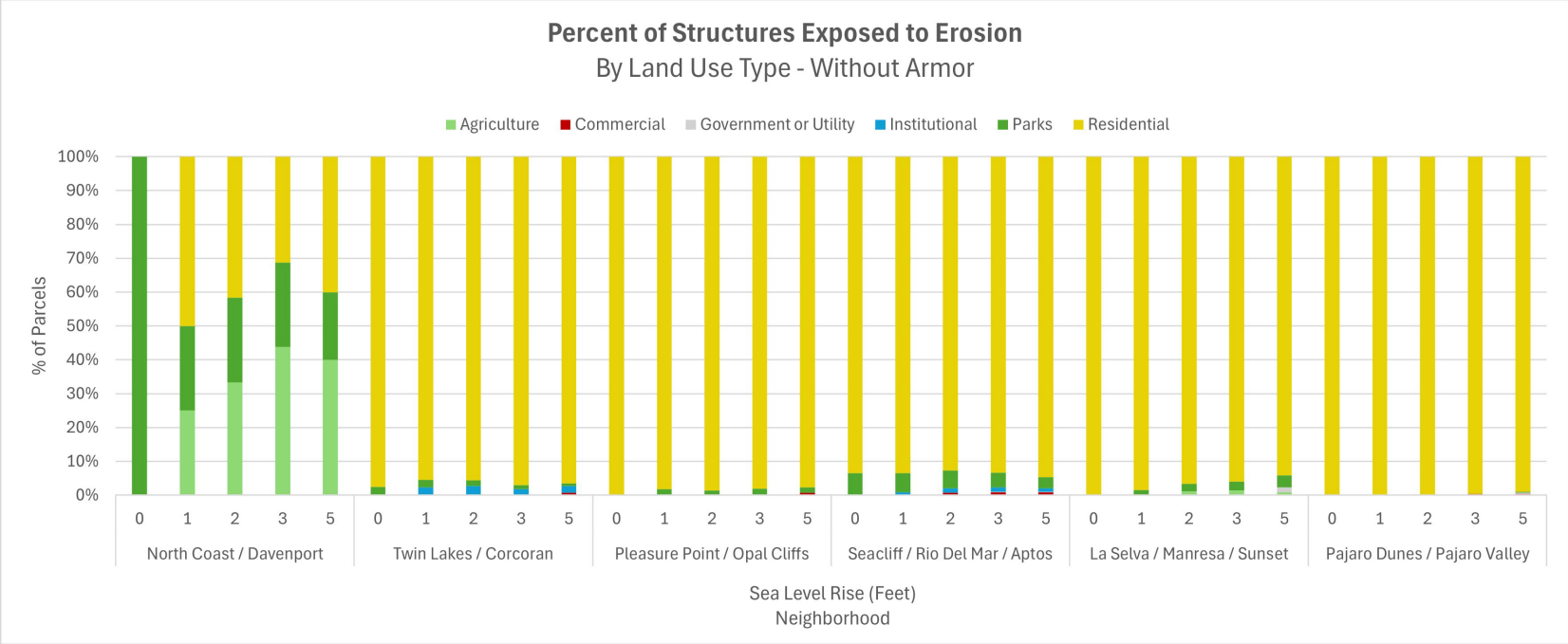


Figure 3-108. Structures Exposed to Coastal Erosion by Land Use Type, Without Armoring, by Neighborhood and SLR Scenario

3.7.1.2 Land Area Exposure

Land Area Exposed to Erosion

Currently, with armoring in place, 490 total acres of property is exposed to coastal erosion. The majority (81%) of this acreage is in the largely undeveloped North and South Coast areas and largely consists of state park land and agricultural lands (Figure 3-109). However, the La Selva / Manresa / Sunset neighborhood has many large rural residential parcels, which also contribute to the exposed parcel area. The rural North and South Coast areas have the greatest number of acres exposed to coastal erosion, but these areas make up a small fraction of the exposed residential acreage and acreage value at risk to coastal erosion (Figure 3-110 and Figure 3-111), given lower values per square foot.

By 2 ft of SLR, with armoring in place, 652 acres is exposed, 12% of which is residential. If coastal armoring is not in place, 1,091 residential properties covering 201 acres are exposed to coastal erosion. Without armoring in place, the most at-risk neighborhood is the Seacliff / Rio del Mar / Aptos neighborhood, representing 45% of the exposed properties and accounting for 191 acres (Figure 3-110 and Figure 3-111).

By 5 ft of SLR, assuming armoring is no longer in place, 1,872 residential properties covering 404 acres are vulnerable to coastal erosion. The most at-risk neighborhood is the Seacliff / Rio del Mar / Aptos neighborhood by value, representing 48% of the exposed properties and 20% of exposed acres (Figure 3-110 and Figure 3-111).

Land Value Exposed to Erosion

Currently, with current armoring in place, $196M in property is exposed to coastal erosion (Figure 3-111). In the near term, the greatest concentration of property value at risk to coastal erosion is in the La Selva / Manresa / Sunset neighborhood. This is due to the high number of rural residential properties that are on average less armored than parcels in more urbanized neighborhoods. Without armoring , Seacliff / Rio del Mar / Aptos has the highest concentration of property value at risk to coastal erosion, at $798M (Figure 3-111).

By 2 ft of SLR, the same pattern between armored and unarmored neighborhoods described above applies. In the armored scenario, La Selva / Manresa / Sunset has the most exposed value at $165M, or 48% of the county total exposed value (Figure 3-111). Without armoring in place, the Seacliff / Rio del Mar / Aptos neighborhood has the highest concentration of property value and represents 54% and of the exposed land value in the county at $1.12B (Figure 3-111). By 2 ft of SLR, assuming armoring in place, a total of $346M in property is exposed to erosion. Without armoring in place, $2.07B in property is exposed to erosion.

By 5 ft SLR, the Seacliff / Rio del Mar / Aptos neighborhood has $1.72B in exposed property value and will maintain the highest share of exposed value representing 52% of the county's

exposed land value. Overall, the County will experience a cumulative exposed value of $3.3B, the majority of which is from residential parcels.

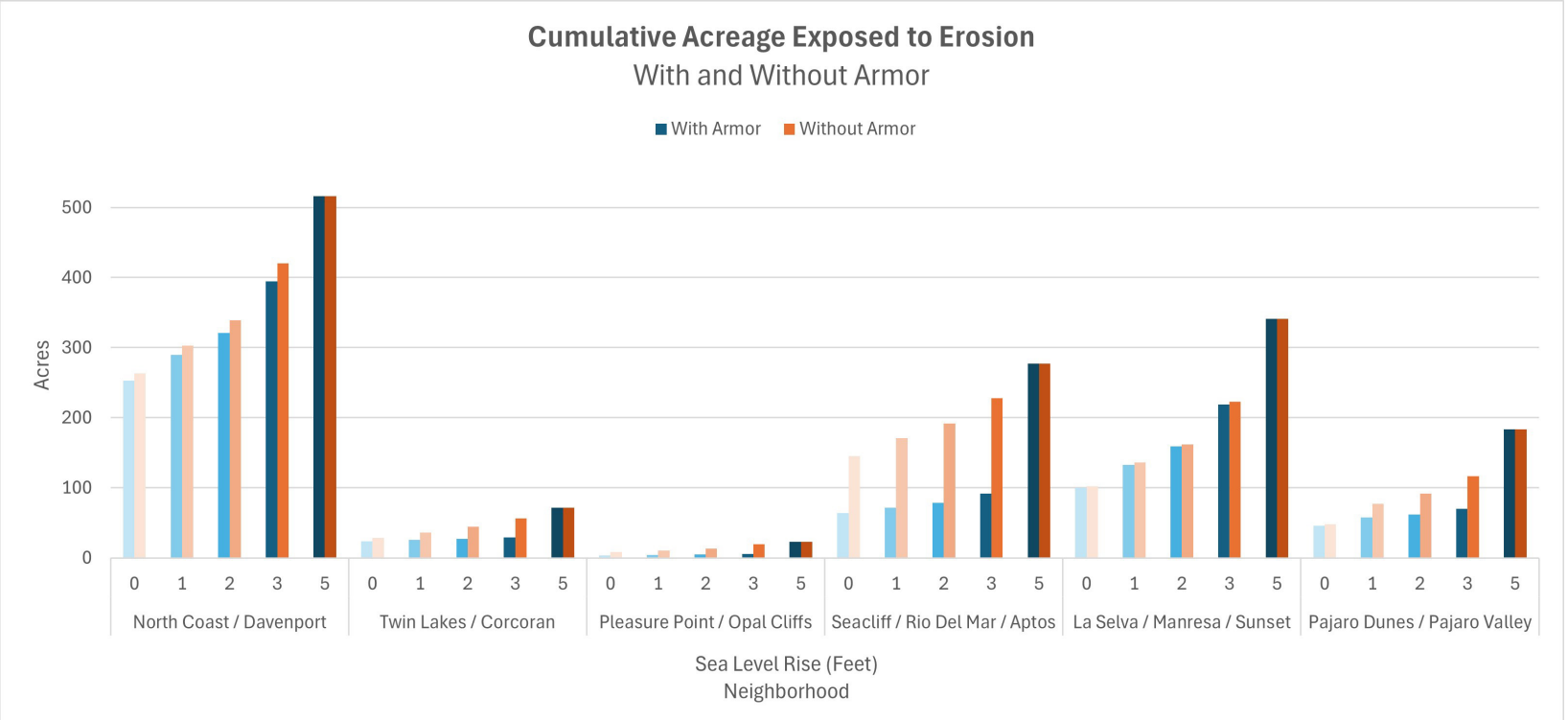


Figure 3-109. Cumulative Acreage Exposed to Erosion, With and Without Armor, by Neighborhood and SLR Scenario

A no-coastal-armoring assumption was made for 5 ft of SLR.

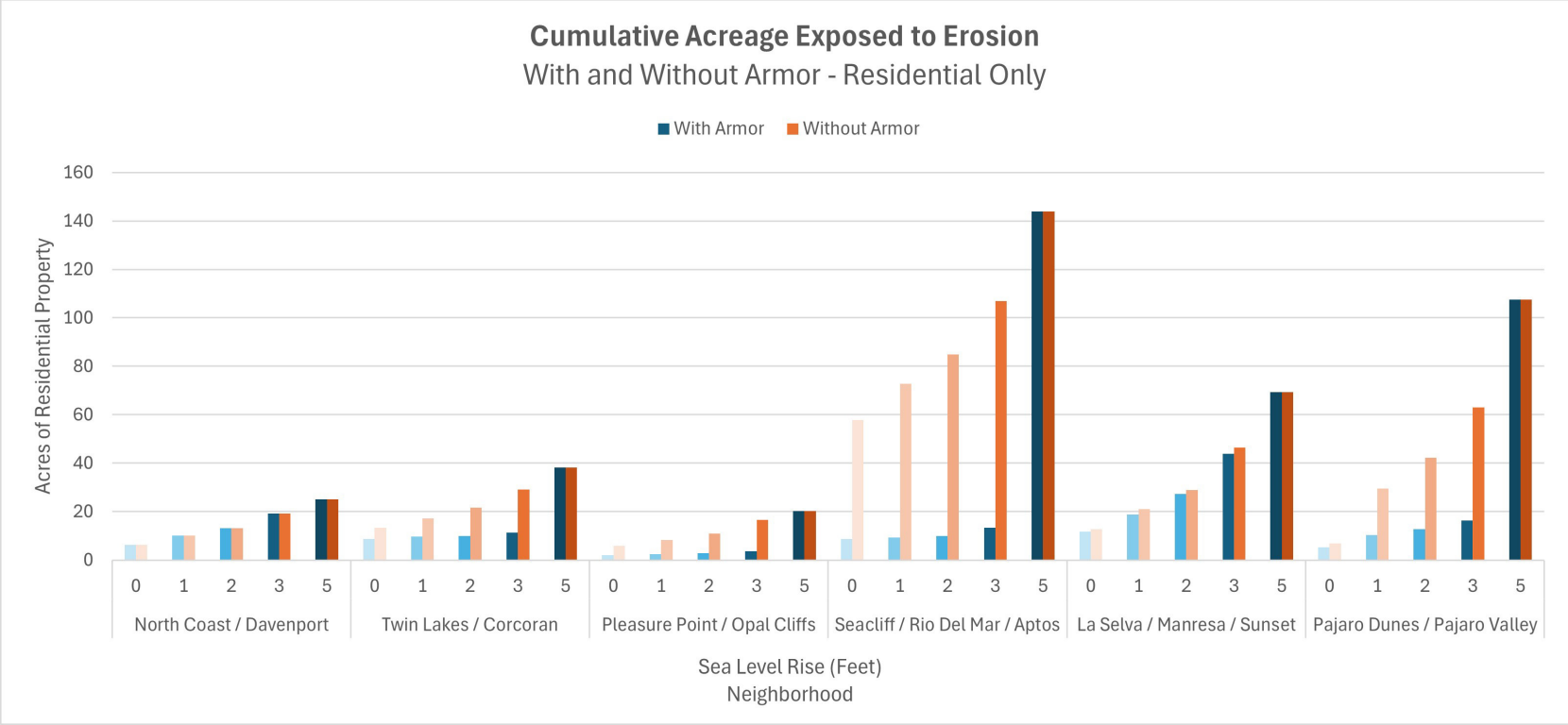


Figure 3-110. Cumulative Residential Acreage Exposed to Erosion, Without and Without Armor, by Neighborhood and SLR Scenario

A no-coastal-armoring assumption was made for 5 ft of SLR.

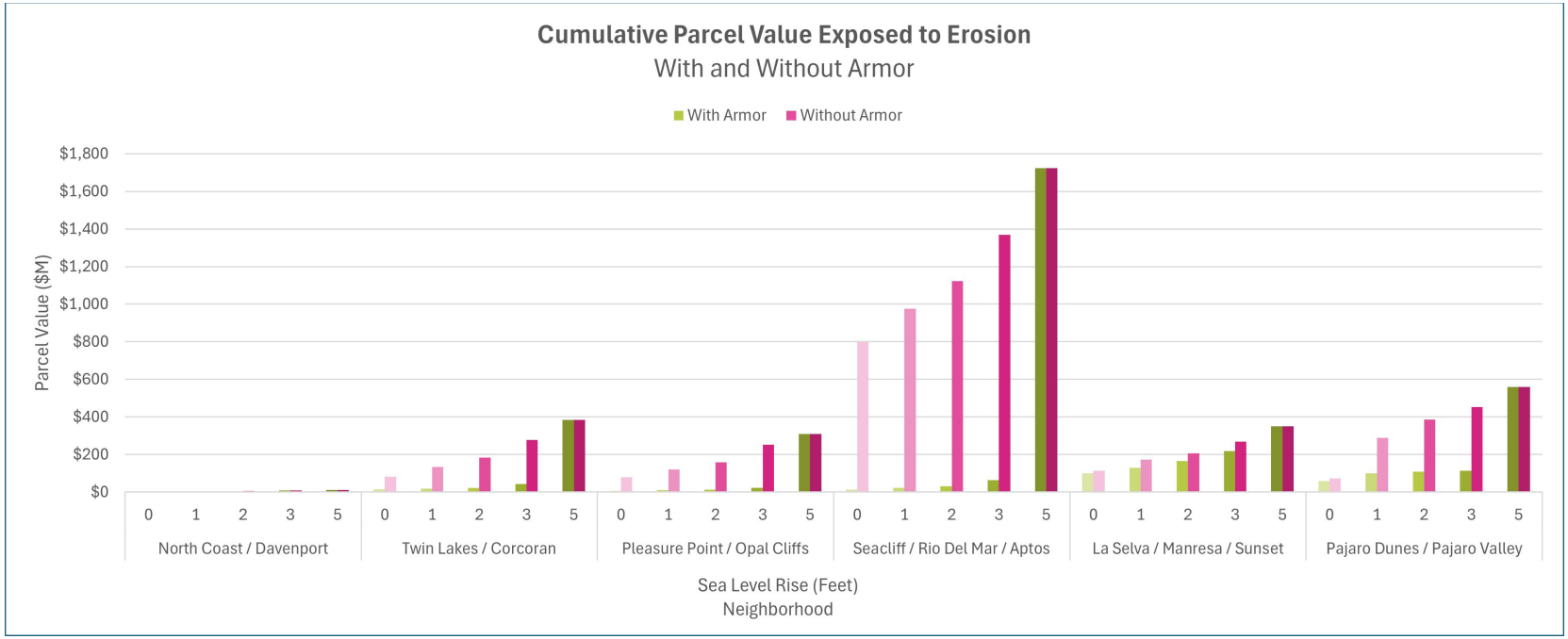


Figure 3-111. Cumulative Value of Parcel Exposed to Coastal Erosion, With and Without Armoring

This includes just the value of the land. All values are in 2024 dollars.

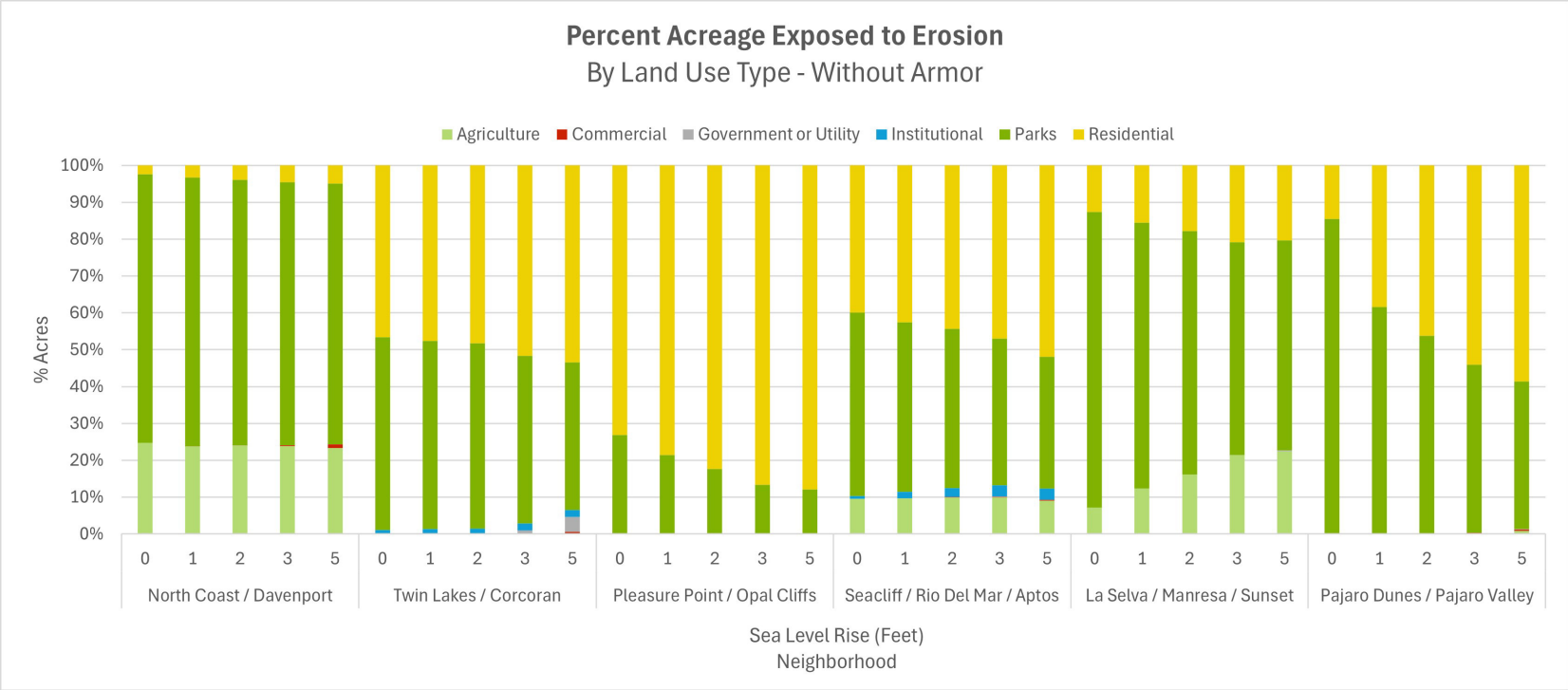


Figure 3-112. Acreage Exposed to Erosion by Land Use Type, Without Armor, by Neighborhood and SLR Scenario

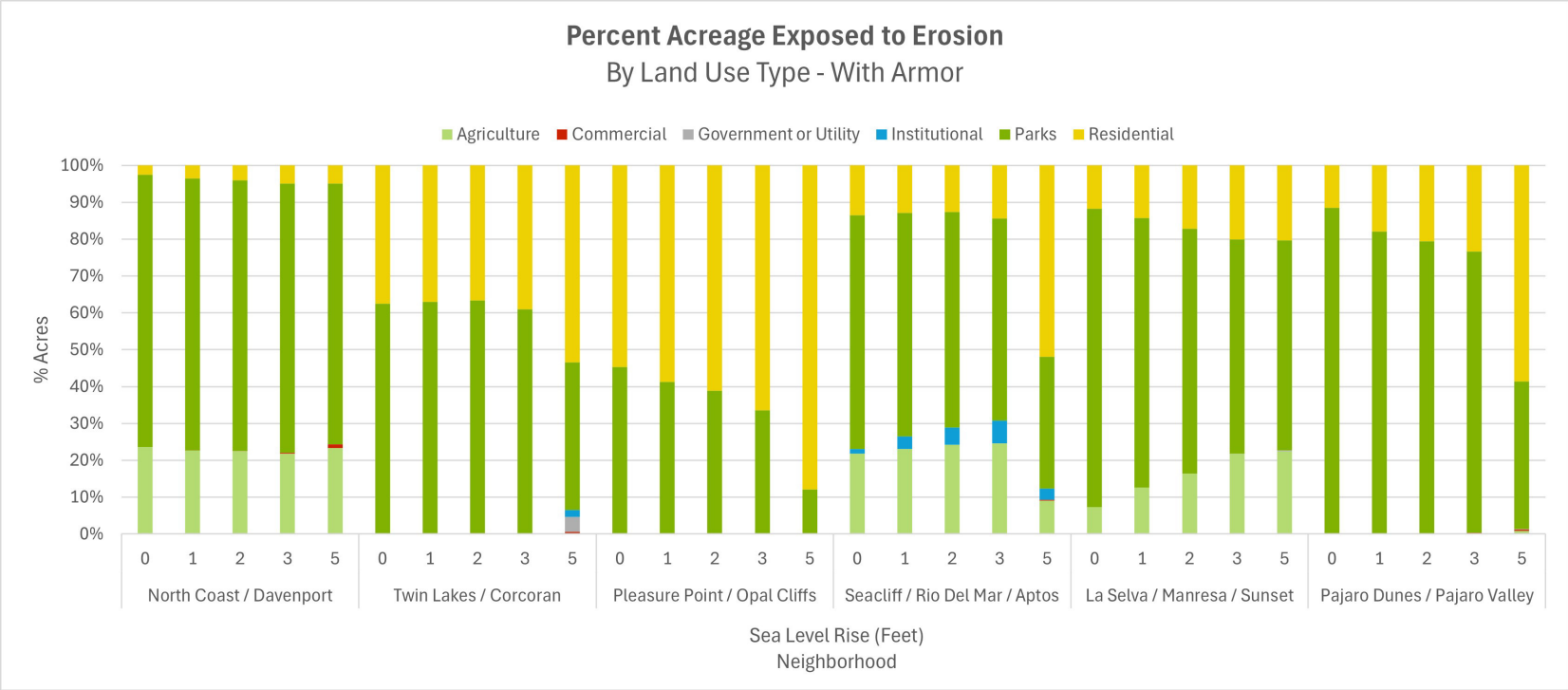


Figure 3-113. Acreage Exposed to Erosion by Land Use Type, With Armor, by Neighborhood and SLR Scenario

3.7.1.3 Combined Structure and Land Value Exposed to Erosion

Combining the structure- and land-value exposure provides perspective on the total financial exposure that the County and its constituents face. Table 3-16 is a summation of this anticipated cumulative exposure by SLR horizon.

Table 3-16. Cumulative combined land and structure value exposure by SLR

SLR (ft)	With Armor	Without Armor
0	$291,974,549	$1,637,941,437
1	$456,887,137	$2,551,007,691
2	$558,701,864	$3,101,206,470
3	$797,845,232	$3,983,199,110
5	--[a]	$5,058,178,910

[a] Armoring assumed to be no longer in place at 5 ft of SLR.

By neighborhood, the distribution of value behaves mostly in accordance with the parcel value analysis. In particular, the North Coast / Davenport neighborhood continues to be a small proportion of overall value exposure despite its larger land holdings in exposed areas. This is due to most of North Coast / Davenport's land use being agricultural, which has lower land value in this analysis, and open space or parkland, for which market values are not available. Meanwhile, Seacliff / Rio del Mar / Aptos is noticeable for its substantial financial exposure while the rest of the neighborhoods are within the general range of $500M by of 5 ft of SLR. Figure 3-114, below, illustrates these points.

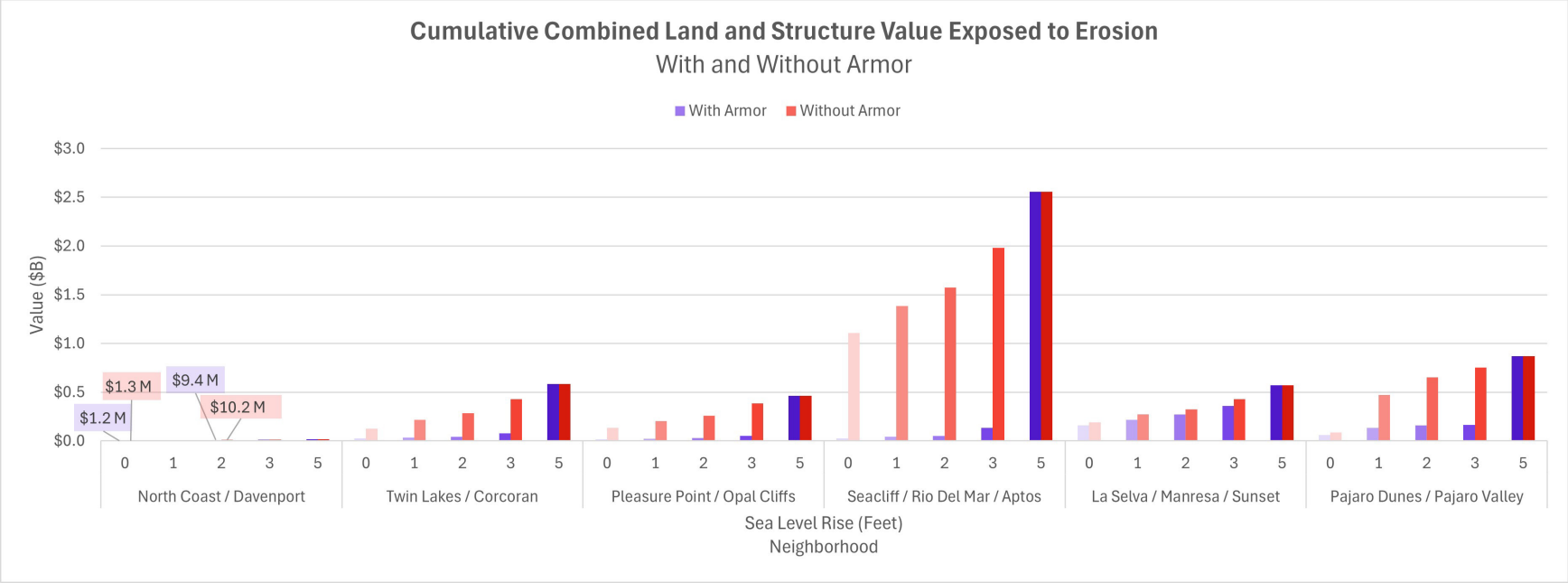


Figure 3-114. Cumulative Combined Land and Structure Value Exposed to Erosion

3.7.1.4 Wastewater, Stormwater, and Water Supply

Assuming coastal armoring is in place through 3 ft of SLR, erosion exposure of wastewater, stormwater, and water supply lines remains relatively limited, with only a few miles of infrastructure affected in each category. This reflects the fact that much of this infrastructure is located within developed coastal areas that are currently armored.

By 5 ft of SLR, assuming existing armoring is no longer in place, erosion exposure increases sharply, with more than 15 miles of both wastewater and water supply lines and nearly 10 miles of stormwater lines exposed (Figure 3-115).

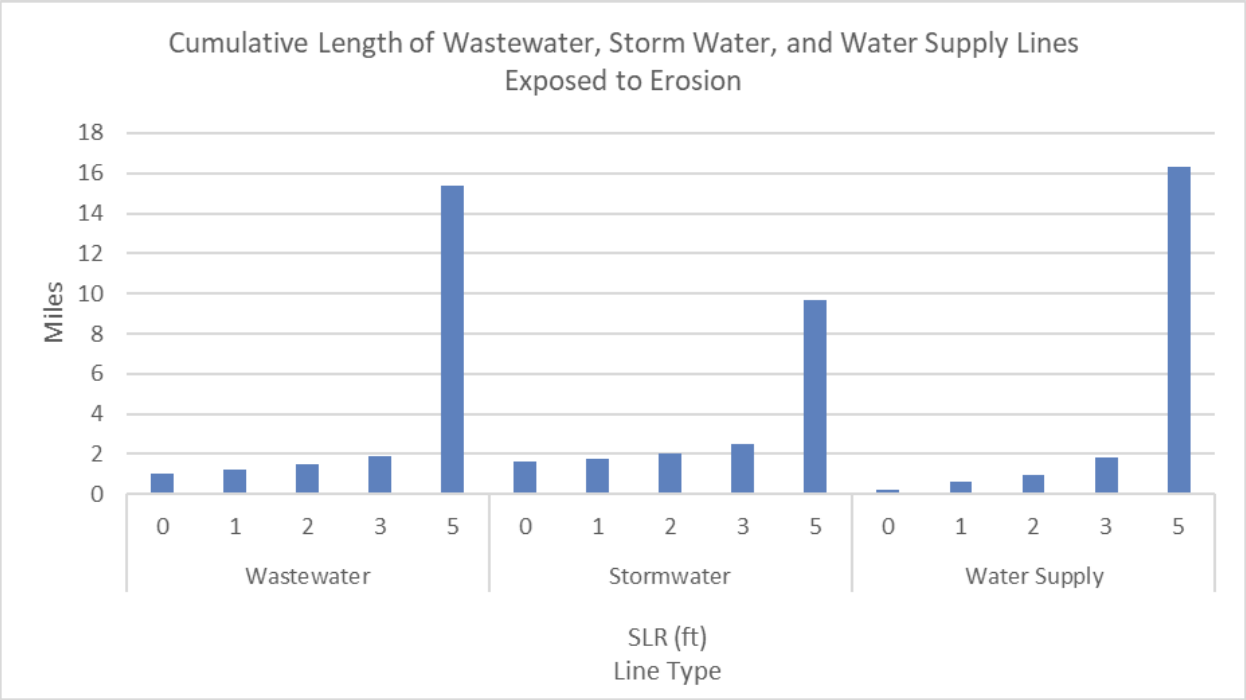


Figure 3-115. Cumulative Length of Wastewater, Stormwater, and Water Supply Lines Exposed to Erosion, Assuming Armoring Is in Place through 3 ft of SLR

Under **current conditions** through **2 ft of SLR**, assuming armoring is in place, exposure of wastewater pump stations is driven primarily by storm wave flooding, while coastal erosion exposure remains limited. This reflects the fact that many pump stations are in low-lying areas but are currently armored (Figure 3-116). **By 3 ft of SLR**, coastal erosion exposure increases, exposing two additional pump stations for a total of three. **By 5 ft of SLR**, assuming armoring is no longer in place, coastal erosion exposure increases sharply to a total of 14 pump stations, and storm wave exposure exposes 6 pump stations (Figure 3-116).

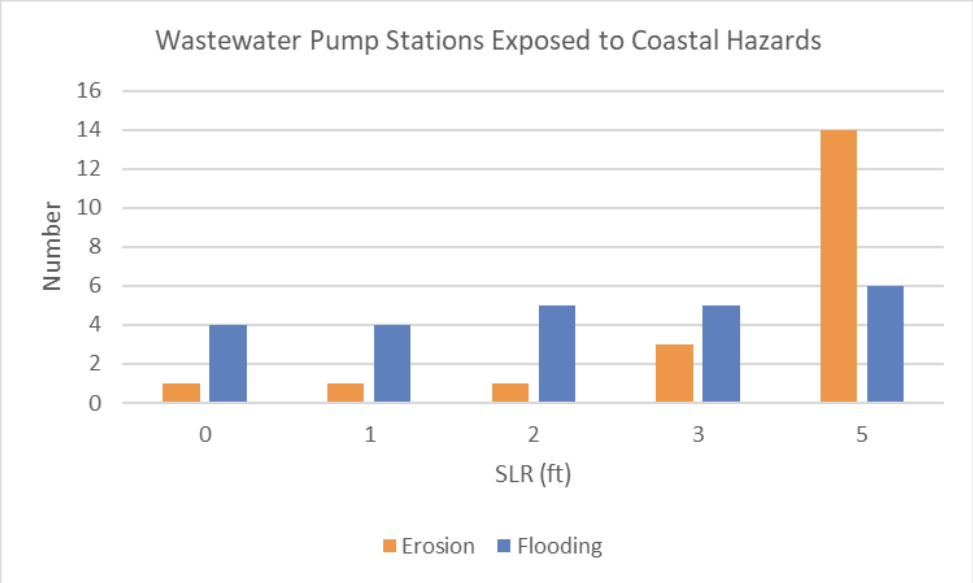


Figure 3-116. Wastewater Pump Station Exposed to Coastal Hazards by SLR Horizons, Assuming Armoring Is in Place through 3 ft of SLR

3.7.2 Roads and Rail

The key transportation infrastructure at risk includes East Cliff Drive, Highway 1, and the Santa Cruz Branch rail line.

Currently, assuming armoring is in place, coastal storm wave flooding is a major hazard of concern, with several miles of roadway exposed in low-lying coastal neighborhoods including East Cliff Drive in Twin Lakes / Corcoran, Highway 1 at Scott Creek, and Waddell Creek in North Coast / Davenport, and local roads in Seacliff / Rio del Mar / Aptos and Pajaro Dunes / Pajaro Valley. This local road exposure is concentrated in low-lying neighborhoods such as the Pajaro Dunes and Lower Pajaro Valley and the Rio del Mar Flats. Exposure of the rail line is limited to short segments, with exposure to flooding in the Lower Pajaro Valley near Harkins Slough, and the only coastal erosion-related exposure located at La Selva Beach (Figure 3-117).

By 2 ft of SLR, assuming armoring is in place, roadway exposure to coastal hazards increases steadily, with flooding remaining the dominant hazard. Coastal erosion-related road exposure remains lower but begins to increase in cliff-backed areas of coastline of the North Coast. Rail exposure also increases modestly, primarily due to flooding in low-lying segments in the Pajaro Valley, and at multiple short segments just south of Davenport including at Davenport Beach, Shark Fin Cove, Bonny Doon Beach, and Panther Beach (Figure 3-117).

By 5 ft of SLR, assuming armoring is no longer in place, roadway exposure to coastal hazards increases substantially, with approximately 18 miles of road exposed to coastal erosion, exceeding the roughly 16 miles exposed to flooding. This includes extensive

segments of East Cliff Drive, Highway 1 near the county line, and many low-lying and cliff-top residential roads in Seacliff / Rio del Mar / Aptos. The same segments of rail continue to be exposed to coastal hazards, with just less than 2 miles of rail exposed to either hazard by 5 ft of SLR (Figure 3-117).

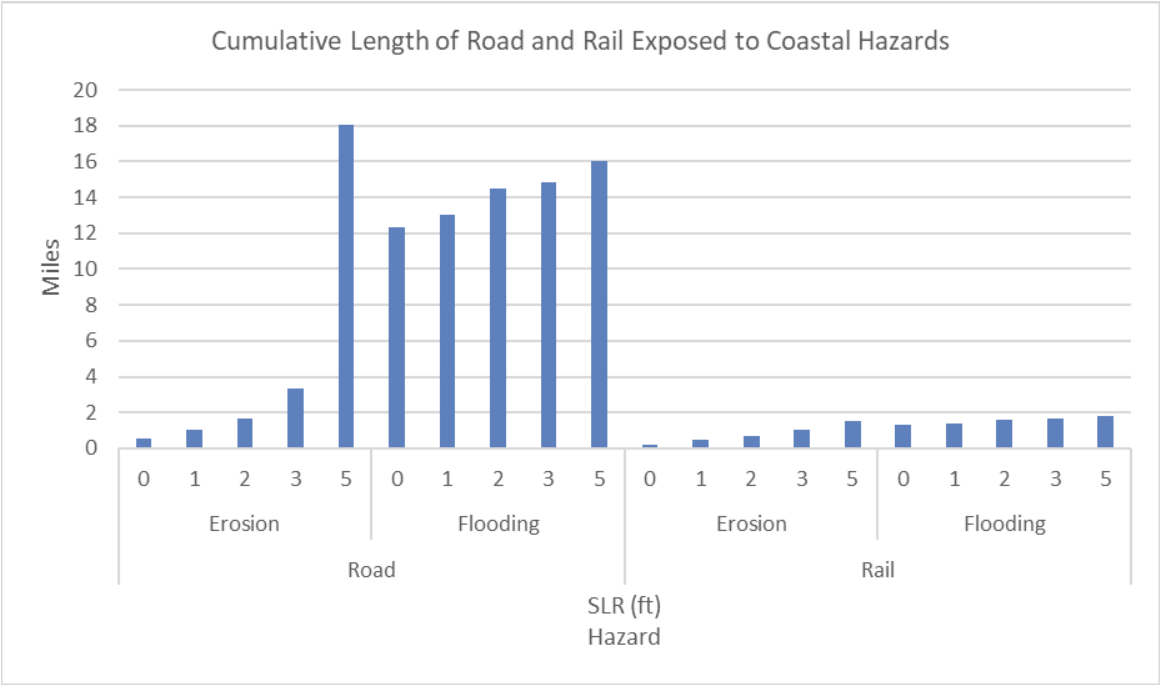


Figure 3-117. Cumulative Miles of Road and Rail Exposed to Coastal Climate Change Hazards at Each SLR Horizon

A no-coastal-armoring assumption was made for 5 ft of SLR.

3.7.3 County Property Tax Implications

With the assumptions outlined in the "Tax Revenue Loss Calculation" section of Appendix D, the County is predicted to experience substantial tax losses. Table 3-17 outlines the cumulative tax losses by SLR horizon and by armoring scenario. Note that property tax revenue is split between the county government, cities, school districts and special districts for services like water and fire protection, with nearly 14% appropriated for County Government (Santa Cruz Local 2025).

Figures presented in this section are conservative, as they are based on the assumption of an average increase of only 2% in taxable values per year as per allowances under Proposition 13, and do not account for substantial increases in assessed value that may occur when a property is substantially altered or sold, resetting the base year for tax assessment purposes. Annual increases in the tax roll in Santa Cruz County have historically exceeded 2% due to new construction and reassessments, with growth of 4.4% in 2023–2024 and 5.95% in 2024–2025. In the absence of information about

expected growth within and outside the coastal hazard zones, the projected losses in tax revenue below should be considered lower-bound estimates.

Table 3-17. Projected tax revenue loss by SLR with and without armor

SLR (ft)	With Armor	Without Armor
0 (2020–2039)	$12,100,000	$82,000,000
1 (2040–2049)	$41,700,000	$282,200,000
2 (2050–2079)	$234,600,000	$1,637,500,000
3 (2080–2099)	$498,900,000	$3,395,100,000
5 (2100–2119)	$1,889,300,000	$6,660,700,000

As this analysis explores a 100-yr timeframe, the annual losses average out to be $18.8M for armored and $66.6M for the unarmored scenarios. By 5 ft of SLR, this equates to a difference of $4.77B over 100 years. In fiscal year 2025, the County collected $137M in property taxes (Santa Cruz County 2025). Collections from 2025 alone cover the tax losses that are projected to occur over the entirety of the first 20-year period almost 12 times over; put another way, tax losses for the SLR 0 period are about 9% of 2025-only collections. In this vein, it is essential that the County compare these projected losses as a percentage of projected future collections to put them in perspective. Table 3-18 describes the projected countywide tax revenue loss alongside the cumulative erosion used in each SLR period and price per square foot. Erosion levels used to assess revenue losses (cumulatively shown in bars by SLR) were updated on a decadal basis to reflect the county assessor's perspective of eroded area as compared to the county's original parcel outlay. Table 3-18 outlines the other major parameter assumptions.

Table 3-18. Parameters used in tax revenue loss calculations

Parameter	Value	Description
Tax rate	1.26%	Proposition 13 rate (1%) plus average voter-approved measures from Ownwell.[19]
Annual property value adjustment	2%	Proposition 13[20] allows the evaluated property to increase at a maximum of 2% year over year. It is assumed the County makes the maximum adjustment each year.
Start year	0	Value adjustments begin on this year
End year	100	Year by which 5 ft of SLR occurs
Erosion assessment frequency	10 years	Property reassessment occurs after a transfer of ownership or a large renovation. Data from the most

[19] https://www.ownwell.com/trends/california/santa-cruz-county
[20] https://www.santacruzcountyca.gov/tax/assrpam.htm

	recent U.S. Census Bureau American Housing Survey[21] for California reports a median home tenure of 10 years. The area of the parcel is assessed at this frequency.

Table 3-18 parameters were used in deriving the lost tax revenues displayed in Figure 3-118, below. Overall, the unarmored scenario is much higher than the unarmored, particularly in the last SLR horizon. This is because by 5 ft of SLR, extensive coastal erosion is assumed, and it is coupled with the highest exponential net taxable value (as is seen in the upward curve of the per square foot taxable parcel value). This creates a larger jump between 3 and 5 ft of SLR than is seen with the other timeframes in the analyses.

[21] https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=00006&s_year=2023&s_tablename=TABLE8A&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup2=1

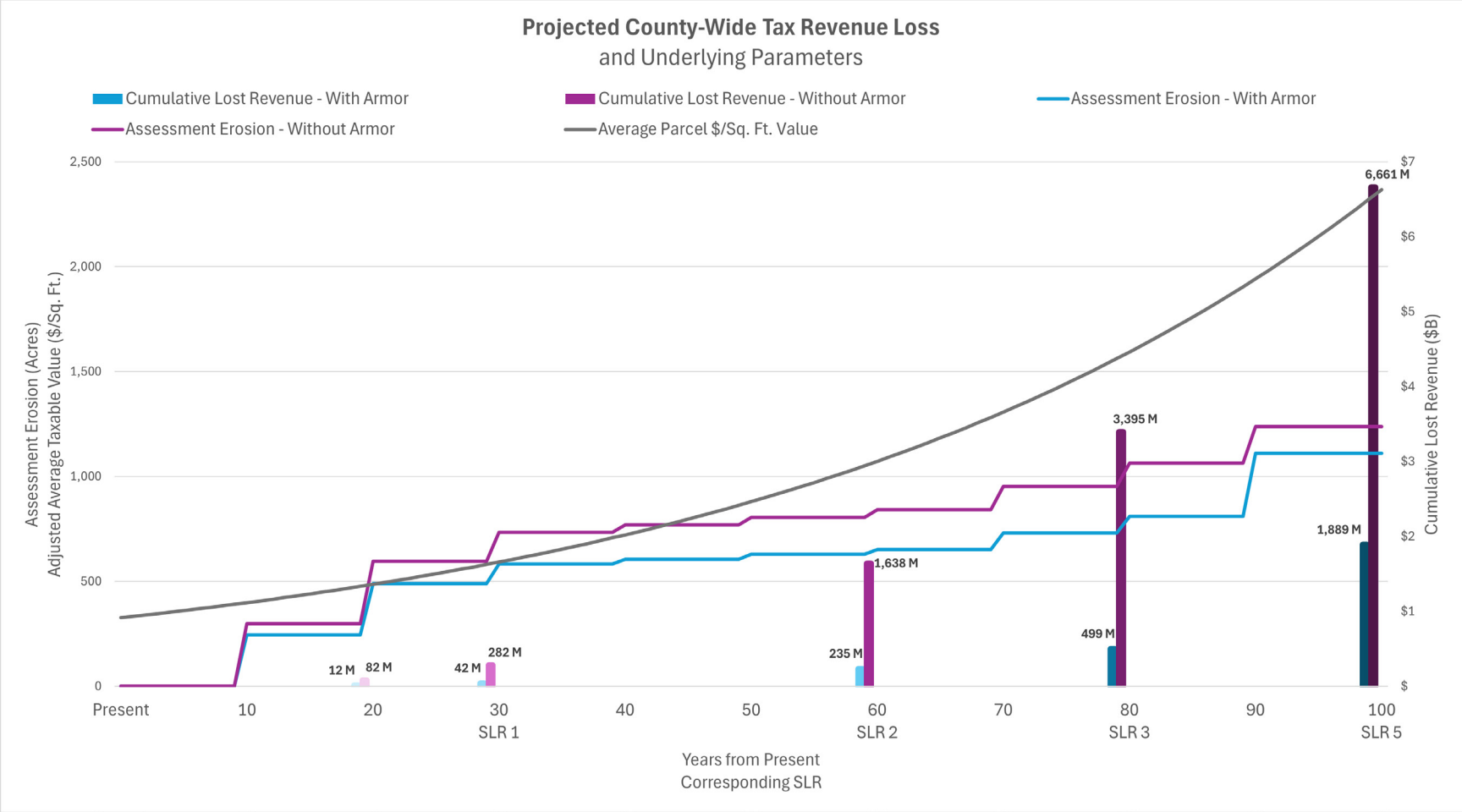


Figure 3-118. Projected Countywide Tax Revenue Loss (bars are cumulative revenue loss by SLR horizon).

County-wide tax revenue is reported in billions of dollars

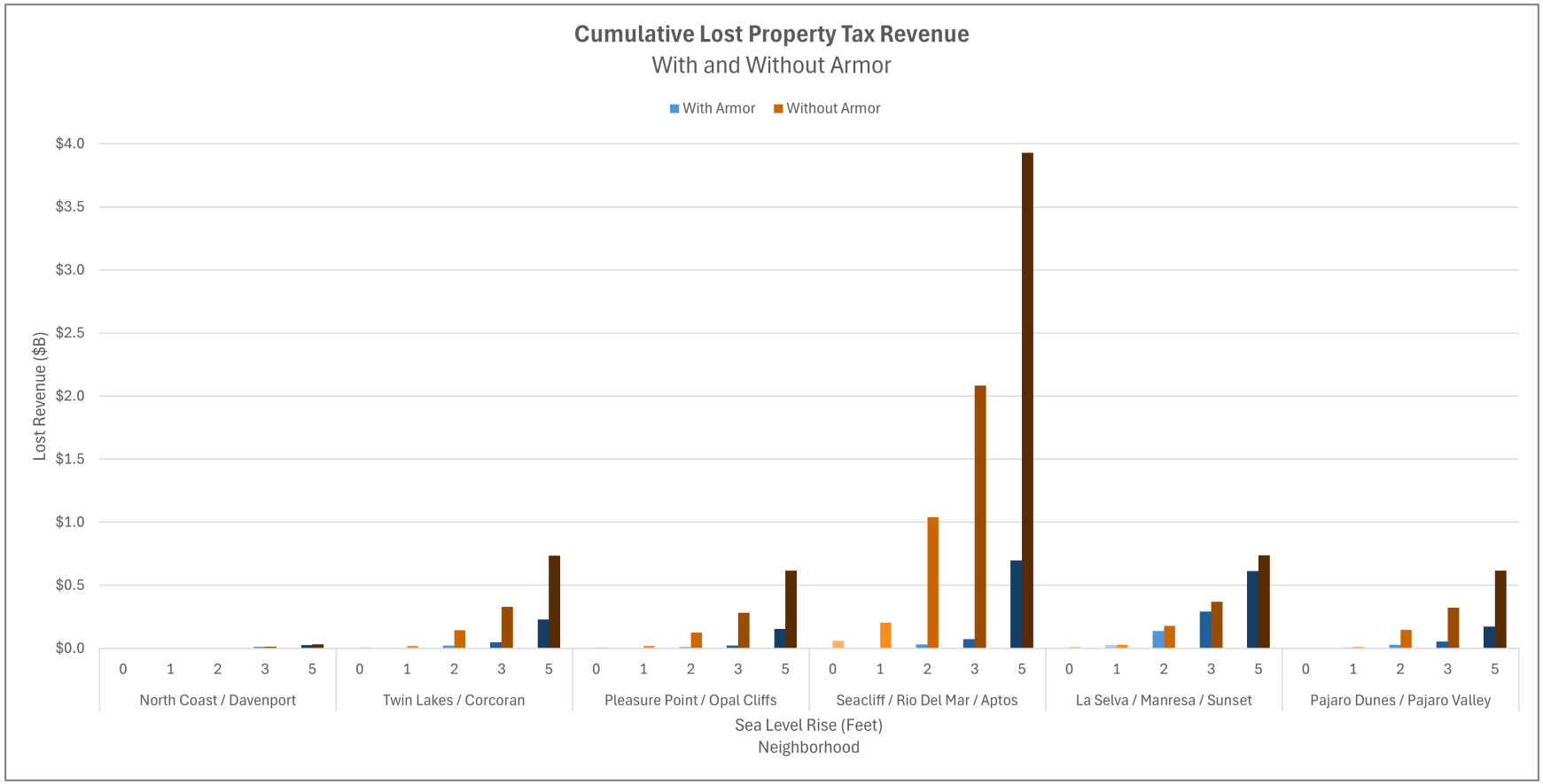


Figure 3-119. Cumulative Lost Property Tax Revenue, With and Without Armor, in Billions of Dollars

When subset into neighborhoods, the lost revenues behave similarly to the other analyses by neighborhood. With armoring, losses are greatest in La Selva / Manresa / Sunset generally. Without armoring Seacliff / Rio del Mar / Aptos bears the highest loss.

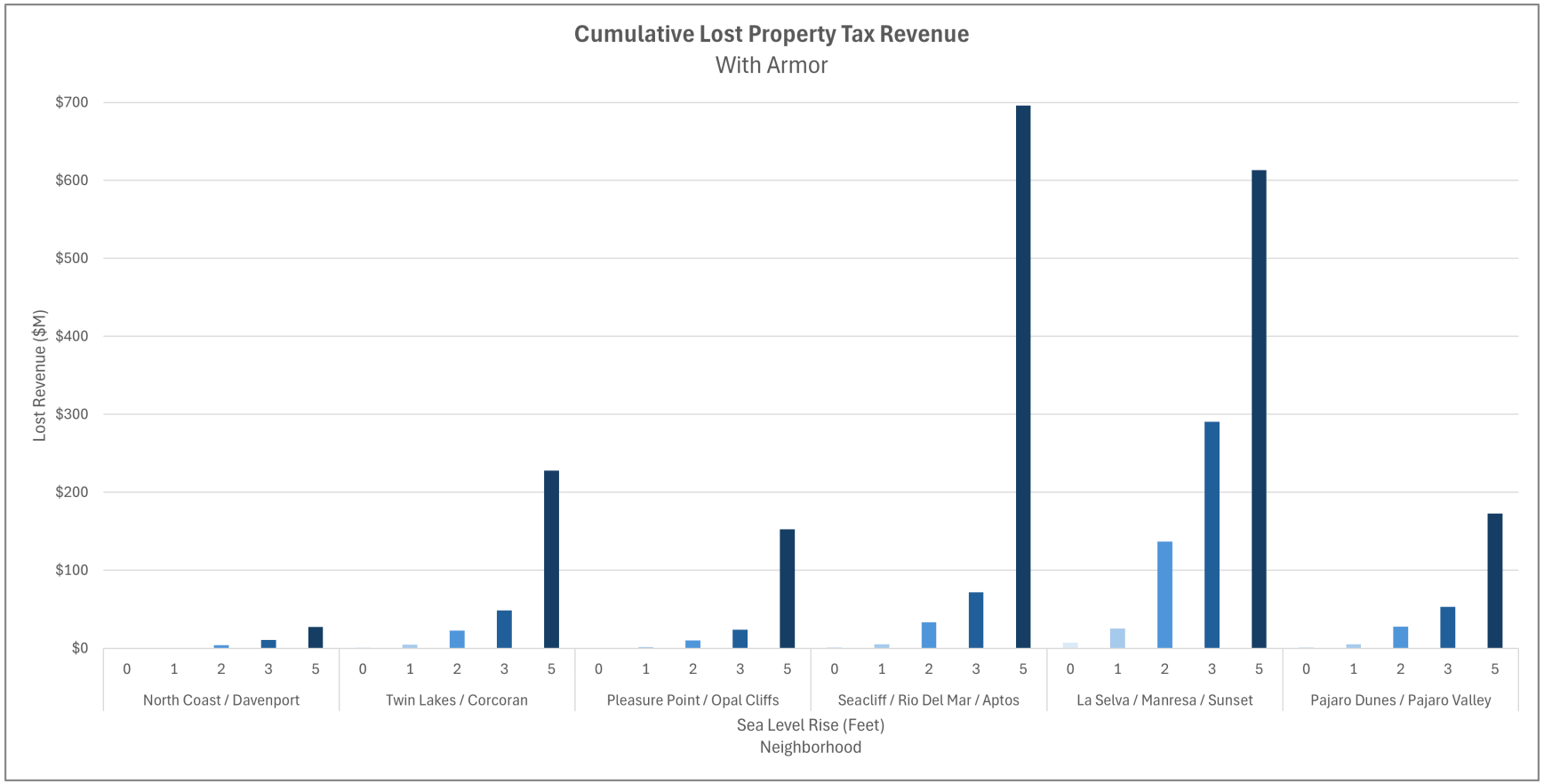


Figure 3-120. Cumulative Lost Property Tax Revenue With Armor, in Millions of Dollars; note the axis change.

3.7.4 Recreation and Cultural Resources

Santa Cruz County's coastal recreation opportunities attract hundreds of thousands of visits each year by locals and visitors alike. There were more than 900,000 beach visits to the unincorporated County's beaches in 2024, and hundreds of thousands more frequented other areas of the coast including trails along the cliff-back coast and around the county's coastal lagoons. Surfers also make a significant recreation group, with approximately 390,000 annual visits to the surf spot locations in Twin Lakes / Corcoran and Pleasure Point / Opal Cliffs neighborhoods. If accounting for surfers in the North Coast / Davenport neighborhood, total yearly visits would be around 500,000 (placer.ai 2024).

The most frequented beaches in the unincorporated County include Twin Lakes State Beach and Seacliff State Beach. Both areas of Twin Lakes State Beach (Schwan and Blacks) attracted nearly 200,000 beach visits in 2024, and Seacliff State Beach from Las Olas to Platform Beach attracted over 230,000 beach visits in 2024 (placer.ai 2024).

The projected changes in beach widths due to SLR will have a substantial impact on visitation and the enjoyment of these beaches in the future. By **2 ft of SLR**, assuming beach development and coastal armoring remains in place, many of the county's most popular beaches will no longer retain dry sand in the summer, and by **3 ft of SLR**, all the most popular beaches will be inundated. Currently, the county's armored beaches are on average 175 ft narrower than the unarmored beaches (Figure 3-121), and beyond 3 ft of SLR, assuming the backshore remains fixed, only the unarmored beaches will retain a dry sand beach.

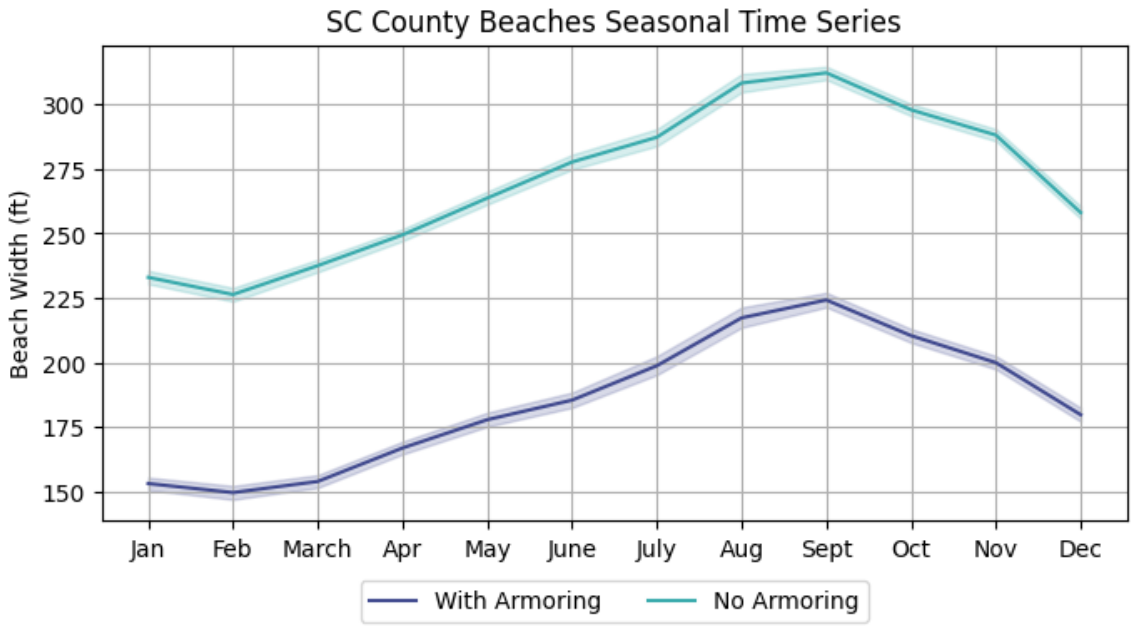


Figure 3-121. Average Seasonal Width of all Unincorporated Santa Cruz County's Beaches (1984–2024) Comparing Beaches Backed by Coastal Armoring and Beaches Without Armoring

Across the unincorporated County coastline, 21% of the coast is armored. So long as coastal armor remains, beaches will be lost and coastal access will be compromised. In the mid-term horizon (1–3 ft of SLR), the maintenance requirements for these structures will increase substantially. In addition, pressures on this armoring, including beach scouring, increased wave loads, and erosion flanking from nearby unarmored properties, mean that properties will not be able to armor their way into the future. As a result, approaching adaptation must take a holistic and neighborhood approach that balances the range of public trust resources that benefit its residents and visitors alike.

It is unrealistic from a public trust perspective (and also undesirable), to expect that up to 12 linear miles of new or replaced coastal armor will be constructed on the shoreline over the next few decades. It is in the entire community's interest to develop policies that balance the community's desire to protect public coastal resources with their individual property concerns such as maintaining coastal armoring and impending construction costs. The next phase of this study will address just that and develop a set of neighborhood-scale adaptation pathways to help direct policy development.

3.7.5 Countywide Risk Summary

Countywide: Near Term (0–1 ft of SLR). By 1 ft of SLR:



903 structures are within a 100-yr storm flood hazard area, and potential damages to structures due to flooding over a 20-yr window range from a middle estimate of $24M to $100M (with a middle estimate of $64M), to a high estimate of $100M to $155M.

The most flood-prone concentration of structures are in the Seacliff / Rio del Mar / Aptos neighborhood with 449 structures located within the 100-yr flood hazard area, followed by the Pajaro Dunes / Pajaro Valley neighborhood with 293 exposed structures. Some of the most vulnerable communities to flooding include Rio Del Mar Flats, Potbelly and Las Olas Dr, Moran Lake, and Pajaro Dunes and Pajaro Valley.

With SLR, many low-lying agricultural fields within the Pajaro Valley will become poor performing. There are currently plans for the purchase and restoration of these fields

Many critical facilities and infrastructure that support coastal development are located at lower elevations and are projected to experience disruptions. This includes critical roadways such as East Cliff Dr, multiple wastewater pump stations, and other critical utilities including electrical transformers, and water and wastewater lines.



Tidal inundation and coastal wave flooding will create disruptions near the bridges over Scott and Waddell creeks, low-lying segments of East Cliff Drive at Schwan, Corcoran, and Moran lagoons, coastal roadways including Potbelly Beach Road, Las Olas Drive, State Park Drive, Rio del Mar Esplanade, and Beach Drive, and the critical coastal access roads for the Pajaro Dunes. These hazards will inhibit traffic flow, block access, and endanger road users and pedestrians.



The wastewater force main beneath East Cliff Drive near Schwan Lagoon and wastewater pipes near Corcoran Lagoon and Moran Lake are vulnerable to flooding.

Numerous wastewater pump stations are exposed to wave-driven flooding during high tides and storms and coastal erosion including Potbelly, A1, Aptos Esplanade, Rio del Mar SB Bathroom, A3, 300 Oceanview Drive (Place de Mer).

The Watsonville Slough pump along Shell Road already experiences flooding during high tides and storms and may become overworked with SLR, increasing inland flooding risk.



Across the County, winter beach widths are reduced by approximately half, from 207 to 110 ft, while summer beach widths remain wider but are still reduced, from 283 to 183 ft. Already narrow beaches will drown including 26th Ave, Pleasure Point, and the western end of Seacliff.

Several surf spots will rarely function including The Harbor, Black's Beach, Sunny Cove, Drainpipes, Murph Bar, and Jack's.



Coastal lagoons will see greater wave overtopping and tidal exchange, leading to a change in salinity with potential effects to habitats and species.

Wetland resources in the lower Pajaro Valley will be vulnerable to saltwater intrusion. Flooding of marsh areas of the lagoon in the spring and summer could adversely affect nesting and foraging waterfowl.

Dune habitats experience increased erosion and storm disturbance, with localized loss of vegetation and reduced habitat stability

Countywide: Mid Term (1–3 ft of SLR). By 3 ft of SLR:



993 structures are exposed to a 100-yr storm, and assuming all existing structures remain in place, potential cumulative damages by this time period due to flooding range from a middle estimate of $216M to $676M (with a middle estimate of $502M), to a high estimate or $676M to $910M.

In Seacliff / Rio del Mar, Aptos and the Pajaro Dunes, many beaches will narrow and disappear in the winter. This will increase the maintenance requirements of coastal armoring. If these requirements are not met, armoring may no longer be effective. In both of these communities, repeated flood exposure may mean many locations are not viable to rebuild at.

High tide flooding will transition from nuisance flooding to chronic flooding in Rio del Mar Flats and low-lying areas in the Pajaro Dunes.



Cliff erosion hazards threaten segments of Highway 1 where the alignment is close to the cliff, including just north and south of Greyhound Rock County Park, at China Ladder and Cliffs Beach, and South of Davenport near Rodini Farms.

East Cliff Drive will continue to be exposed to chronic flooding, coastal storm wave overtopping, and exposure to beach scour and dune erosion. This could lead to pavement washouts and erosion of underlying materials.

Portola Drive at Corcoran Lagoon and Rodeo Creek Gulch may experience flooding during large storm events.

All low-lying coastal access roads in Seacliff / Rio del Mar / Aptos are exposed to storm wave overtopping and flooding.

The Santa Cruz Branch Rail Line, which runs close to Manresa Beach, is vulnerable to coastal erosion.

Access to the Pajaro Dunes along W. Beach Road, Shell Drive, and River Road (Rio Boca Road) will be increasingly disrupted by tidal flooding.



Low-lying utilities and infrastructure will experience maintenance and repair challenges due to higher groundwater levels and surface inundation. This includes the wastewater system, which could experience overflows and backflow, as well as reduced conveyance and increased pumping requirements.

Buried pipes in low-lying areas of Rio del Mar and the Pajaro Valley may experience increased buoyancy forces and deterioration of facility components.

At the Rio del Mar Flats, higher groundwater levels could result in more inflow and infiltration into the wastewater collection system, as well as corrosion issues to the electrical infrastructure.

Water mains along Las Olas Drive, Beach Drive, and other armored coastal corridors remain largely protected from erosion but are increasingly exposed to flooding.

Slough gate malfunction along the Watsonville Slough may increase significantly, which could have cascading impacts up and downstream of the gates.

Exposure of the Watsonville wastewater treatment plant to flooding could impact wastewater quality, treatment needs, and the recycled water program.



Across the County, winter beach will be reduced to an average width of 29 ft., and summer beach widths will be an average of 52 ft. Most beaches will be drown in the winter, except for beaches at coastal waterway outlets and beaches along the North Coast.

Most of the County's surf spots will rarely function except those near Pleasure Point.



Wave overtopping into the County's coastal lagoons will affect water quality and likely cause a significant change in habitats.

Portions of Sunset State Beach and Manresa State Beach will experience chronic loss of foredunes.

Wetland resources in the lower Pajaro Valley experience continued saltwater intrusion, leading to ongoing stress and shifts in wetland habitat conditions.

Countywide: Long Term (3–5 ft of SLR). By 5 ft of SLR:



1,129 structures are exposed to a 100-yr storm, and assuming all existing structures remain in place, potential cumulative damages due to flooding by this time period range from a middle estimate of $414M to $1.0B (with a middle estimate of $809M), to a high estimate or $1.0B to $1.38 B

More than half of all coastal structures, or ~1,200 structures, will be in a very high probability of impact to coastal hazards categories

1,892 structures, representing $1.7B in structural improvements, and 5.06B in cumulative land and structural value, are exposed to coastal erosion.

The most at-risk neighborhood is the Seacliff / Rio del Mar / Aptos neighborhood by value, representing 48% of the exposed properties and 20% of exposed acres in the County.

The Pajaro Dunes, which includes approximately 270 structures, is exposed to a combination of hazards including dune erosion, storm wave flooding, fluvial flooding, barrier beach lagoon flooding, rising tides, and rising groundwater levels, significantly threatening the viability of the community.

Large portions of the Lower Pajaro Valley, currently under agricultural production, will become a tidally influenced system.



Approximately 3 miles of Highway 1 is exposed to coastal erosion and wave hazards, with regular high-tide flooding near Waddell Creek. Cliff erosion increasingly threatens segments of Highway 1 near Greyhound Rock, China Ladder, Cliffs Beach, Scott Creek, and south of Davenport, while even armored sections near Año Nuevo and the county line face erosion that could impede access to San Mateo County.

East Cliff Drive through Twin Lakes will be subject to chronic inundation, with dune erosion exposing substantial portions of the roadway.

Cliff erosion threatens more than 1 mile of East Cliff Drive in Pleasure Point from 32nd Avenue to 41st Avenue.

In **Seacliff / Rio del Mar / Aptos**, erosion could extend into the cliff-top neighborhoods and expose roadways, including Seacliff Drive, Coates Drive, Kingsbury Drive, Seaview Drive, and Bay View Drive.

Access to Palm Beach State Beach via Beach Road and access to and from the Pajaro Dunes via Beach Road, Rio Boca Road, Shell Drive, and River Road may be permanently underwater, affecting both public recreation and residential access.



Co-located utilities along East Cliff Drive and Portola Avenue will become increasingly exposed to coastal hazards.

In **Seacliff / Rio del Mar / Aptos**, all back-beach utilities will experience exposure to wave runup, beach scour, and tidal inundation, and critical wastewater and water supply infrastructure faces a high risk of failure and service disruption.

Chronic flooding and elevated groundwater compromise slough gates and pump systems in the Pajaro Valley, resulting in persistent drainage failures and flooding, along with ongoing inflow, corrosion, and service disruption to wastewater and electrical infrastructure.



Across the County, winter beach will be reduced to an average width of 15 ft., and summer beach widths will be an average of 24 ft. The North Coast will be the only area that consistently retains beaches in the summer.

Most beach access will be highly constrained with accelerating SLR.

All the County's surf spots will rarely function.



SLR will lead to substantial dune habitat loss, with chronic erosion and inundation limiting dune formation, persistence, and habitat value in more constrained locations.

Chronic saltwater intrusion and sustained inundation result in substantial loss of freshwater wetland function, with many areas transitioning to brackish or tidally dominated systems.

4 CONCLUSION

This hazard evaluation is intended to provide a projected chronology of future hazards in order to support local adaptation planning and support informed discussions between state regulatory and funding agencies, local decision makers and the public.

This hazard assessment provides predictions of future hazards so the community can begin planning for strategic adaptation to these hazards rather than responding to future climatic events as they happen without sufficient forethought or understanding of costs and consequences. Low lying areas of Santa Cruz County are uniquely vulnerable to climate change. State funding is available to help communities adapt to future risks projected within this study. Continued progress towards defined adaptation strategies is needed for Santa Cruz to compete for limited adaptation funding.

Mechanisms to implement the identified adaptation strategies require further investigation, coordination with other municipalities within Monterey Bay, and development of partnerships that support efficient implementation of adopted strategies. Additional strategic dialog with California Coastal Commission staff is also needed. The climate report team will work with Santa Cruz County to obtain additional funding to expand the adaptation opportunity analysis for Santa Cruz County, more fully develop the environmental and economic implication analysis, and further define an adaptation implementation strategy that meets the needs of the community for integration into general plans and local coastal programs.

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Appendix A

Background Review and
Existing Planning Landscape

Appendix A
Background Review and Existing Planning Landscape

Sea Level Rise Vulnerability Assessment Report
Santa Cruz County

Prepared for
County of Santa Cruz
701 Ocean Street
Santa Cruz, CA 95060

Prepared by

Integral Consulting Inc.
200 Washington Street
Suite 201
Santa Cruz, CA 95060

October 5, 2026

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ACRONYMS AND ABBREVIATIONS

Caltrans	California Department of Transportation
CCC	California Coastal Commission
cfs	cubic feet per second
CIP	Capital Improvement Plan
City	City of Santa Cruz
Coastal Act	California Coastal Act of 1976
cy	cubic yard
EOP	Emergency Operations Plan
ESA	Environmental Science Associates
FEMA	Federal Emergency Management Agency
LCIP	Local Coastal Implementation Plan
LCP	Local Coastal Program
LHMP	Local Hazard Mitigation Plan
LUP	Land Use Plan
NAVD88	North American Vertical Datum of 1988
OPC	California Ocean Protection Council
PRC	Public Resources Code
Regional Water Boards	Regional Water Quality Control Boards
RTC	Regional Transportation Commission
SCCC	Santa Cruz County Code
SLR	sea level rise
State Water Board	State Water Resources Control Board
USACE	U.S. Army Corps of Engineers

1 INTRODUCTION

The County of Santa Cruz's coastal management and resilience efforts operate within a broader set of existing plans and policies.

Documents reviewed in this appendix include:

- **Existing Policies, Plans, and Regulatory Framework**: A description of existing local, state, and federal policies and regulations impacting coastal management.
- **Environmental and Technical Studies**: A description of scientific data and technical studies, including climate change projections, shoreline erosion, habitat protection, and coastal resilience strategies.
- **Community and Stakeholder Insights**: A description of reports on community perspectives, stakeholder priorities, and public input related to Local Coastal Program (LCP) development.
- **Existing Permits and Permitted Actions:** A description of current permits and permitted actions within the coastal area. These are intended to provide an understanding of ongoing and approved development activities, land uses, and mitigation measures.
- **Relevant Projects and Developments**: A description of ongoing or upcoming projects and developments in the coastal area of Santa Cruz County, including infrastructure, conservation efforts, and private/public sector initiatives that may impact the future of the coastline.

Each of these groups is organized by local, state, and federal policies, programs, and studies, and each provides a short description and any related context as it applies to this study.

2 EXISTING POLICIES, PLANS, AND REGULATORY FRAMEWORKS

The sections below describe the existing policies, plans, and regulatory frameworks for the study area, organized by entity including the County of Santa Cruz, the California Coastal Commission (CCC), other cities and localities, and federal entities.

2.1 COUNTY

2.1.1 Measure J, Growth Management Referendum

The rapid growth rate of the 1970s, coupled with the community desire for agricultural and environmental protection and preservation of quality of life, led to the passage in 1978 of a ballot referendum, Measure J (the growth management referendum). Measure J called for a comprehensive growth management system, including population growth limits, the provision of affordable housing, preservation of agricultural lands and natural resources, the retention of a distinction between urban and rural areas, and an enhancement of the quality of life within the county's urban areas. In the early 1980s, the County adopted a series of reports and ordinances with the 1980 General Plan and LCP to implement this ballot referendum (Santa Cruz County 2024).

2.1.2 Santa Cruz County General Plan/Local Coastal Plan

The County General Plan is a blueprint for long-term land use and development, guiding the county's future growth and development, and it is where the LCP resides. The plan recognizes that there is limited land available for building and development due to the geography of the county (mountains inland, ocean to the west), the importance of agriculture along the northern and southern coasts, and the importance of preserving the natural landscape. Considering the defining features of the Santa Cruz County landscape, the most appropriate location for more intense urban development and human activity are those areas without prime agriculture soils that are generally flat to gently sloping along the coastline and extending inland 1 to 4 miles. Approximately one-third of the urban land area appropriate for development is inside the coastal zone (Santa Cruz County 2024).

The California Coastal Act of 1976 (Coastal Act) requires local jurisdictions to adopt an LCP to regulate development within the coastal zone (see Figure 1-4 for the County's coastal boundary). The Coastal Act requires jurisdictions to have an LCP consisting of both a Land Use Plan (LUP) and a Local Coastal Implementation Plan (LCIP) with implementing actions that are consistent with the statewide Coastal Act policies. The LCP is legally binding on the County and provides a permanent program for coastal protection. The County's LUP is contained within the General Plan; goals, objectives, policies, and implementation strategies in each chapter of the

General Plan that are also part of the LUP are noted by the acronym "LCP." The County's LCIP implementing ordinances are listed in Santa Cruz County Code (SCCC) section 18.60.050 and include portions of SCCC Titles 7 – Health and Safety, 12 – Building Regulations, 13 – Planning and Zoning Regulations, 15 – Community Facilities, 16 – Environmental and Resource Protection, 17 – Community Development, and 18 – Procedures.[1] Once a jurisdiction's LCP has been certified, the local jurisdiction is responsible for development review in the coastal zone, while the CCC maintains regulatory authority over tidelands, submerged lands, and public trust lands, as well as an appealable area.

In addition to the required permitting for development within the coastal zone, seven areas along the County's coast, because of their unique scenic, historical, or beachfront character, require special design standards. The County Planning Department reviews all permits, but some local approvals may be appealed to the CCC.

2.1.3 Capital Improvement Plan

The County of Santa Cruz's 2025–2030 Capital Improvement Plan (CIP) is a strategic roadmap guiding public investment in essential infrastructure, facilities, and community spaces over the next 5 years. Developed in close partnership between the County Executive Office, the Community Development and Infrastructure Department's Public Works Division, the County Parks Department, and the General Services Department, this CIP reflects a coordinated, countywide approach to capital planning. The Public Infrastructure section focuses on maintaining and improving the County's core systems—roads, bridges, stormwater systems, and other essential public works. The Government Facilities section addresses the modernization and sustainability of County-owned buildings and service centers. The Parks and Open Spaces portfolio invests in recreational facilities, trails, and natural resource stewardship. Much of this public infrastructure along the coast is affected by coastal processes (Santa Cruz County 2025).

2.1.4 Santa Cruz County Local Hazard Mitigation Plan, 2021–2026 (update forthcoming)

The purpose of the Santa Cruz County Local Hazard Mitigation Plan (LHMP) is to implement and sustain actions that reduce vulnerability and risk from hazards or reduce the severity of the effects of hazards on people and property. The Santa Cruz County LHMP identifies hazards with the potential to cause widespread loss of life, damage to property, infrastructure, and natural resources within the County. The hazards identified include natural ones such as earthquakes as well as natural hazards exacerbated by the use of land such as building along a cliff or on the beach. The plan also identifies ways to provide a tool to implement and sustain actions that reduce vulnerability and risk from the hazards identified in the plan. Mitigation actions include both short-term and long-term activities that reduce the impacts of hazards, reduce exposure

[1] https://www.codepublishing.com/CA/SantaCruzCounty/

to hazards, or reduce effects of hazards through various means including preparedness, response, and recovery measures. Effective mitigation actions also reduce the adverse impacts and cost of future disasters (Santa Cruz County 2021).

As of the time of writing in 2026, Santa Cruz County is developing a Multi-Jurisdictional Hazard Mitigation Plan to identify key risks from natural hazards and develop mitigation strategies to address them. Participating jurisdictions include:

County of Santa Cruz
City of Capitola
City of Scotts Valley
City of Watsonville
Scotts Valley Water District
Soquel Creek Water District
Pajaro Valley Water Management Agency
Resource Conservation District of Santa Cruz County
Santa Cruz Port District
Cabrillo College

The Multi-Jurisdictional Hazard Mitigation Plan ensures that local jurisdictions remain eligible for federal mitigation funding and provides a roadmap for reducing disaster impacts. This work is funded by the Federal Emergency Management Agency's (FEMA's) Hazard Mitigation Grant Program.[2]

2.1.5 Santa Cruz County Operational Area Emergency Management Plan

The Santa Cruz County Operational Area Emergency Operations Plan (EOP) provides the foundational framework for an organized response to emergencies. The EOP takes into consideration the County's Operational Area obligations and authority and sets a vision for a more equitable human-centered approach to emergency management throughout the county. The EOP delineates operational concepts, risks, and hazards across all phases of the emergency management cycle: Mitigation and Prevention, Preparedness, Response and Recovery (Santa Cruz County 2024).

2.1.6 Santa Cruz County Flood Control and Stormwater

Within County Public Works, the Flood Control Division uses science-based information and technology to reduce flood risk and to inform emergency managers and the public of real-time flooding potential during storms. Flood control engineering work is strongly focused on the Pajaro River and its tributaries. Flood Control works with the County Planning Division on flood

[2] https://mitigatehazards.com/santacruzmjhmp/

insurance needs in the county and works closely with Environmental Health on woody debris management in the watersheds of the Santa Cruz Mountains.[3]

2.1.7 Santa Cruz County Parks Strategic Plan, 2018–2027

The County Parks Strategic Plan guides the Parks Department's overall planning and services, with a focus on maintaining and enhancing park facilities, strengthening organizational effectiveness, and providing recreational and cultural programs. An update to the plan in 2023 describes how the 2023 storms, associated flooding, and erosion and debris caused damage to 6 County Parks facilities and 13 coastal access points.[4]

2.1.8 California Coastal Act

The Coastal Act is a state law that protects California's coastal resources by regulating development and ensuring public access to the coast. It mandates the preservation of natural resources, promotes public recreation, and ensures the long-term sustainability of coastal ecosystems. The CCC is responsible for administering the Coastal Act and implementing its policies.[5]

The basic goals of the Coastal Act, as stated in Public Resources Code (PRC) Section 30001.5[6] are to:

(a) Protect, maintain, and where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and man-made resources.

(b) Assure orderly, balanced utilization and conservation of coastal zone resources taking into account the social and economic needs of the people of the state.

(c) Maximize public access to and along the coast and maximize public recreation opportunities in the coastal zone consistent with sound resource conservation principles and constitutionally protected rights of private property owners.

(d) Assure priority for coastal-dependent development over other development on the coast.

(e) Encourage state and local initiatives and cooperation in preparing procedures to implement coordinated planning and development for mutually beneficial uses, including educational uses, in the coastal zone.

[3] https://cdi.santacruzcountyca.gov/PublicWorks/FloodControlStormwater.aspx
[4] https://parks.santacruzcountyca.gov/Home/AboutUs/CountyParksStrategicPlan.aspx
[5] https://www.coastal.ca.gov/history/
[6] https://law.justia.com/codes/california/code-prc/division-20/

2.1.8.1 Relevant Sections

Section 30235: Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alter natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fish kills should be phased out or upgraded where feasible.

Section 30253: New development shall (1) minimize risks to life and property in areas of high geologic, flood, and fire hazard; (2) 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.

Section 30270: This section requires CCC to incorporate the effects of sea level rise (SLR) into coastal planning and management by identifying, assessing, and, when feasible, avoiding and mitigating its impacts. This includes considering SLR in local coastal programs and requiring new development to be consistent with the Coastal Act's policies, particularly by adapting to potential future hazards like increased flooding.

2.1.8.2 Coastal Zone Boundary

PRC Section 30103(a) specifically defines California's coastal zone as that land and water area of the State of California from the Oregon border to the border of the Republic of Mexico extending seaward to the state's outer limit of jurisdiction. In Santa Cruz County, the coastal zone extends anywhere from 0.6 miles inland to about 5 miles inland from the mean high tide line of the sea, depending on the specific location on the coast.

2.1.9 California Coastal Commission Sea Level Rise Policy Guidance

The 2024 CCC Sea Level Rise Policy Guidance provides a framework for addressing SLR in LCPs and Coastal Development Permits (CCC 2024). The Commission recommends seven steps to address SLR as part of the development of an LCP, LCP Amendment, or other plan. The intent of this project is to provide Santa Cruz County with a sufficiently detailed "sea level rise vulnerability assessment" to address Steps 1–3 of the guidance and support integration of these findings into future LCP updates for these areas.

2.2 OTHER RELEVANT CALIFORNIA COASTAL COMMISSION GUIDANCE DOCUMENTS

Listed below are a selected list of relevant state guidance documents.

- Sea Level Rise Policy Guidance, 2024 Update
- Draft Sea Level Rise Coastal Adaptation Planning Guidance for Residential Development, 2018
- Environmentally Sensitive Habitats and Other Natural Resources, 2013
- Water Quality Protection, 2017
- Planning and Locating New Development and Archaeological/Cultural Resources, 2013
- Critical Infrastructure Guidance, 2021
- California Coastal Commission Environmental Justice Policy, 2019
- Informational Briefing on Lower-Cost Accommodations, 2024[7]
- Fair Housing in the Coastal Zone, July 2024
- Affordable Housing and the Coastal Act, 2023

2.2.1 California Ocean Protection Council 2024 Sea Level Rise Guidance

The 2024 draft guidance was developed by the California Ocean Protection Council (OPC), in partnership with the California Ocean Science Trust, a scientific task force, and informed by member agencies from state government and consultation with California Native American tribes. The guidance document updates and replaces the previous 2018 OPC guidance. The guidance is updated approximately every 5 years and includes updated projected SLR through 2150. For most planning and projects, the guidance recommends evaluating intermediate, intermediate–high, and high SLR scenarios to assess a spectrum of potential impacts (OPC 2024).

2.2.2 Regional Water Quality Control Board 401 Water Quality Certification Program

This 401 Water Quality Certification program is responsible for regulating discharges of dredged or fill material to waters of the state. The State Water Resources Control Board (State Water Board) and the Regional Water Quality Control Boards (Regional Water Boards) have the authority to regulate these discharges under section 401 of the Clean Water Act and the Porter-Cologne Water Quality Control Act.

[7] https://www.coastal.ca.gov/lower-cost-coastal-lodging/

2.2.3 State Park Planning Documents

The following list includes the coastal State Parks (i.e., located wholly within the coastal zone boundary) that are located within the County of Santa Cruz and have a published planning document:

State Park	**Planning Document (Date)**
Wilder Ranch State Park	General Plan (1986)
Natural Bridges State Beach	General Plan (1998)
Big Basin Redwoods State Park	General Plan (2013)

These Park Plans do not include consideration of SLR.

State Parks is currently working on an SLR vulnerability assessment and adaptation plan for Seacliff State Beach.[8]

[8] https://www.seacliffresilience.org/



Figure 2-1. Process for Addressing Sea Level Rise in Local Coastal Programs and Other Plans (Source: CCC 2024)

2.3 OTHER CITIES AND LOCALITIES IN THE COUNTY

2.3.1 City of Santa Cruz–Resilient Coast Santa Cruz, Ongoing

The City of Santa Cruz (City) Resilient Coast mission is to protect and enhance the unique coastal environment of the City and ensure it remains vibrant and resilient in the face of climate change. This effort is responsible for the following efforts: 50-yr vision for West Cliff,

the City's Living Shoreline project, West Cliff Drive Adaptation and Management Plan, and the City's LCP Beaches and Bluff update.[9]

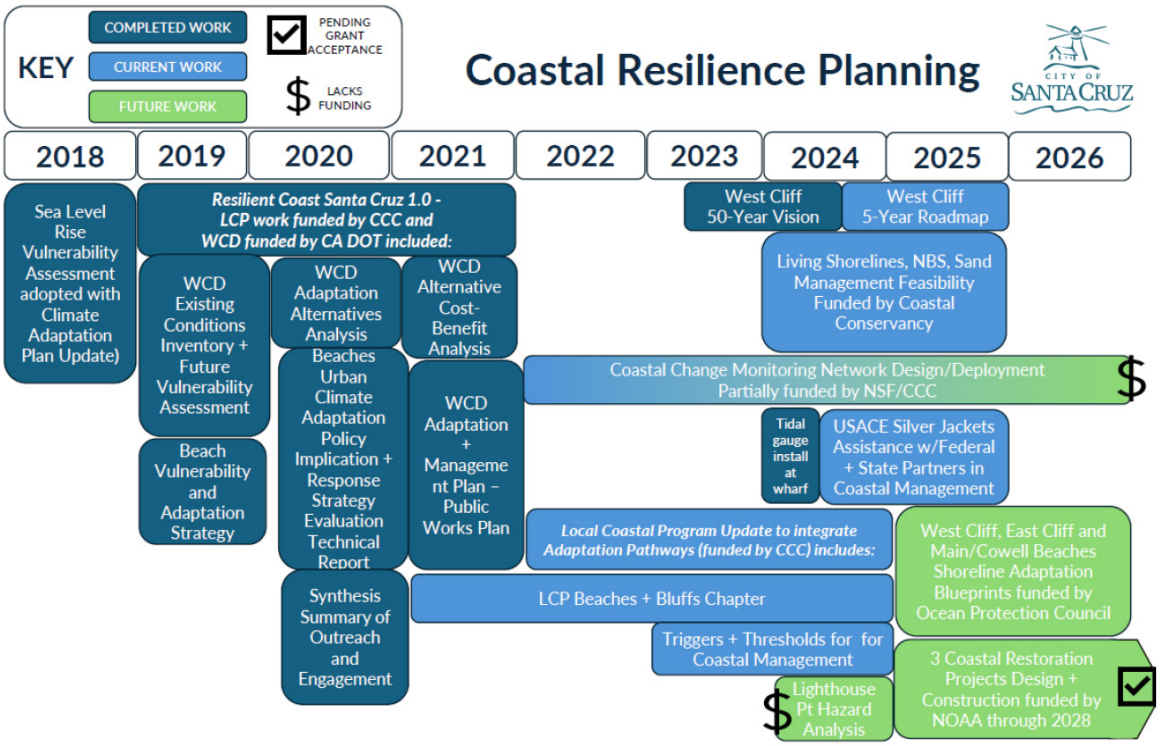

Figure 2-2. Timeline of City of Santa Cruz Coastal Resilience Planning (Source: City of Santa Cruz)

The City of Santa Cruz is updating its LCP to address resiliency and climate change by creating a new Beaches and Bluffs policy chapter. The updated policies aim to protect the shoreline's natural beauty, public access, and safety of homes and infrastructure, while also planning for long-term resilience. The LCP Beaches and Bluffs chapter includes policies to protect development, respond to coastal erosion, and minimize new seawall construction. The LCP Beaches and Bluffs chapter lays the foundation for the City to develop more detailed Shoreline Adaptation Management Plans for West Cliff, Main/Cowell Beaches, and East Cliff over the next 2 years.

2.3.2 Santa Cruz Harbor Dredge Management Plan, Strelow Consulting, 2009

Pursuant to recommendations from the Monterey Bay National Marine Sanctuary staff, the Santa Cruz Harbor Dredge Management Plan provides an overview of dredging within the Santa Cruz Harbor, including a review of existing permits, dredging and disposal history, sediment sources, effects of dredge disposal, and potential dredge disposal alternatives. The report

[9] https://www.santacruzca.gov/Government/Climate-Initiatives/Resiliency/Resilient-Coast-Santa-Cruz

provides an overview of dredge disposal areas, sediment sources, effects of existing dredge disposal, and alternatives (Strelow Consulting 2009).

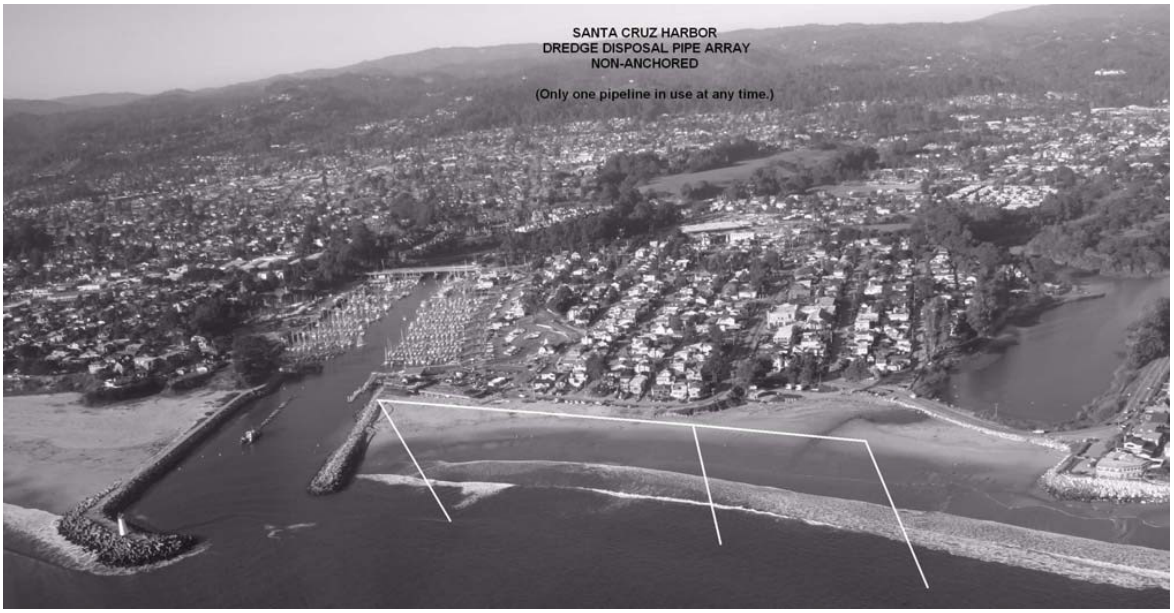

Figure 2-3. Dredge Disposal Sites and Pipeline Configurations

2.3.3 Pleasure Point Community Plan, 2007

The Pleasure Point Community Plan was developed jointly by the County of Santa Cruz Planning Department, Redevelopment Agency and Pleasure Point community members in 2006–2007 to address community concerns and neighborhood issues in Pleasure Point. The plan recommends maintaining and enhancing coastal access points in keeping with neighborhood character, evaluating access impacts caused by rip-rap and other types of coastal armoring, and developing design standards for coastal protection structures that minimize access problems. The plan recommends that efforts should also be made to evaluate the impacts to public coastal access created by rip-rap and other coastal armoring structures, and an effort should be made to develop local shoreline protection structure standards (Santa Cruz County 2007). The plan was never adopted by the CCC; however, portions of it were codified into the County's LCP.

2.3.4 North Coast Facilities Management Plan

The North Coast Facilities Management Plan, developed with funding from the California Coastal Conservancy and California State Parks, identifies priority projects to enhance visitor experiences, manage impacts, and protect the natural environment (Santa Cruz County 2024).



Figure 2-4. North Coast Facilities Planning Area

Examples of proposed projects include restroom facilities, improved parking, and potential cabins at Greyhound Rock County Park. In the plan, the North Coast is divided into nine zones, allowing for targeted improvements and management strategies for specific areas.

2.4 FEDERAL

2.4.1 Section 404 of the Clean Water Act

Section 404 of the Clean Water Act requires a permit from the U.S. Army Corps of Engineers before the discharge of dredged or fill material into waters of the United States (which includes all navigable waters but also extends to many other water bodies and wetlands). It regulates the discharge of dredged or fill material in waters of the United States.[10]

2.4.2 Monterey Bay National Marine Sanctuary

Monterey Bay National Marine Sanctuary is a federal marine protected area offshore of California's central coast stretching from Rocky Point in Marin County to Cambria in San Luis Obispo County and encompasses waters offshore of Santa Cruz County. The Sanctuary was established for the purpose of resource protection, research, education, and compatible

[10] https://www.epa.gov/cwa-404/overview-clean-water-act-section-404

human use. The Sanctuary Management Plan[11] guides current and future activities to conserve and promote its natural and cultural resources. Permits may be issued to allow certain activities in the sanctuary that would otherwise be prohibited such as construction, seawall maintenance, and operation of equipment on the beach among many other activities.

[11] https://montereybay.noaa.gov/intro/mp/welcome.html

3 ENVIRONMENTAL AND TECHNICAL STUDIES

The sections below describe environmental and technical studies, organized by entity including the County of Santa Cruz, cities and localities, state, regional, and federal entities.

3.1 COUNTY

3.1.1 Santa Cruz County Coastal Climate Change Vulnerability Report, Central Coast Wetlands Group, 2017

The 2017 County Vulnerability Assessment analyzes risks to resources and assets along the Santa Cruz County coastline across three different time horizons (2017–2030, 2030–2060, 2060–2100) and provides potential strategies for climate adaptation across each. The vulnerability assessment further provides adaptation strategies by coastal hazard (wave run-up, coastal erosion, rising tides, fluvial flooding) as well as identifies strategies within existing plans such as the Santa Cruz County Climate Action Plan and the Santa Cruz Littoral Cell Study. This report serves as a foundation for which the current vulnerability assessment for this study is based (CCWG 2017).

3.1.2 Santa Cruz County Climate Adaptation Vulnerability Assessment and Transportation Priorities Report, 2024

Led by the Santa Cruz County Regional Transportation Commission (RTC), the County of Santa Cruz Department of Community Development & Infrastructure, and the Santa Cruz County Office of Response, Recovery & Resiliency partnered to develop a Climate Adaptation Vulnerability Assessment and Transportation Priorities Report for unincorporated Santa Cruz County maintained roads and the entirety of the Santa Cruz Branch Rail Line. The emphasis of the vulnerability assessment is on identifying transportation infrastructure assets in the county that may be particularly vulnerable to climate hazards and developing a prioritization list to identify the order in which those assets should undergo detailed assessments for climate resilience actions and implementation (SCCRTC 2024).

3.1.3 Climate Action and Adaptation Plan, 2022

Developed by an interdepartmental working group, the 2022 Climate Action and Adaptation Plan includes the most current data on climate impacts for unincorporated Santa Cruz County. The plan comprises actionable steps towards reducing the causes of global warming, adapting our communities to climate hazards, and ensuring the safety and well-being of those most

vulnerable to climate change (Santa Cruz County 2022). A story map with a description of the project is also available.[12]

3.1.4 Climate Vulnerability Technical Compendium, Rincon Consultants, Inc., 2022

The Climate Vulnerability Technical Compendium is a high-level report on County-wide climate change vulnerabilities and community sensitivities. This report was intended to support the 2022 Santa Cruz County Climate Action and Adaptation Plan (Rincon 2022).

3.2 OTHER CITIES AND LOCALITIES IN THE COUNTY

3.2.1 Pajaro Dunes Seawall Maintenance and Repair Plans Project, Hailey & Aldrich, 2024

This report on the Pajaro Dunes seawall maintenance and repair plans project updates assessment amounts and establishes a source of funding to return the existing rock revetment to its original design geometry. The work items will include the following: removal of rock material temporarily added to State Park Lands during the early 2000s, removal of rock material temporarily added to Pajaro Dunes property during the early 2000s, and restacking of existing revetment rock material (Hailey & Aldrich 2024).

3.2.2 Pajaro Dunes Annual Inspection of Rock Revetment-Memorandum No.4, Cal Engineering & Geology, Inc., 2024

This report is the most recent inspection and is part of a routine monitoring plan. In the past, Haro Kasunich & Associates and Arup North America, Ltd. performed periodic inspections as well as engineering design of repair alternatives.

This armoring inspection report was undertaken on July 16, 2024, at the request of the Pajaro Dunes Geologic Hazards Abatement District. The inspection was of 6,000 linear feet of rock revetment, comprising approximately 110,000 tons of riprap and constructed in three segments between 1986 and 1988 along the ocean side of the Pajaro Dunes development. The top of the revetment varies in elevation from 19.5 to 22.0 ft above mean sea level.

Not part of the jurisdiction of this inspection is the steel sheet pile wall constructed in 2003 that begins near the terminus of the rock revetment and trends for about 500 ft around the Pelican townhouses, curves around the townhouses, and terminates about 200 ft up the

[12] https://experience.arcgis.com/experience/e5bb44474dc84990b6411598bcdcdfb0

Watsonville Slough. The sheet piles are approximately 58 ft deep, about 5 ft or less exposed above the ground surface. This steel sheet pile wall is referred to as the "river wall."

The rock revetment has been repeatedly damaged by coastal erosion during relatively severe winter storms since its original construction at least two times, in 2002/2003 and in 2004. Following each damaging storm event, emergency repairs were implemented by placing riprap in selected areas along the revetment where excessive erosion had occurred. Following damages in the past, the CCC indicated that a permit could not be issued for repairs or maintenance to the rock revetment that extends outside of the original geometry of the rock revetment documented under the original development permit.

The team made recommendations on portions of the wall to receive maintenance at the discretion of the Pajaro Dunes Geologic Hazards Abatement District in the form of restacking the rock revetment to its original slope configuration where it has become over-steepened. Although final project costs have not been determined (as of May 2024), the district estimates that the Project will cost around $3.5M (Cal Engineering 2024).

3.2.3 Pajaro River Breaching, Alternatives Analysis Work Program for the County of Santa Cruz, Schaaf & Wheeler, 2007

This report is an alternative analysis requested by the CCC and identifies and discusses the full range of alternatives to mechanically breaching the seasonal Pajaro River sandbar for flood control purposes. The team discusses the flood risk priorities that motivate the breaching program, including flooding of Beach and Shell roads and the Pajaro Dunes Community sanitary system, and potential damage to agricultural fields, private structures, and the Pajaro Dunes electricity system. Under the current program, Pajaro Dunes experiences regular flooding of the Cypress House, a community building located near Pump Station #1 in the Pajaro Dunes North area. Both the Pajaro Dunes Homeowners' Association and the County consider this nuisance flooding.

The range of breaching alternatives considered includes:

1. Installation of additional flap gates along Beach and Shell roads
2. Elevation of Shell and Beach roads sufficient to eliminate flooding of these roads
3. Flood-proofing of the Shell Road Pump Station
4. Flood-proofing of sewer lines and the sewer pump station
5. Elevation of electrical boxes
6. Elevation of Rio Boca Road and sewer manholes
7. Installation of a weir or a flume along the lagoon edge
8. Replacement of Beach Road drainage ditch flap gate

9. Construction of a flood wall along Rio Boca Road
10. Installation of a tide gate at the Watsonville Slough mouth
11. Flood-proofing of the Cypress House community building
12. Continuation of current breaching program with no additional projects
13. Discontinuation of breaching with no additional projects (i.e., "do nothing").

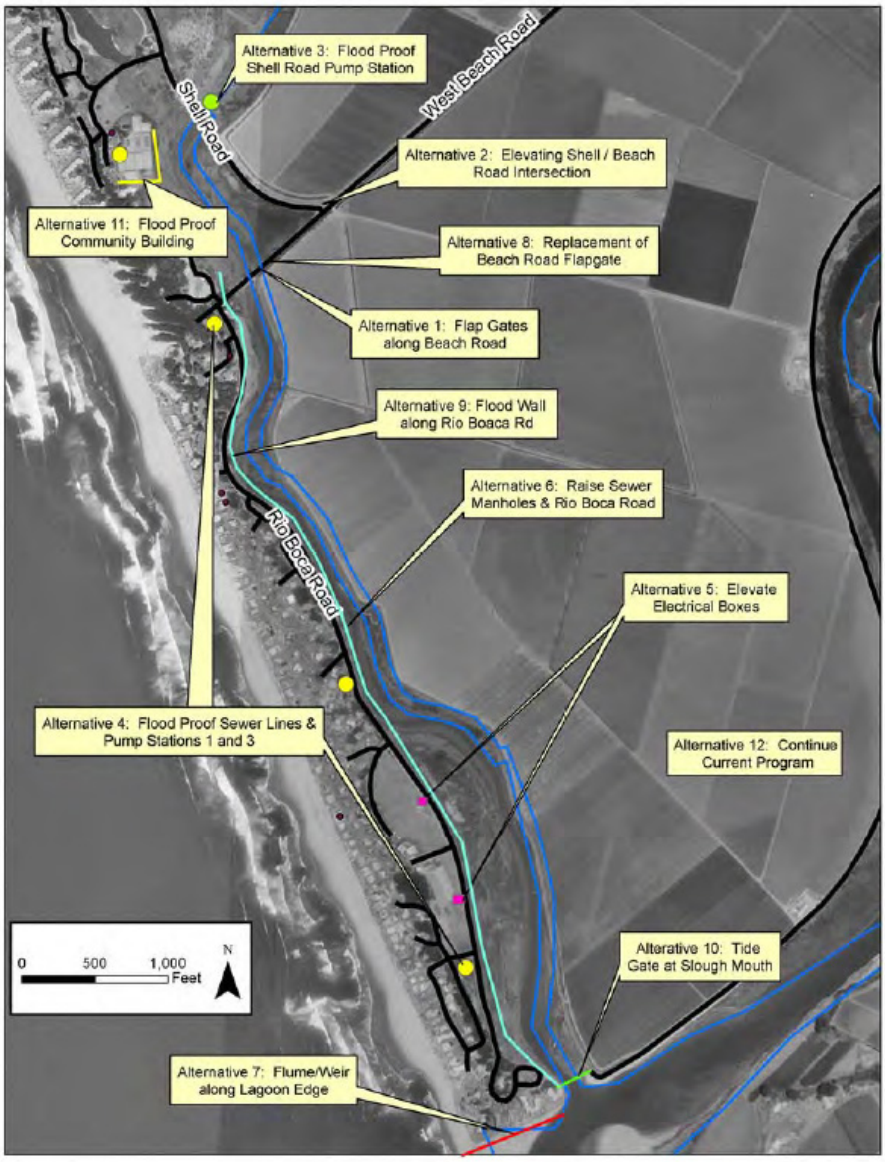

Figure 3-1. Alternatives for Pajaro River Breaching

Based on the factors considered, Schaaf & Wheeler (2007) recommended the following alternatives:

- Elevate the Shell & Beach Road intersection, with the potential to be combined with Alternative 4, Flood Proofing of the Sanitary Sewers and Pump Stations
- Construct a tide gate at Watsonville Slough mouth
- Continue the Current Breaching Program.

3.2.4 Pajaro Dunes and Lagoon Flood Vulnerability Assessment, ESA, 2018

This flood vulnerability assessment is at a local level for the Pajaro Dunes community. Environmental Science Associates (ESA) related staff water level gauges in the vicinity to a consistent datum, worked with County staff to capture the range of flooding elevations possible under existing conditions, and then determined flooding thresholds for a range of assets and infrastructure. Potentially vulnerable infrastructure included pump stations, electrical and telephone boxes, roads, and numerous Pajaro Dune's community buildings including Dunes Hall, Cypress House, and the Lagoon House (dining and meeting rooms), and the Gatehouses. Also vulnerable are several drinking water wells and a booster station off Shell Road, and two sewage pump stations, one off River Road and one off Shell Road. Flood hazard zones were then mapped from 7.5 to 14 ft above mean sea level in 0.5-ft increments. ESA determined that most public parks and agriculture parcels are flooded at all elevations above 8 ft mean sea level, and water levels of around 10 ft characterize the potential flooding vulnerabilities in the Pajaro Dunes community area (ESA 2018).

3.2.5 Rio Del Mar Flats Stormwater Drainage Improvement Benefit-Cost Analysis Report, Goettal & Associates Inc., 2018

The cost–benefit analysis report addresses the frequent problem of ponded water accumulating during rainfall runoff events. While the neighborhood is subject to a confluence of flood factors including overbank flooding from Aptos Creek related to winter storms or barrier beach flooding, and coastal wave overtopping and flooding from the Pacific Ocean, those factors were not considered in this report.

Ponded flooding occurs frequently, typically several times per year, and occurs because the existing gravity flow stormwater drainage system has inadequate conveyance, in large part because of the very gentle slopes in this neighborhood, which result in low-flow velocities. The limited conveyance is also exacerbated by frequent impairment of conveyance from sediment and vegetative debris accumulation in the pipes. Significant flood damage to neighborhood buildings occurs with local rainfall events starting with the 2-yr event.

Flood elevations were determined by hydrologic and hydraulic modeling of local rainfall events by Schaaf & Wheeler Consulting Engineers. Schaaf & Wheeler calculated flood elevations for 2-yr, 5-yr, and 10-yr events for various combinations of flood parameters. Results are presented in Table 3-1.

Table 3-1. Flood elevations at Rio Del Mar Flats across varying time horizons

	Flood Elevation (NAVD 1988)		
Condition	2 yr	5 yr	10 yr
24-Hour Breached Mouth	12.8	13.6	14.0
72-Hour Breached Mouth	12.8	13.5	13.9
24-Hour Closed Mouth	13.4	14.1	14.2
72-Hour Closed Mouth	13.5	14.1	14.2
24-Hour Breached Mouth Poor Pipe Condition	13.5	14.2	14.2
72-Hour Breached Mouth Poor Pipe Condition	13.5	14.1	14.2
24-Hour Closed Mouth Poor Pipe Condition	14.0	14.2	14.3
72-Hour Closed Mouth Poor Pipe Condition	13.8	14.2	14.4
Average of Range of Conditions	**13.41**	**14.00**	**14.18**

First floor elevations for 43 buildings at low elevations in the Rio Del Mar Flats neighborhood were surveyed by Santa Cruz County Public Works staff in 2012. Using FEMA standard depth-damage functions the team assessed damages to buildings and contents under various return periods. The team calculated that potential building damages from a 10-yr storm to be $2,360,071, and content damages to be $591,038. After mitigation, the proposed mitigation project was estimated, very conservatively, to reduce damages by 95%, 90%, and 80% for 2-yr, 5-yr and 10-yr events, respectively.

The proposed mitigation project has two main elements: 1) construct a storm water pump station, which will substantially increase the conveyance capacity of the storm water drainage system, and 2) construct a gravity flow pipe to intercept runoff flowing down the steep section of Rio Del Mar Flats at an elevation well above the flats. The total project cost estimate (in 2018) was $4,802,704. The total cost for the benefit-cost calculations including detailed engineering evaluation and development of the mitigation project design and consideration of the annual maintenance costs for the mitigation project was found to be $7,223,560 (2018 dollars).

The proposed mitigation project was designed, permitted, and funded for construction. However, a ballot measure asking area property owners to fund ongoing maintenance through property assessments failed and the project did not move forward (Goettal & Associates Inc. 2018).

3.2.6 Rio Del Mar Flats Benefit Assessment District, NBS, 2021

This report provided a general plan and specifications for improvements to be maintained, an estimate of costs, and a description of services to alleviate the stormwater-related flood hazards for the Rio Del Mar Flats area. The study determined that total implementation cost for stormwater upgrades would be $5.6M (2021 dollars and funded form grant sources) and the yearly pump system and road collection system maintenance and operation costs (along with tax collector costs) were estimated to be $120,664 (2021 dollars).

3.3 STATE

The SLR vulnerability assessment of Seacliff State Beach and New Brighton State Beach looks at the future of these beaches with the goal of using a range of nature-based strategies, hybrid solutions, and managed retreat to help preserve and protect the state park to continue to provide recreational benefits to visitors into the future (Moffatt & Nichol 2024).[13] This assessment was initiated in 2023 and is ongoing.

3.4 REGIONAL

The 2014 Monterey Bay SLR vulnerability study and The Nature Conservancy Coastal Resiliency Mapping Tool are designed to project the impacts of coastal erosion and coastal flooding for Monterey Bay, extending from Año Nuevo Point to Wharf 2 in Monterey. A technical methods report presents technical documentation of the methods used to map erosion and coastal flood hazards under various future climate scenarios (ESA and PWA 2014). The climate-change-exacerbated coastal hazard modeling considered different scenarios of SLR, wave climate, and sand mining. This study and model outputs provide much of the hazard identification used in support of the City's vulnerability assessment.

3.5 FEDERAL

3.5.1 Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell

In September 2015, Monterey Bay National Marine Sanctuary and the U.S. Army Corps of Engineers (USACE) completed a consensus-driven guidance and policy document for the 75-mile stretch of coastline from Moss Landing to Pillar Point, which encompasses the entire Santa Cruz County coastline. The plan's purpose is to present ways to restore and maintain coastal beaches and other areas of sediment deficit, to reduce the proliferation of coastal

[13] https://www.seacliffresilience.org/

armoring, to sustain recreation and tourism, to enhance public safety and access, and to restore coastal sandy habitats. This study also included a high-level vulnerability assessment, which this study will aim to refine (MBNMS and USACE 2015).

3.5.2 FEMA Pacific Coastal Flood Mapping, 2018

FEMA, as part of its Congressional mandate, maps regulatory Flood Insurance Rate Map and Special Flood Hazard Area designations to determine flood insurance premiums. The flood mapping follows federal guidelines to delineate potential flood impacts from a 1% annual chance storm event. The flood mapping comes from two primary sources, wave run-up and fluvial flooding. The wave run-up mapping is determined by the combination of high tides and maximum wave run-up elevations (aka total water level). The wave run-up is calculated three different ways depending on the type of backshore (e.g., armored, sandy beach, or cliff) and the highest run-up elevation is mapped. The mapped hazard zones are delineated as a high wave velocity (V or VE) zone or a ponded water (A or AE) zone. FEMA updated the Pacific Coastal flood maps through the California Coastal Analysis and Mapping Project for Region 9 in 2018.

Local SLR and coastal erosion were not factored into this coastal regulatory map update and so the FEMA model is primarily used as a basis for existing conditions and a 1% annual chance wave event. The coastal wave flood hazard zones and the special flood hazard area for Rio Del Mar were utilized in the vulnerability assessment for this study.[14]

[14] https://www.fema.gov/flood-maps

4 COMMUNITY AND STAKEHOLDER INSIGHTS

The County Board of Supervisors adopted the Coastal Hazards Local Coastal Program Amendments (LCP Amendment) in September 2020. The County's LCP Amendment project occurred over a period of several years with an intense 2-year period of community meetings and numerous public hearings at the Planning Commission and Board of Supervisors. The LCP Amendment was submitted to the CCC for certification. In October 2022, the CCC denied the LCP Amendment.

The CCC staff report described the various ways in which the LCP Amendment did not adequately protect coastal resources and was, therefore, not consistent with the Coastal Act. Inconsistencies cited within the staff report include shoreline armoring, policy inconsistency across shoreline types and development types.

CCC suggested that a starting point for a successful LCP Amendment should be a vulnerability assessment, and robust community collaboration including property owners, environmental and community groups, business groups, surfing advocates, advocates for parks and trails, environmental justice groups, and tribal consultation. A neighborhood or community scale planning approach was recommended to avoid dealing with the same issues permit by permit (CCC 2022).

5 EXISTING PERMITS AND PERMITTED ACTIONS

The following section describes the Santa Cruz Harbor dredging permit and the California Department of Transportation (Caltrans) permitting history for Waddell Creek.

5.1 SANTA CRUZ HARBOR DREDGING PERMIT

Santa Cruz Harbor receives a permit from USACE to dredge, pursuant to the provisions of Section 404 of the Clean Water Act of 1972. In addition, the act requires a non-federal applicant seeking a federal license or permit to conduct any activity occurring in or affecting the coastal zone to obtain a Consistency Certification that indicates the activity conforms with the state's coastal zone management. In 2022, the Harbor District secured a new 10-year dredge permit from USACE, with a maximum of 2,860,000 cubic yards (cy) of sediment over that span.

The Harbor District proposed to dispose of the dredged material at the following sites: the nearshore disposal site (nearshore immediately east of the east jetty), the Off-Shore Moss Landing Monterey Bay Disposal Site (SF-14), separately permitted wetlands restoration projects (after the restoration projects are permitted), or on an upland site located outside of USACE regulatory jurisdiction. During the past 10 years, the majority of the dredged material from Santa Cruz Harbor has been disposed of at the nearshore disposal site, and it is anticipated that most of the dredged material will continue to be placed at the nearshore disposal site (Holland 2025, pers. comm.).

5.2 WADDELL CREEK, CALIFORNIA DEPARTMENT OF TRANSPORTATION PERMITTING HISTORY

At Waddell Creek, Caltrans permitting history goes back to the 1980s. Caltrans maintenance activities include the removal of cliff-derived debris and sediments from the road by either pushing it over the edge of the highway or repurposing the sediment at the State Park beach parking lot. Caltrans is permitted to push debris over the edge of the road because it replicates natural erosional process and contributes to the sediment supply at the beach.

6 RELEVANT PROJECTS AND DEVELOPMENTS

The sections below describe relevant projects and developments.

6.1 SANTA CRUZ HARBOR DREDGING AND SEDIMENT SUPPLY

The Santa Cruz Port District was formed in 1950 to develop harbor facilities in the Santa Cruz area. Since its completion in 1964, dredging the Harbor entrance became necessary almost immediately because of sand incursion at the mouth of the harbor, and inner-harbor dredging also has been required periodically. Annual dredging is performed to ensure sufficient depth at the harbor entrance to permit the safe passage of vessels transiting the entrance and avoid shoaling conditions. Dredging and disposal of dredge materials are regulated and permitted by USACE, the Monterey Bay National Marine Sanctuary, CCC, and the Regional Water Board (Santa Cruz Harbor 2025).

The Port District's dredging operation occurs between November and April of each year. This has occurred each year since the harbor was first constructed in 1964. Sand, which moves downcoast through the process of littoral drift, becomes trapped in the harbor entrance channel. The dredging operation picks up the sand deposited in the entrance and places it downcoast, bypassing the east jetty, so it can continue to provide beach replenishment and protection downcoast of the harbor (Santa Cruz Harbor 2025).

The dredge crew utilizes three types of disposal methodologies, including surf-line disposal. Surf-line disposal is most often used to replenish the beach with high quality sand or when the Port District's offshore pipeline is unavailable. Disposal of dredged material in the nearshore achieves multiple objectives, which include replenishing beaches and surfing areas downcoast of the harbor with sand, protecting bluffs, roadways, and public utilities, as well as park assets on Twin Lakes State Beach and Harbor Beach.

In accordance with regulatory permits issued and reviewed by various agencies listed above, the Port District performs all required physical, chemical, and biological analyses on material proposed to be dredged on an annual basis. Regulators from each agency review the sampling and analysis data to confirm the sediment is suitable for aquatic disposal or land disposal as clean, beach-quality sand.

The district conducts entrance channel dredging and semiannual dredging of north harbor slips and fairways for navigation. On average, north harbor volumes are estimated at approximately 4,500 cy/year, which is minimal (Holland 2025, pers. comm.). The harbor district has supplied dredge volume history for the harbor dating back to 1985, and the average yearly dredge

volumes at the entrance since 1985 is approximately 230,000 cy, with significant variability depending on the season. Scientific reports for 2008–2018 are available online.[15]

6.2 SAN VICENTE–WADDELL RESILIENCY PROJECT

The San Vicente–Waddell Resiliency Project, which at the time of writing (2026) is currently assessing responses to a request for proposals, would be completed in partnership between Santa Cruz County Regional Transportation Commission, the Santa Cruz County Resource Conservation District, and Caltrans District 5. The project would involve preparing a plan for coastal resilience along the Highway 1 Corridor at Waddell and San Vicente creeks. The final coastal resilience plans for the two locations will identify short, medium, and long-term alternative project concepts for viability and resilience to climate stressors of these coastal ecosystems and the transportation infrastructure that traverses them.[16]

6.3 COASTAL TRAIL EXPANSION

The Monterey Bay Sanctuary Scenic Trail Network is a 50-mile bicycle and pedestrian pathway along the coast of Santa Cruz County, from the San Mateo County line in the north to the Monterey County line at Pajaro. Much of the trail network is located within the right-of-way of the Santa Cruz Branch Rail Line, which in several locations is subject to coastal hazards as described in the RTC climate adaptation vulnerability assessment described above.[17]

6.4 LAND TRUST OF SANTA CRUZ COUNTY CONSERVATION BLUEPRINT AND BEACH RANCH PROJECT

The Land Trust of Santa Cruz County is a nonprofit organization dedicated to protecting, caring for, and connecting people to the diverse and extraordinary lands of Santa Cruz County. Its mission is to ensure that the county's wild and working forests, beaches, coastline, unique habitats, and rich agricultural heritage are preserved for future generations. In 2011, the Land Trust of Santa Cruz County released its Conservation Blueprint, a science-based, 25-year planning document and roadmap on how to protect the County's natural resources.[18]

The Land Trust of Santa Cruz County is currently involved in protection and restoration activities near the Pajaro River mouth, restoring marginal non-productive acres to estuarine habitat, and establishing living shorelines that improve water quality, capture and store carbon, and protect inland areas. This has involved the acquisition and conservation of 247 acres at Beach Ranch (Figure 6-1). The Land Trust aims to create a resilient physical landscape that

[15] https://www.santacruzharbor.org/dredging-scientific-studies-reports
[16] https://www.sccrtc.org/funding-planning/environmental-planning/sanv-wa/
[17] https://www.sccrtc.org/projects/trail/monterey-bay-sanctuary-scenic-trail/
[18] https://landtrustsantacruz.org/conservation-blueprint/

protects prime farmland and buffers the surrounding at-risk community from some of the worst impacts of climate disruption.

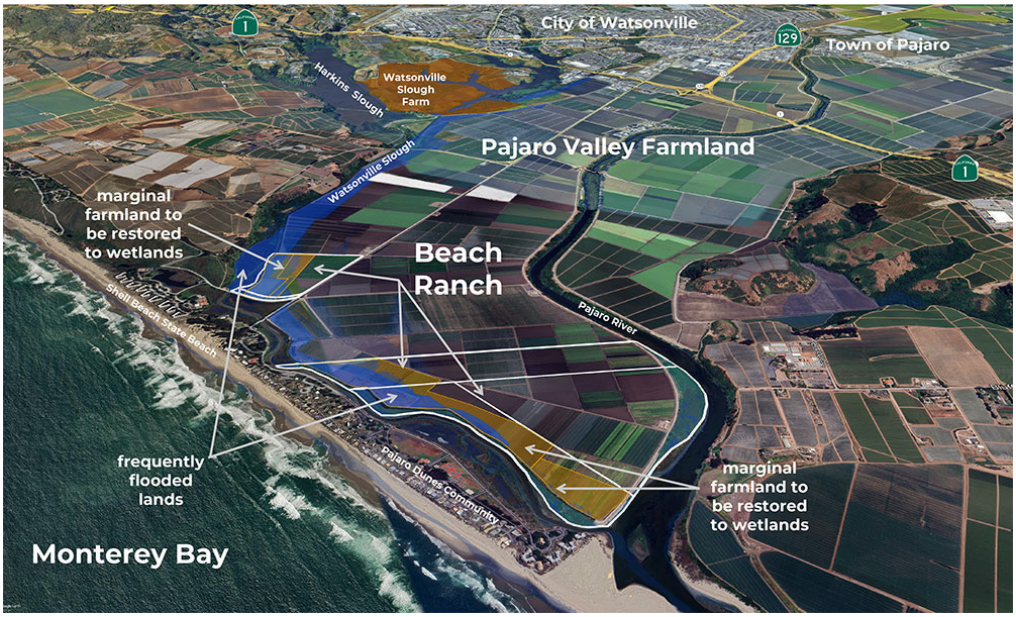

Figure 6-1. Areas Involved in the Land Trust Santa Cruz County Protection and Restoration Activities (Source: Land Trust Santa Cruz County)

6.5 RESOURCE CONSERVATION DISTRICT OF SANTA CRUZ SCOTT CREEK RESTORATION PROJECT

Scott Creek is a small coastal watershed located north of the unincorporated town of Davenport along Highway 1 in northern Santa Cruz County. Its lagoon and marsh ecosystem form a vital mosaic of habitats for numerous native species. To address the ecological degradation of this critical coastal wetland and the challenges posed by aging infrastructure, a multi-agency partnership—including the Resource Conservation District of Santa Cruz County, the Santa Cruz County RTC, Caltrans District 5, and various state and federal resource agencies—has been working collaboratively to develop a comprehensive strategy that balances public access, conservation, and climate change resiliency.

Planning and design phases of the project have been funded through a combination of local resources and competitive grants, including Proposition 1 and 68 funding from the California State Coastal Conservancy and the California Department of Fish and Wildlife. A key innovation of this effort is a Memorandum of Understanding that aligns Caltrans and resource agencies to coordinate technical studies, restoration planning, and a bridge replacement project. This memorandum supports a redesign that extends the bridge span and restores the lagoon and creek outlet to the north, promoting recovery of salmon and steelhead populations, enhancing lagoon function, and improving transportation safety and SLR adaptation.

The Scott Creek project represents a new planning paradigm for major transportation infrastructure—one in which ecological understanding shapes engineering design. By integrating ecosystem restoration with public safety and climate resilience goals, the project offers a transferable model of consensus-driven collaboration that yields innovative, effective, and efficient use of public funds in support of public access, coastal resilience, ecosystem health, and public trust resources.[19]

6.6 COUNTY OF SANTA CRUZ REQUEST FOR PROPOSAL: SANTA CRUZ COASTAL LAGOONS AND EAST CLIFF DRIVE RESILIENCY PLAN

The County of Santa Cruz was awarded a State Coastal Conservancy grant to develop the Santa Cruz Coastal Lagoons and East Cliff Drive Resiliency Plan. The project will develop an initial planning-level feasibility study of nature-based adaptation strategies to SLR for roughly 0.5-mile of East Cliff Drive at three locations where the roadway crosses the three coastal lagoons (Schwan Lagoon, Corcoran Lagoon, and Moran Lagoon) in mid-Santa Cruz County.

The feasibility analysis will analyze a range of adaptation strategies to projected SLR for the three coastal lagoons. The project will result in the identification of a preferred adaptation strategy for each location that prioritizes the use of nature-based solutions, protection and enhancement of coastal resources and ecosystems, maintenance of coastal access, and resilience of infrastructure and property. The project will include beach berm surveys, hydrologic monitoring, and other studies that will result in the development of conceptual models that can predict the response of the beach/lagoon system to various SLR scenarios. The models will be used to guide development of adaptation strategies. Further, significant and robust community, stakeholder, and tribal engagement will be conducted to identify the needs of the community and guide the development of strategies.

The feasibility analysis will lead to the development of a preferred alternative(s) for each location along with a final report detailing the selection of the preferred alternative. The project goal is to identify an alternative that can be further developed through preliminary design, environmental review, final design, and permitting in a future phase (Santa Cruz County 2025).

6.7 BUREAU OF LAND MANAGEMENT, COTONI COAST DAIRIES NATIONAL MONUMENT

Cotoni-Coast Dairies is an onshore unit of the California Coastal National Monument. Near Davenport in Santa Cruz County, Cotoni-Coast Dairies extends from the steep slopes of the Santa Cruz Mountains to the marine coastal terraces overlooking the Pacific Ocean.

[19] https://www.rcdsantacruz.org/scotts-creek

Cotoni-Coast Dairies was donated to the U.S. Bureau of Land Management in 2014 by the Trust for Public Land. Beyond supporting riparian and wetland communities, Cotoni-Coast Dairies' waterways provide important habitat for anadromous and freshwater fish as well as water for the city of Santa Cruz and surrounding communities. The area supports a wide variety of habitats and wildlife, including coho salmon, steelhead trout, California red-legged frogs, mule deer, and mountain lions. A phased approach to recreation development will help protect the property's sensitive biological and cultural resources. The plan identifies half the area as core habitat for fish and wildlife that will have limited recreational access.[20]

6.8 MONTEREY BAY LIVING SHORELINE PROGRAM

The Monterey Bay Living Shoreline Program is developing tools, strategies, and a framework to help California State Parks manage and protect coastlines within the Monterey Bay region.[21] The program focuses on planning and implementing nature-based projects that enhance coastal resilience against the impacts of climate change such as SLR, erosion, and coastal storms. The program is led by State Parks, and facilitated by the California Marine Sanctuary Foundation, Central Coast Wetland Group, Coastal Conservation & Research, and others. The team is developing a prioritization framework for implementing living shoreline projects at state parks, conducting a community engagement project, and simultaneously conducting native planting and restoration efforts at Salinas River State Beach, Natural Bridges, and Rio Del Mar.

6.9 PAJARO RIVER LEVEE REPAIRS

Levees were completed along the Pajaro River by USACE in 1949. Levees along the north bank begin just upstream of the mouth at the Pacific Ocean and continue to approximately River Mile 11.8 (Murphy Road); levees along the south bank begin just upstream of the mouth and continue to River Mile 10.6. The levees increased the capacity of the Pajaro River to 22,000 cubic feet per second (cfs) downstream of Salsipuedes Creek, equivalent to a 25-year flood (Santa Cruz County 2021). Major flooding of the Pajaro River and a breach in the levee occurred in March 2023 and led to widespread flooding in the town of Pajaro in Monterey County, forcing thousands to evacuate and damaging hundreds of homes and businesses.[22] Upgrades and repairs will take around 6 years to complete, working on repairs in sections or reaches. In October 2024, USACE broke ground on improvements to provide 100-yr flood risk reduction in the area.[23] Construction of the project is managed by USACE, the Pajaro River Flood Management Authority, and the State. The Pajaro River Flood Management Authority is a joint

[20] https://www.blm.gov/cotoni-coast-dairies
[21] https://www.mblsp.org/
[22] https://www.kqed.org/science/1994168/the-pajaro-flood-forced-them-to-flee-californias-high-rents-forced-them-to-return
[23] https://www.gov.ca.gov/2024/10/02/pajaro-river-flood-protection-project-breaks-ground/

powers authority of the County of Santa Cruz, Santa Cruz County Flood Control and Water Conservation Zone No. 7, the County of Monterey, the Monterey County Water Resources Agency, and the City of Watsonville (State of California Office of the Governor 2024). Formed in 2021, the agency will plan, finance, and implement projects and programs to reduce flood risk from the lower Pajaro River and its tributaries in Santa Cruz and Monterey Counties.

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Appendix B

Coastal Policy Challenges

Appendix B
Coastal Policy Challenges

Sea Level Rise Vulnerability Assessment Report
Santa Cruz County

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October 5, 2026

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ACRONYMS AND ABBREVIATIONS

CCC	California Coastal Commission
CDP	Coastal Development Permit
LCP	Local Coastal Program
LUP	Land Use Plan
PRC	Public Resources Code
RSL	rural services line
SMP	Shoreline Management Plan
SSRA	special shoreline resiliency area
USL	urban services line

1 INTRODUCTION

This appendix summarizes the primary shoreline adaptation policy challenges for Santa Cruz County as it works to update its Local Coastal Program (LCP) to address sea level rise and coastal hazards. After certification by the California Coastal Commission (CCC), the LCP allows the County to make discretionary decisions on most coastal development permits. This appendix provides some background and discussion of prior policy differences between Santa Cruz County and the CCC, including those underlying the 2022 CCC denial of the County's proposed LCP amendment. It then draws on current CCC policy discussions and actions to identify other challenges and strategies going forward. Issues discussed include the following:

- Background on county development patterns and changes in the coastal hazards policy setting over last several decades
- Adaptation policy challenges, including armoring impacts, the definition of existing development, redevelopment, and disaster rebuilds
- Recommendations for policy approaches in the LCP update, including neighborhood-scale, adaptation pathways planning.

The county's shoreline, which includes both rural shorelines (headlands, dune, cliff and bluff-backed beaches, low-lying coastal lagoons), and highly urbanized beach and lagoon neighborhoods, is already experiencing impacts from coastal erosion, wave attack, and flooding that threaten public access, infrastructure, ecological resources, and private property. In response, the County previously proposed a comprehensive update to its LCP to modernize its coastal hazard policies and improve climate resilience. Like other jurisdictions in California's coastal zone, the County is seeking to address difficult shoreline policy challenges in a manner consistent with the California Coastal Act—the controlling statewide law for LCPs overseen by CCC. These include how the LCP should govern the existing shoreline development and redevelopment, and the impacts of armoring on coastal resources, particularly beach access and public trust resources.

This appendix frames a forward-looking policy discussion considering the recent CCC approval of the Pacifica LCP's Land Use Plan (LUP) and the ongoing statewide discussion of neighborhood-scale adaptation planning between the CCC and local governments. These activities provide potential direction for the County, and coupled with an adaptation pathway approach, point to policy and planning strategies that may bridge the past differences between the County and the CCC. This includes countywide policy and context-driven neighborhood-scale shoreline management approaches to both address Coastal Act concerns and balance shoreline hazards risk reduction with the protection of public coastal resources.

2 BACKGROUND AND CONTEXT

Santa Cruz County's 32-mile shoreline is characterized by more remote and largely undeveloped bluffs in the north, state beaches and agricultural lands in the south, and intensely developed residential neighborhoods concentrated in central coastal areas like Live Oak and Aptos. The unincorporated rural and urban coastline supports vital public access and recreation, a robust visitor economy, coastal ecosystems, and a large amount of private development—much of it sited on eroding bluffs and cliffs, and increasingly reliant on shoreline armoring. The urbanized central shoreline of the County, including the cities of Santa Cruz and Capitola, is about 75% armored (Figure 2-1). In the unincorporated County, most of the existing armoring (both permitted and unpermitted) is along the shoreline between the cities of Santa Cruz and Capitola, and the developed shorelines in Aptos. In 2022, the CCC noted that some of this armoring predated the Coastal Act, some was permitted, some was unpermitted, and some was pending review. In addition, significant portions of armoring were first placed or repaired through emergency actions (CCC 2022, 2025b).

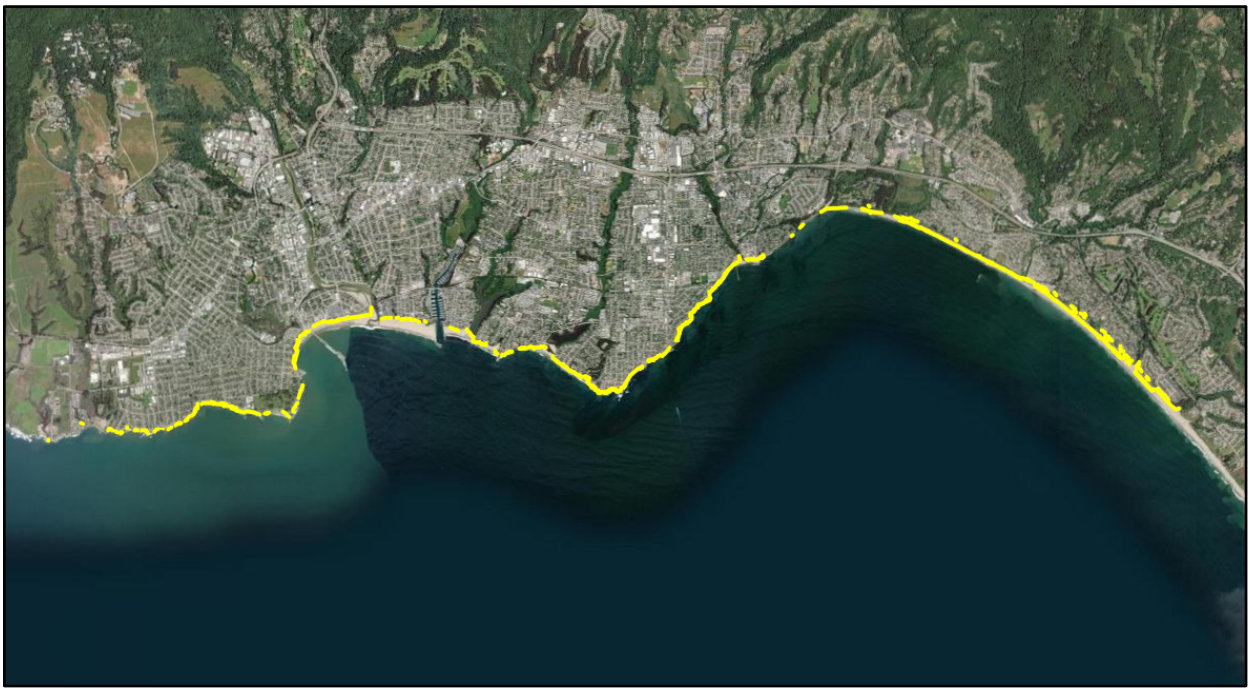

Figure 2-1. Armoring in Urban Santa Cruz County (CCC 2025a)

The County's LCP was originally certified in 1983. Although the County has amended the LCP dozens of times over the years, coastal hazard and other relevant policies have not been amended to address sea level rise. Since the LCP's adoption, coastal conditions and scientific understanding have evolved significantly. Urban development patterns have remained largely the same in the higher-risk, already-developed shoreline zones, but shoreline armoring has

incrementally expanded in these areas. Under the California Coastal Act, local governments take over coastal permitting authority once their LCPs are certified. Santa Cruz County has been the lead coastal permitting agency in the unincorporated areas of the County above the mean high tide since certification of the LCP, reporting more than 3,000 coastal development permits since 1983 (CCC 2025b).[1] Development immediately along the shoreline, though, is often in the CCC's original jurisdiction, and in the case of seawalls and revetments, which may be seaward of or straddling the mean high tide line, the CCC is often the lead permitting authority. Even for areas clearly above the mean high tide, the CCC is typically involved in oversight of local permit reviews given the agency's appeal authority over any local permit between the sea and the first public road paralleling the sea or within 300 ft of the inland extent of any beach or of the mean high tideline (PRC § 30603). This oversight and review may extend Coastal Development Permit (CDP) timelines and create uncertainty for applicants, depending on the significance of the issues being raised and the capacity of the CCC and applicants to address them in a timely manner.

Since the County's LCP was certified, the CCC has continued to apply and refine its interpretations of key Coastal Act provisions that govern new shoreline development (PRC § 30253[2]) and shoreline structures (PRC § 30235[3]), in an effort to minimize coastal hazard risks to development while protecting sensitive resources such as public beaches and habitats (see below). The CCC has developed more specific methods and requirements for assessing development setbacks on eroding cliffs and bluffs (Lester and Matella 2016; Johnsson 2005), refined permit conditions on new development to avoid future seawalls (Lester 2013), and applied more exacting methodologies for quantifying and mitigating the impacts of shoreline structures (like seawalls) on coastal resources (Lester 2005). In the last decade, the CCC has focused increasingly on the long-term acceleration of coastal hazards due to sea level rise, including promulgating interpretive guidance for addressing sea level rise in LCPs and development reviews (CCC 2015/2018/2024). Most recently, the CCC has developed additional guidance to implement new state law directing that environmental justice be taken into account in coastal management decisions (CCC 2019) and promulgated guidance to address the protection of public trust tidelands, particularly in light of projected sea level rise and the coastal squeeze (CCC 2023).

In the context of shoreline hazards, two other CCC policy dynamics deserve mention. CCC has heightened its attention to the question of the definition of an "existing structure" (PRC § 30235[4]) for purposes of implementing Coastal Act policy that limits the potential use of shoreline armoring. This question was recently addressed in the California appeals court concerning a case in Half Moon Bay (see below). CCC also has devoted considerable resources to the challenge of updating LCPs through a statewide grant program launched in 2013. More

[1] The cities of Santa Cruz County have also been certified for more than 35 years with Santa Cruz certified in 1985, Watsonville in 1988, and Capitola in 1990.
[2] California Coastal Act, Public Resources Code Sec. 30000 et seq.
[3] ibid.
[4] California Coastal Act, Public Resources Code Sec. 30000 et seq.

recently the CCC convened a Commission/Local Government working group to consider LCP planning challenges. This effort has helped frame a neighborhood-scale planning approach for ongoing LCP updates. The Santa Cruz County LCP update is being supported with grant funding from the CCC, including for technical analysis with extensive outreach and community engagement.

In 2022, the County submitted a proposed LCP amendment to update the coastal hazards section of its LCP. However, the CCC denied the proposed amendment, identifying what it found to be several areas of inconsistency with the Coastal Act (CCC 2022). In particular, the CCC found the proposal's treatment of shoreline armoring and redevelopment overly permissive, especially with regard to the possibility of including seawall exception areas where the typical application of Coastal Act policies would not allow such an approach. It also observed that it found the policy structure of the LCP as proposed to be amended overly complex. At the same time, both the County and CCC recognized the need for further collaboration to shape a workable and forward-thinking adaptation approach. The 2022 County proposal and subsequent CCC denial helps to frame the adaptation challenges that need to be addressed by the County going forward if it is to be successful updating its LCP to address coastal hazards and sea level rise. The evolution and refinement of shoreline management policy as summarized above must also be considered.

3 KEY ADAPTATION CHALLENGES FOR THE LCP UPDATE

Shoreline management is complex. LCP policies are often detailed and cover many different aspects of resource and risk management. Coastal permitting reviews are equally complex, often resulting in detailed, legally precise development conditions. The history and experience in Santa Cruz County are no exception. Still, several core challenges stand out that need to be considered in the development of a successful LCP update.

3.1 ARMORING IMPACTS: BEACH DEGRADATION, COASTAL SQUEEZE, AND THE PUBLIC TRUST

The shoreline adaptation challenge is particularly acute in Santa Cruz County's urban areas, where armoring already dominates key segments of the shoreline. The adverse impacts of seawalls, revetments, and other shoreline structures have long been understood, such as placement loss—the physical displacement of beach recreational or habitat area due to the placement of a structure on the beach. Shoreline structures may also block lateral beach access, especially at higher tides. Perpendicular structures like groins certainly can do this and may also disrupt surfing areas and other water recreation. Revetments also have a tendency to degrade and sink over time, and rocks and boulders may migrate into the surf zone, becoming a hazard for beach walkers, surfers, and other recreational uses. Shoreline armoring also prevents the natural erosion of a bluff or cliff that would normally contribute sand to the littoral cell, though typically less so than other major inputs like rivers and streams, where each input differs depending on any given littoral cell. Shoreline structures are also a visual blight on natural coastal landforms, especially in places where unplanned and ad hoc responses may add up to a hodgepodge of unnatural incursions along the shore. There are ways to mitigate aesthetic impacts, such as the natural sculpting and coloring of the Pleasure Point seawall—one of the best examples of such impact mitigation in California.

Armoring's greatest impact by far, especially in light of long-term sea level rise, is the "coastal squeeze"—the loss of beach width between rising seas and a fixed backshore—resulting in the cumulative degradation of the beach, including loss of public access, recreational value, habitat, and other social and cultural values inherent in beaches. Fixing the backshore will also eventually prevent the natural recession of surf breaks as they come up against the backshore and may degrade surfing experiences by changing reflective wave patterns. Ultimately, the coastal squeeze may result in the need to reconcile shoreline protection of both private and public upland property with the long-term public trust values inherent in public tidelands—perhaps one of the most difficult long-term sea level rise adaptation issues (Lester 2021).

The CCC's recent guidance concerning protection of public tidelands (lands below the mean high tide) squarely frames a fundamental long-term adaptation challenge for the County and the LCP. Rising seas are expected to move the mean high tide line inland, potentially converting private land into public tidelands under the public trust doctrine. This raises difficult legal and

planning questions about development that over time may eventually come to be located seaward of the public trust boundary.

For example, in a neighborhood like Potbelly Beach, existing parcel maps show private property lot-lines extending well on to the beach, above an identified mean high tide line (Figure 3-1). But we know that sea level rise will drive the mean high tide inexorably inland, as demonstrated by the overlay of modeled shoreline change with future sea level rise (Figure 3-2). This, in turn, will eventually result in the existing revetment coming to be located on public tidelands. It is this future conflict between private and public property rights that raises the prospect of more fundamental policy and political conflict.

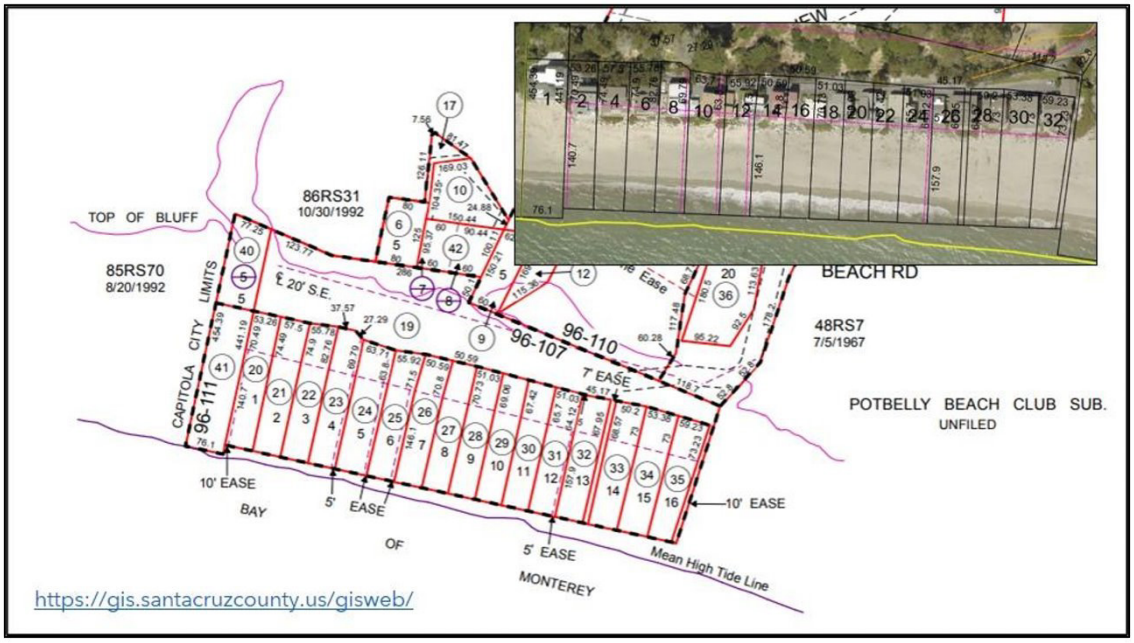

Figure 3-1. Parcel Map at Potbelly Beach in Santa Cruz County (yellow line representing the surveyed mean high tide line at the time of development) (Source: Lester 2021)



Figure 3-2. Shoreline Change at Potbelly Beach with Sea Level Rise (colors represent modeled shoreline change with future sea level rise) (Source: Lester 2021)

The outcome of this future conflict will depend on legal and political factors, and how the County's LCP and other applicable policies plan for it. It is difficult to predict, but at least one case from the Federal Court's ninth circuit suggests that upland development, such as private structures on the beach, may have to yield to the approaching public trust line absent agreement by the public tidelands trustee holders that a trespass of development on tidelands is acceptable. According to the court: they do not have a right to stop the inland movement of the shoreline by armoring absent consent from the tideland owners.[5]

In recent years, the CCC has been anticipating the eventual clash between private upland development and public tidelands by incorporating a recognition of public tidelands into deed restrictions for new shoreline development. These require that homeowners acknowledge that their development may come to be located on public tidelands, and that the development therefore may need to be removed in the future. As discussed above, the County and the CCC were in general agreement on incorporating such requirements into the LCP. Regardless, this looming legal conflict points to the importance of the adaptation planning frame to better anticipate and avoid the deep conflict inherent in the migration of public tidelands with sea level rise. The County's LCP must be able to anticipate and adapt to these changing spatial and legal realities. In doing so, it must safeguard public trust uses—access, recreation, navigation, and habitat—while recognizing the challenges posed to private owners.

[5] *United States v. Milner*, 583 F.3d 1174 (9th Cir. 2009).

3.2 EXISTING DEVELOPMENT

A defining challenge for Santa Cruz County's adaptation to coastal change is the extent and value of existing development in hazardous areas and its vulnerability to future hazards, including those hazards that will be accelerated by sea level rise, such as wave attack, long-term cliff erosion, and extreme storm events. Much of the county's urban coast is largely built-out, consisting of high-value residential properties built on bluffs or behind and on beaches. As summarized above, most of these properties are already armored with seawalls or revetments, a testament to historical storm events and damages and long-term shoreline recession. Properties that are not yet armored are at risk of requiring shoreline protection soon. The vulnerability assessments completed to date project substantial damage and loss as sea level rise and associated effects, like extreme storm damage, increases. Reducing or avoiding these future costs is a central consideration for the LCP update.

3.2.1 Coastal Act Policy

The Coastal Act includes a basic policy for when and how to protect existing development, as well as coastal-dependent uses and public beaches, from coastal hazards. Section 30235[6] states in part:

> 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 from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply.

Accordingly, for the existing developments along the County's shoreline, protective structures such as seawalls or revetments shall be approved if an "existing structure" is threatened by erosion, if the structure is the necessary response, and if the impacts to the local shoreline sand supply are eliminated or mitigated. For example, the law would not allow a seawall to be built for a threatened development if the development could be easily relocated out of harm's way (Lester 2005). Section 30235 would also potentially allow a shoreline structure to protect a threatened coastal-dependent development, such as a seawater intake, or perhaps construction of a sand retention device to protect a public beach—a possibility of potential relevance to consideration of adaptation alternatives to maintain sandy beaches.

3.2.2 The Question of "Existing Structure"

In its sea level rise guidance and in many planning and permit decisions, the CCC has understood "existing structure" to mean a structure in existence prior to the effectiveness of the Coastal Act (i.e., development legally authorized and built prior to January 1, 1977) and

[6] Coastal Act

that has since not been substantially redeveloped (meaning essentially alterations to more than 50% of a structure, see below). As summarized above, Coastal Act section 30235 states that shoreline structures, such as seawalls, "shall be permitted when required to . . . protect existing structures."

The CCC is concerned with the interpretation of "existing structure" because of its implications for allowing future seawall development that would have adverse impacts on coastal resources, including public access (see below). The CCC has thus pressed the question, including in a Half Moon Bay case that was recently addressed by the Courts of Appeal of the State of California, First Appellate District.[7] The court sided with the CCC in December 2024, concluding that "'existing structures,' in context, means structures that existed before the Coastal Act's effective date." In March of 2025 the California Supreme Court declined to review this decision, effectively settling the question of how to interpret the term for purposes of section 30235 review of proposed shoreline structures.

The County's 2022 LCP amendment proposal used the term "existing structure" but did not define it (see Appendix A for more detailed comparison of differences between the County's 2022 LCP update and the CCC's adopted findings concerning key aspects of coastal hazards policy). The CCC found this problematic, concluding in its denial of the amendment that this could lead to new shoreline armoring even in rural areas outside of developed urban areas and rural nodes where the County was suggesting that managed retreat would be the default policy:

> . . . the proposed LUP amendment also lacks clear enough definition for making these important determinations regarding what constitutes a [*sic*] an "existing structure." The lack of clarity on this critically important term means that even in areas outside of the USL and RSL where ostensibly the County's plan is to require managed retreat, it appears that the LCP could be applied by the County to require shoreline armoring for new development proposals (CCC 2022).

It is notable that in the recent CCC approval of the LUP portion of the City of Pacifica's LCP, the CCC observed that the City also had not defined "existing structure" in its submittal. However, citing the Casa Mira case, the CCC noted that its interpretation would apply in the City's application of a proposed shoreline structure policy that essentially mirrored Coastal Act section 30235:

> *As such, while the term existing structure is not explicitly defined in the City's LUP in relation to its armoring provisions, the interpretation of the term absent an explicit definition continues to be structures legally in existence prior to January 1, 1977 and not redeveloped since.*[8]

[7] *Casa Mira Homeowners Association v. California Coastal Commission*, A168645

[8] Pacifica LUP Policy CR-I-32, concerning new shoreline protection structures, states:

As discussed below, the inclusion in the Pacifica LUP of certain zones in the city where the shoreline structure policy (and definition of existing structure) simply would not apply perhaps partly explains why the definition of "existing structure" was not a sticking point in that case. Given the similarities between Pacifica and urban Santa Cruz County, it may be that this approach (i.e., not defining or being silent about the term) would be a practical approach for a new LCP submittal by the County, especially given the outcome of the Casa Mira case since the County's last LCP amendment submittal. Regardless, the County must still address the reality of its urbanized shoreline, made up of both development that might qualify as "existing" under the Casa Mira rule and development that surely would not, having been constructed or significantly redeveloped since 1976. Clearly accepting the definition of "existing structure" as affirmed by the court, then, may be the better and more transparent course of action.

3.3 NEW DEVELOPMENT AND REDEVELOPMENT

The Santa Cruz County shoreline has sections that are urbanized (within the urban services line [USL]), sections that are considered rural but within public service areas (within rural services lines [RSL]), and sections that are rural but without public services. In the 2022 LCP amendment, the County and the CCC were largely in agreement on how to treat new development in locations that did not have existing shoreline structures, such as vacant lots and unconstrained rural areas (Attachment B-1). The more challenging questions concerned how to treat the redevelopment of existing structures in more urban areas, like Pleasure Point, Opal Cliffs, and Aptos.

3.3.1 Coastal Act Policy

In contrast to Coastal Act section 30235, which allows shoreline protection for structures that were existing at the time of the Coastal Act passage, section 30253[9] requires that new development minimize coastal hazards risks and not ever require a shoreline structure. The section states, in part:

> Shoreline protection structures, including revetments, breakwaters, groins, seawalls, cliff retaining walls, deep piers and caissons, and other such construction that alters natural shoreline processes shall only be permitted if consistent with Section 30235 of the Coastal Act, and only when required to serve coastal dependent uses or protect existing structures (including existing critical infrastructure) or public beaches in danger from coastal hazards, when there is no less environmentally damaging feasible alternative and when designed to avoid, and where unavoidable, minimize to the maximum extent feasible adverse impacts on local shoreline sand supply and other coastal resources, where unavoidable coastal resource impacts are required to be commensurately mitigated.

[9] Coastal Act

New development shall:

> (1) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.
>
> (2) 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.

This policy specifically requires that new development not be premised on the construction of a shoreline protective device such as a seawall. Property owners must assume the risks of developing in hazardous locations by assuring that development is located and designed to be safe without artificial means of protection. This requirement is an explicit effort to stop the proliferation of seawalls, revetments, and other shoreline structures that cumulatively degrade the coastline (Lester 2005).

3.3.2 Siting New Development

In the 2022 LCP amendment, the County and the CCC were largely in agreement about the general approach for new development in hazardous areas (Attachment B-1). This included LCP policy language to:

- Require new development to be sited and designed to avoid or minimize hazards
- Use best available science in determining development setbacks, including to account for sea level rise, with a minimum 75 or 100-yr (critical structure) hazards setback (for the life of development)
- Apply minimum 25-ft setbacks
- Require recorded property restrictions on new development that require permit applicants to:
  - Assume and accept risks of hazardous development
  - Waive liability claims against the County/State
  - Indemnify and hold harmless the County/State
  - Acknowledge that the property owner is responsible for any damage
  - Acknowledge flood insurance programs
  - Acknowledge that a Geological Hazard Abatement District or Community Services Agency may form that includes the property
  - Acknowledge that public funds may not be available to continue services for the site and that the County does not guarantee such services and that occupancy of unserved sites may be prohibited

  - Acknowledge that the structure may eventually be located on public trust lands
  - Acknowledge that development may need to be removed or relocated and the site restored

- Not allow subdivision or creation of new lots within coastal hazard zones.

One notable exception to this generally agreeable framework for new development was whether applicants would need to record a property restriction that assured that shoreline armoring would not be constructed to protect the development (waive any rights to armoring that may exist). This is the so-called "no-future seawall" condition used by the CCC for more than three decades, which was not included in the County's submittal. The other major difference in policy was the question of how to treat the redevelopment of existing structures and whether certain sections of the coast would be exempted from the new development policies, discussed in the next section.

3.3.3 Redevelopment and Shoreline Exception Areas

The CCC generally treats redevelopment work that replaces more than 50% of any one structural component (i.e., roof, exterior walls, foundation) of a structure as "new development" for purposes of section 30253.[10] Hence, if a home has been substantially rebuilt, remodeled, demolished and replaced, etc. it must comply with the usual requirements to minimize risks, such as being set back to be safe for its economic life, as well as the requirement to not rely upon or require a shoreline structure to be safe. This policy is critical for framing adaptation options along urbanized shorelines such as the central portion of Santa Cruz County's coast. Regardless of when a structure was originally built, most properties are redeveloped over their lifetime, which can then trigger the requirements for new development. This is a major potential requirement for beach-level and blufftop homes that may already be relying on shoreline structure and/or have little room to comply with the theoretical setbacks that would be needed for a new development to be safe over its lifetime The CCC also looks at the cumulative redevelopment of a structure over time, so a series of small remodels or modifications to a house will at some point trigger a cumulative 50% threshold of change.

The County's 2022 LCP amendment was partially in accordance with the CCC's approach (Attachment B-1). Both the County and the CCC embraced a redevelopment standard based on "50% modification of major structural components" to trigger the rules for new development. However, the County limited this threshold to a period of 5 years, meaning that the clock would start anew after this period. The CCC's approach looked to ascertain the cumulative change in a structure since 1977—its baseline for determining if a structure was "existing" or not for

[10] Currently there are differences between how the County and CCC do this calculation, and methodological alignment will be developed in the LCP amendment.

purposes of section 30235.[11] This is a significant difference for homeowners looking to redevelop their homes without complying with setback rules or the requirements not to rely on a shoreline structure for site safety. The County and the CCC also did not agree on a related policy question of whether setbacks for new development could take into account existing shoreline structures, with the CCC saying no, and the County proposing to allow this approach for legally established shoreline armoring within the USL and RSL.[12] The implications of such a rule for redevelopment options in the urban areas of the County that are already substantially armored or have limited space on parcels for moving development back from the bluff edge, are significant.

The disagreements about redevelopment rules framed a larger disagreement between the County and the Commission regarding so-called exception areas for application of shoreline development rules. The County and the Commission agreed to define a "Shoreline Protection Exception Area" between Soquel Point and Capitola limits or as may be agreed to in a subsequent Shoreline Management Plan (SMP), and both also agreed that existing shoreline protection could be relied upon in this area for determining new development setbacks.[13] The County, though, proposed expanding the exception area to properties in both the USL and the RSL for purposes of calculating setbacks for properties with shoreline structures, to which the CCC did not agree. More significantly, the County also proposed that properties within the USL and RSL be allowed a one-time exception to the 50% redevelopment rules until 2040, and that both existing and proposed shoreline structures could be relied upon within the exception area. The CCC concluded that this set of policies effectively amounted to an overly broad and unacceptable allowance of coastal resource impacts for the foreseeable future.

As a result, the one-time USL/RSL redevelopment exception equates to an allowance for nearly all new shoreline development in the County to rely on and receive protection from existing, legally established shoreline armoring (that could be repaired, maintained, modified, or improved as desired/needed), even though the Coastal Act in most cases limits allowable shoreline protection to structures in existence when the Coastal Act took effect (i.e., January 1, 1977), thus continuing the negative impacts these structures have on coastal resources for the lifetime of a new generation (easily 75 to 100 years) of structures.

The details of the conflicts concerning redevelopment policy are less important than their framing of the larger adaptation challenge on how to address the existing, heavily armored

[11] The CCC also included clarifying that language additions and alterations that lead to more than a 50% increase in floor area for the development or that *cost* 50% or more of the market value of the existing structure before construction would trigger the redevelopment threshold.

[12] Currently, the County asks applicants to "prove" they have an active maintenance agreement and that the established setback is based on a "stable" revetment which doesn't need any repair work to provide a 100-year setback. Alignment between the County and CCC on maintenance of existing armoring will be required for the LCP amendment.

[13] The CCC added language that such development also must enhance resources over the existing baseline.

development pattern of portions of the County's coast with the projected and accelerating sea level rise—the challenge of the coastal squeeze and the public trust.

The challenge is to establish clear and enforceable criteria for when redevelopment triggers adaptation responsibilities, and to apply them consistently across different shoreline areas. Ambiguity in redevelopment definitions can lead to inconsistent outcomes and further appeals.

3.3.4 A Note on Disaster Replacement Policy

Related to redevelopment, the replacement of structures destroyed in a disaster presents a particular challenge in coastal hazards management.[14] California Coastal Act §30610(g) allows in-kind replacement of structures destroyed by a disaster—so long as the rebuild is for the same use, does not exceed 10% more in size, and occupies the same location—without requiring a CDP. Santa Cruz County mirrors this in its local code (SCCC §13.20.063), providing virtually identical criteria for exemption, including inclusion of landscaping and erosion-control features.[15] Together, these provisions remove a common regulatory hurdle from disaster recovery by giving property owners a largely automatic right to rebuild to pre-disaster conditions.

While §30610(g)[16] already provides an expedited path for like-for-like replacement of disaster-damaged structures without a CDP, a recent City of Malibu LCP amendment approved by the CCC further expands and streamlines the §30610(g) allowances (LCP-4-MAL-25-0012-1). The amendment builds on recent Governor's executive orders that suspended Coastal Act and California Environmental Quality Act requirements for Palisades Fire rebuilds and then extends additional exemptions and "*de minimis* waiver" options for future disaster scenarios. These new provisions broaden the scope of exempt or waivable projects to include not just replacement homes in the same footprint but also related site improvements such as replacement or upgraded septic systems, minor driveway and road changes, replacement seawalls in the same footprint, and relocation of structures to new sites on the same parcel if

[14] For purposes of rebuilding under the Coastal Act, the County Code definition of disaster mirrors the definition in the Coastal Act.

[15] 13.20.063. Replacement after disaster exemption.
Subject to SCCC 13.20.060, no coastal development permit is required for the replacement of any legal structure (including associated landscaping and erosion control structures/devices) that existed prior to the occurrence of a disaster, other than a public works facility, that is destroyed by a disaster (i.e., any situation in which the force or forces which destroyed the structure to be replaced were beyond the control of its owner); provided, that the replacement structure will:

(A) Conform to all applicable LCP requirements, including SCCC 16.10.070(H)(4), Coastal Bluffs and Beaches, Alteration of Damaged Structures;

(B) Be for the same use as the destroyed structure;

(C) Not exceed the floor area, height, or bulk (i.e., the total interior cubic volume as measured from the structure's exterior surface) of the destroyed structure by more than 10 percent; and

(D) Be sited in the same location on the affected property as the destroyed structure. [Ord. 5182 § 1, 2014; Ord. 4836 §§ 117, 118, 2006;* Ord. 3435 § 1, 1983].

[16] Coastal Act

deemed "substantially superior" for safety or environmental reasons. The ordinance also establishes a new "rebuild development permit" with a 15-day processing target and no provision for appeal, locally or to the CCC.

The CCC's approval of the Malibu amendment makes post-disaster rebuilding in Malibu even less subject to discretionary coastal review than under §30610(g) alone, effectively allowing for streamlined reconstruction in hazard-prone areas with only limited substantive reassessment of siting, design, or long-term hazard exposure. While the amendment includes conditions to minimize direct impacts to environmentally sensitive habitat areas, public access, and visual resources, it preserves and, in some cases, expands the ability to replace structures in high-risk coastal and bluff-top areas with minimal change from pre-disaster conditions. As a result, the balance tips further toward immediate recovery and property restoration, and away from using the post-disaster window as an opportunity for hazard retreat, risk reduction, or climate adaptation planning. This highlights the policy tension between disaster-relief imperatives and long-term resilience objectives in California's coastal management framework.

In the alternative, a recent action in the City of Rancho Palos Verdes is moving in a somewhat different direction. In August 2025, the City Council introduced an ordinance to permanently prohibit new residential construction—including additions—within the Portuguese Bend Landslide Complex, while still allowing in-kind replacement of existing homes within their original footprint. Owners may apply for an exception (a "Landslide Exception Permit") but must demonstrate, via geotechnical review, that the rebuild won't aggravate hazardous land movement. This approach emphasizes hazard avoidance and perhaps represents a shift from the "automatic in-kind rebuild" model toward a managed retreat–informed strategy that better aligns rebuild rights with long-term safety and risk mitigation.

Taking a step back, short of a prohibition on replacement structures, multiple jurisdictions, including California (and Santa Cruz County), use various hazard policy mechanisms to try to get ahead of the disaster rebuild problem. These include:

- Permanent Buyouts and Deed Restrictions—Government acquisition programs (often the Hazard Mitigation Grant Program under the Federal Emergency Management Agency or the Community Development Block Grant Disaster Recovery program under the U.S. Department of Housing and Urban Development) purchase damaged properties and record open-space deed restrictions prohibiting future habitable structures.
- Hazard Zone Moratoria and No-Build Overlays—Local ordinances or state law designating geologic hazard, erosion, or flood zones where rebuilding is prohibited or severely limited.
- Nonconforming Use and Damage Thresholds—Zoning rules that require destroyed structures to meet current codes; if lots cannot conform (e.g., setbacks, elevation), rebuilding may be denied.

- Insurance and Subsidy Withdrawal—Removal of federal insurance or infrastructure support, such as Coastal Barrier Resources Act designations, which makes rebuilding financially infeasible.
- Limits on shoreline armoring (like California's no future seawall condition) or rolling easements can preclude rebuilding over time.
- Limitations on repetitive loss properties.

However, to be effective, the underlying provisions of the 30610(g) allowances would need to be changed.

3.3.5 Complexity and Internal Consistency of Policy Framework

The County's proposed 2022 LCP revision featured a tiered structure with general policies, shoreline-type policies, and project-type policies. The CCC noted the good intentions behind this framework but also found it to be overly complicated and perhaps confusing and at times contradictory. The CCC's direction was to seek more clarity in the policy framework to assist the public, planners, and applicants to better navigate the LCP and future development permit requirements.

The need for simplicity, as well as the contrasts between the central urbanized shoreline and more rural areas of the County and between rural service areas and more general areas, suggest a planning approach that leverages the neighborhood scale concept and the idea of adaptation pathways. As discussed in the next section, both of these concepts may provide a more intuitive policy framework and help bridge the policy differences between the county and the state, private and public interests, and risk avoidance and coastal resource protection that are inherent in a shoreline development context like Santa Cruz County.

3.3.6 Pathways Forward: Phased, Place-Based Shoreline Adaptation Planning

As detailed in prior sections, Santa Cruz County faces acute policy and planning challenges in updating its LCP to address sea level rise and coastal hazards, especially along its urbanized shoreline where extensive armoring, high-value development, and beach-dependent public uses intersect. Building on the background of past policy differences and recent guidance and actions by the CCC, this section outlines an emerging framework for future adaptation: a phased, place-based approach grounded in neighborhood-scale shoreline management planning and the development of clearly defined adaptation pathways.

This framework draws from recent precedents such as the City of Pacifica's LUP update and aligns with evolving CCC guidance promoting scalable, site-sensitive adaptation strategies. It represents a potential way forward for Santa Cruz County to reconcile Coastal Act consistency

requirements with the realities of its existing development pattern and the need to protect public coastal resources.

3.3.6.1 Phased Adaptation Horizons and Adaptive Management

A fundamental element of the County's proposed LCP amendment in 2022 was its use of a planning horizon—specifically, a time-limited framework to extend through 2040. This kind of phased approach allows for regulatory clarity and a period of policy stability while creating the space to develop more tailored strategies over time. The 2040 horizon provides a clear timeline for the development and certification of more detailed shoreline management strategies. Aligning LCP updates with the County's five-year Local Hazard Mitigation Plan cycle also could facilitate regular review of adaptation progress and integration of new scientific data, legal precedents, and community perspectives.

The phased planning horizon can also support the sequencing of adaptation measures over time—what is increasingly referred to as adaptation pathways. These pathways anticipate a progression of strategies (e.g., armoring, nourishment, accommodation, eventual retreat), tied to physical or social thresholds, that enable communities to progress systematically toward specific shoreline goals and potentially adjust course as conditions evolve. Incorporating this framework into the County's adaptation planning may support long-term resilience while recognizing near-term constraints.

3.3.6.2 Neighborhood-Scale Shoreline Management Plans

Given the variability of shoreline types and development patterns across Santa Cruz County, a countywide one-size-fits-all policy cannot adequately address site-specific risks and opportunities. The County will still need to propose overarching County-wide policies and definitions to meet the basic requirements of the Coastal Act, but the challenge of addressing the diversity of its local shoreline can perhaps be met by the prior approach calling for the development of SMPs for defined coastal segments.

SMPs offer a platform for place-based adaptation planning—the development of tailored strategies based on shared physical characteristics (e.g., bluff stability, wave exposure), land use context (e.g., residential density, infrastructure), and community values. When integrated into the certified LCP, SMPs can function as enforceable planning tools to guide future development decisions, manage risk, and protect coastal resources. SMPs may have unique place-based visions and strategies, but when taken together, SMPs can also address the overarching goals and needs of the County as well as the statewide requirements of the Coastal Act.

Each SMP should consider multiple factors, including:

- Establishing a shared vision for the long-term future of the shoreline segment, based on community input, resource assessments, and input from public interests, including the CCC and other agencies.
- Identifying phased adaptation pathways responsive to local hazard dynamics and development patterns.
- Defining key triggers for transitions between adaptation phases (e.g., loss of beach width, infrastructure exposure).
- Incorporating monitoring and performance metrics (e.g., sediment budgets, access conditions, flood frequency)

Providing a legal and policy framework for balancing hazard reduction and resource protection, as well as consistency with the Coastal Act, both within and potentially across SMPs.

By anchoring adaptation planning at the neighborhood scale, the County can promote greater community buy-in, policy clarity, and responsiveness to evolving conditions.

3.3.7 Time-Limited Armoring and Adaptation Progress: Lessons from Pacifica

The City of Pacifica's 2024–2025 LCP LUP update provides an important case study of how short-term shoreline protection can be integrated into a broader vision for long-term adaptation (CCC 2025c). Pacifica established special shoreline resiliency areas (SSRAs) where armoring is allowed on a time-limited basis (typically 20 years), primarily to protect critical public infrastructure.

Key features of the Pacifica approach include:

- Sunrise provisions, requiring completion of shoreline management planning and demonstration of public benefits before armoring exception policies apply. It should be noted, though, that the CCC expressed some concern that sunrise provisions (such as completed planning and identification of public benefits) should ideally be completed before consideration of the SMP approach.
- Sunset provisions, requiring reevaluation and potential phase-out of armoring exception policies after a defined period unless superseded by LCP amendments implementing long-term strategies
- Structured adaptation pathways embedded in SMPs for each SSRA, linking present-day shoreline management to long-term coastal resilience.

This framework creates a transitional policy space—a legal and practical bridge between the need for near-term protection and the longer-term objective of reducing shoreline armoring. While Pacifica's LUP does not explicitly define "existing structure," the CCC's approval relied on

the Casa Mira decision and conflict resolution provisions of the Coastal Act (PRC §30007.5[17]), which allows balancing of Coastal Act policies in favor of the most protective outcome when conflicts between them are unavoidable.

In Santa Cruz County, a similar structure may be appropriate in urbanized shoreline segments such as Opal Cliffs or Rio del Mar, where high-density development, existing armoring, and public access pressures intersect. Limited-duration allowances for shoreline structures, if linked to defined performance metrics and community-endorsed adaptation pathways, may offer a pragmatic and Coastal Act-consistent strategy. However, such provisions must be carefully thought through, narrowly tailored, time-bound, and tied to mitigation and transition planning toward a broader vision consistent with the overall policy goals of the Coastal Act.

While Pacifica's approach emphasizes time-limited allowances for shoreline protection, another instructive precedent—Santa Barbara County's Isla Vista Bluff Policy—illustrates how a neighborhood-scale plan can be structured around physical hazard triggers that progressively guide properties toward retreat, creating a clear and enforceable adaptation pathway without long-term reliance on armoring.

3.3.8 Case Example of Trigger-Based Adaptation Pathway at Neighborhood Scale

Santa Barbara County's Isla Vista Bluff Policy offers a compelling neighborhood-scale example of how an LCP can operationalize an adaptation pathway through clear, enforceable triggers. Along Del Playa Drive, decades of bluff retreat and sudden collapses prompted the County to adopt a progressive intervention framework, updated in 2020, that escalates property owner obligations as the bluff continues to erode. Action thresholds are tied to measurable physical distances from the bluff edge to a building's most seaward foundation element—20 ft triggers notification and a mandatory geotechnical study, 15 ft triggers a notice of violation if no abatement plan is in place, and 10 ft triggers an order to vacate affected portions of a structure.[18] The updated policy doubled the assumed maximum single-event failure from 5 to 10 ft, based on geotechnical evidence, and requires annual monitoring and site-specific trigger conditions to ensure action is taken before structures become unsafe.

This trigger-based approach effectively functions as a managed retreat pathway, discouraging indefinite reliance on shoreline protection and steering property owners toward timely hazard abatement, often through building cutbacks or relocation. While technically allowing for deep foundation strengthening, the policy's permitting requirements, cost, and uncertainty make it a less favored alternative. Instead, the County relies on a progressive discipline model, integrated with CDP requirements, that aligns hazard reduction with broader Coastal Act objectives to avoid new protective devices where feasible. The Isla Vista program builds on

[17] California Coastal Act, Public Resources Code Sec. 30000 et seq.
[18] The details of any local policy would need to consider realistic implementation scenario(s) for Santa Cruz County.

long-standing LCP provisions that require relocation over armoring and has been reinforced by CCC decisions, such as the denial of a large-scale seawall in 1998 due to feasible non-armoring alternatives.

For other jurisdictions, Isla Vista demonstrates how neighborhood-specific shoreline management can be structured around objective, site-specific hazard triggers; predictable enforcement steps; and integration with both building safety codes and coastal resource protections. Implementing a similar model elsewhere would require consistent bluff monitoring, access to qualified geotechnical expertise, and political commitment to relocation as a long-term strategy. When embedded in a neighborhood-scale SMP, such a policy could provide regulatory clarity, foster community buy-in, and ensure that adaptation decisions are tied to observable physical thresholds. In Santa Cruz County, a trigger-based framework—adapted to local bluff dynamics, land use patterns, and community values—could serve as a practical tool for linking present-day risk management with longer-term retreat or transformation goals, especially in segments where dense development and high public use limit the feasibility of other strategies.

3.3.9 Policy Conflict Resolution and Legal Considerations

Pacifica's LUP also illustrates how the CCC may resolve apparent Coastal Act conflicts when approving LCP updates. In approving the Pacifica plan, the CCC invoked Section 30007.5 of the Coastal Act, which allows for the balancing of competing act objectives (e.g., public access, infrastructure protection, natural resource preservation) when full consistency with all policies is not possible.

This balancing requires a strong factual record demonstrating how specific policies, even if in tension with a single provision, advance the overarching purposes of the act. In Pacifica, the CCC found that allowing limited-term armoring with accompanying public benefits better supported the act's goals than continuing ad hoc shoreline permitting in the absence of a certified LCP.[19]

For Santa Cruz County, this suggests that narrowly defined, time-limited shoreline exceptions embedded within robust SMPs and adaptation pathways could be found approvable under conflict resolution principles—especially where policies:

- Clearly distinguish between areas with different risk profiles
- Are supported by extensive monitoring and review mechanisms

[19] Key to the CCC's findings were the narrow geographic focus and limited duration of armoring allowances, the public-serving nature of the infrastructure being protected, the offsetting public benefits provided (e.g., access improvements, armoring removal elsewhere), and a clear commitment to future shoreline planning and subsequent LCP amendments.

- Contribute net positive benefits to public access, resource protection, or hazard reduction, particularly for other Coastal Act priorities.

Still, such balancing must be approached cautiously and transparently, with the clear goal of eventual transition to more sustainable shoreline strategies.

By integrating phased adaptation horizons, neighborhood-scale shoreline planning, and sequenced adaptation pathways, Santa Cruz County can move toward an LCP update that acknowledges both the urgency of near-term challenges and the inevitability of long-term change. Grounded in community values and Coastal Act principles, this approach provides a roadmap for reconciling local and state interests—and for protecting both coastal resources and shoreline neighborhoods as sea levels rise.

4 CONCLUSION

While much of the policy discourse around updating Santa Cruz County's LCP has necessarily centered on legal definitions—such as what constitutes "existing development," the thresholds for "redevelopment," and the permissibility of shoreline armoring under Coastal Act provisions—these regulatory constructs, while essential, tend to focus on static interpretations of policy. In contrast, the adaptation pathway framework emphasizes a dynamic, forward-looking, and problem-solving orientation. Rather than anchoring shoreline policy in fixed legal categories, adaptation pathways offer a structured process to sequence near-term strategies and long-term goals, allowing communities to adjust in response to changing conditions and shared visions of the future shoreline. This approach can better support inclusive planning, integrate public values such as access and ecological protection, and ultimately foster a more resilient and adaptive LCP. A neighborhood-scale phased planning strategy grounded in adaptation pathways thus provides an alternative—and complementary—paradigm for coastal governance: one that builds trust and flexibility into the LCP, rather than relying solely on legalistic thresholds to determine when and how adaptation must occur.

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Attachment B-1

Summary of Santa Cruz County and Coastal Commission Proposals for New Shoreline Development

NEW SHORELINE DEVELOPMENT

POLICY ELEMENT	SANTA CRUZ COUNTY PROPOSAL	COASTAL COMMISSION PROPOSAL
Framework for new and existing shoreline development (next slide)	• Policies in effect until 2040	• Exception Area policies expire in 2040
	• Seek funding for Shoreline Management Plans	• Shoreline Management Plans Required
	• 5-year reviews/updates with LHMP updates	
Bluff and Shoreline Development Setbacks	• Best Available Science, including SLR, with minimum 75- or 100-year (critical structure) hazards setback (life of development)	• Best Available Science, including SLR, with minimum 75- or 100-year (critical structure) hazards setback (life of development)
	• Minimum 25-foot setback	• Minimum 25-foot setback
	• Exception for a shorter expected design lifespan if property owner accepts risk and agrees to future removal when necessary	• Exceptions for public recreational access and critical public infrastructure; limited space; and avoidance of property takings
	• Setback may rely on existing, legally-established shoreline armoring within Urban and Rural Services Lines (see next)	• Setback shall not factor in the effect of any existing or proposed shoreline protective devices
Policy Exceptions • **Shoreline Protection Exception Areas** • **Urban and Rural Service Areas**	• Shoreline Protection Exception Area is between Soquel Point and Capitola limits or as may be designated in SMP	• Shoreline Protection Exception Area is between Soquel Point and Capitola limits or as may be designated in SMP
	• Within SPEA, blufftop development setbacks may rely on existing and/or proposed shoreline protective devices.	• Within SPEA, blufftop development setbacks may rely on existing and/or proposed shoreline protective devices. Development must enhance resources over existing baseline.
	• Within USL/RSL, blufftop development setbacks may rely on existing and/or proposed shoreline protective devices.	• No USL/RSL Exception

NEW SHORELINE DEVELOPMENT

POLICY ELEMENT	SANTA CRUZ COUNTY PROPOSAL	COASTAL COMMISSION PROPOSAL
Required Recorded Deed Restriction for New Development	Recorded Restriction must • assume and accept Risks; • Waive Liability • Indemnify and hold harmless • State Property Owner Responsible • Acknowledge Flood Insurance programs • Acknowledge a GHAD or CSA may form • Acknowledge that public funds may not be available to continue to services to the site • Acknowledge County does not guarantee services to the site and that occupancy unserved sites may be prohibited; • That the structure may eventually be located on public trust lands; • That development may need to be removed or relocated and the site restored	Recorded Restriction must • assume and accept Risks; • Waive Liability • Indemnify and hold harmless • State Property Owner Responsible • Acknowledge Flood Insurance programs • Acknowledge a GHAD or CSA may form • Acknowledge that public funds may not be available to continue to services to the site • Acknowledge County does not guarantee services to the site and that occupancy unserved sites may be prohibited; • That the structure may eventually be located on public trust lands; • That development may need to be removed or relocated and the site restored
		• Assure that shoreline armoring shall not be constructed to protect the development (waive any rights to armoring that may exist)
Land Division in Coastal Hazard Areas	• Do not allow the creation of new lots or parcels	Do not allow land division, including but not limited to resubdivision, creation of new lots, lot consolidation, and lot line adjustment.

NEW SHORELINE DEVELOPMENT

POLICY ELEMENT	SANTA CRUZ COUNTY PROPOSAL	COASTAL COMMISSION PROPOSAL
Redevelopment Definition	Modification, reconstruction or replacement of 50 percent of the major structural components—consisting of the foundation, floor framing, exterior wall framing, and roof framing—of an existing habitable structure within any consecutive five-year period, or modification, reconstruction or replacement of 50 percent of the major structural components of an existing critical structure or facility, as defined by this chapter, within any consecutive five-year period, whether the work is done at one time or as the sum of multiple projects. For the purpose of this chapter, the following are not considered major structural components: exterior siding; nonstructural door and window replacement; roofing material; decks; chimneys; and interior elements including but not limited to interior walls and sheetrock, insulation, kitchen and bathroom fixtures, mechanical, electrical and plumbing fixtures. The extent of alterations to major structural components will be calculated in accordance with administrative guidelines adopted by resolution of the Board of Supervisors	(1) alteration (including interior and/or exterior remodeling and renovations, demolition or partial demolition, etc.) of 50% or more of the major structural components (including exterior walls, floor and roof structures, and foundations) of such development; (2) additions and alterations to such development that lead to more than a 50% increase in floor area for the development; or (3) additions and alterations to such development that costs 50% or more of the market value of the existing structure before construction. Changes to floor area and individual major structural components and the costs of such changes are measured cumulatively over time from January 1, 1977.
Redevelopment Policy	• In USL/RSL allow one project that qualifies as new, a substantial remodel or "redevelopment/ replacement" before 2040	No allowance

EXISTING SHORELINE DEVELOPMENT

POLICY ELEMENT	SANTA CRUZ COUNTY PROPOSAL	COASTAL COMMISSION PROPOSAL
Definition of Existing Structure	Not formally defined. As applied, means extant at time of review.	A structure in existence prior to the effectiveness of the Coastal Act (i.e., development legally authorized and built prior to January 1, 1977) and that has not been redeveloped since.
Shoreline Protective Devices	Shoreline protective devices shall only be allowed if they are: (1) required to serve a coastal-dependent use; or (2) to protect a public beach or an existing principal structure (2) Least Damaging Alternative; (3) sited and designed to avoid impacts to the maximum possible extent; (4) mitigated in 20-year increments, with reevaluation/permitting; (5) regularly monitored (6) reevaluated if redevelopment; (7) authorized until the existing principal structure that is protected by such a device: (1) is no longer present; (2) no longer requires armoring; or (3) is redeveloped; (8) repaired and maintained as necessary; only temporary if approved as an emergency.	Shoreline protective devices shall only be allowed if they are: (1) required to serve a coastal-dependent use; or (2) to protect a public beach or an existing principal structure* (2) Least Damaging Alternative; (3) sited and designed to avoid impacts to the maximum possible extent; (4) mitigated in 20-year increments, with reevaluation/permitting; (5) regularly monitored (6) reevaluated if redevelopment; (7) authorized until the existing principal structure that is protected by such a device: (1) is no longer present; (2) no longer requires armoring; or (3) is redeveloped; (8) repaired and maintained as necessary; only temporary if approved as an emergency.
	Alternatively, an approved Shoreline Management Plan or projects within a designated Shoreline Protection Exception Area may authorize hard armoring for identified sections of the coast.	*or an existing principal structure that was present in roughly the same form as exists today on January 1, 1977 (and that has not been changed in a way that constitutes redevelopment)

Appendix C

Coastal Processes and Sea Level Rise

Appendix C
Coastal Processes and Sea Level Rise

Sea Level Rise Vulnerability Assessment Report
Santa Cruz County

Prepared for
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October 5, 2026

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ACRONYMS AND ABBREVIATIONS

cfs	cubic feet per second
ENSO	El Niño southern oscillation
FEMA	Federal Emergency Management Agency
IPCC	Intergovernmental Panel on Climate Change
mm/yr	millimeters per year
NOAA	National Oceanic and Atmospheric Administration
PDO	Pacific decadal oscillation
SLR	sea level rise
TWL	total water level

1 INTRODUCTION

The Santa Cruz County coastline is influenced by a multitude of marine forces including tides, waves, and wind, and it extends seaward to the point at which waves no longer interact with the seabed. The county also has a range of backshore types ranging from undeveloped high cliffs and low dunes to development on beaches, dunes, and cliffs. Coastal processes that create coastal hazards include tides, waves, and related storm conditions. Coastal storms, erosion, and extreme high tides are natural processes, but as sea levels rise, these hazards become more frequent and severe, increasing risks to this coastal development.

A combination of large waves occurring at high tides during storm conditions poses the largest potential threat to coastal development and is the most likely to contribute to coastal erosion. Coastal erosion comprises both beach narrowing and dune and cliff retreat. In this study, all of these processes are reported independently; however, they are intimately related. For instance, a narrower beach can lead to increased wave exposure at the top of the cliff, contributing to cliff retreat. In the future, as sea levels rise, both the wave run-up dynamics and the tidal elevations will change, leading to higher total water levels (TWLs)[1] for longer durations, accelerating both beach narrowing and cliff retreat. As a result, sea level rise (SLR) will not create new coastal hazards but will intensify those that already exist. Figure 1-1 illustrates these processes.

[1] An important measure of coastal hazards is the total water level (TWL) elevation, which is the combined effect of wave run-up height, storm surge, tides, and sea level elevations.

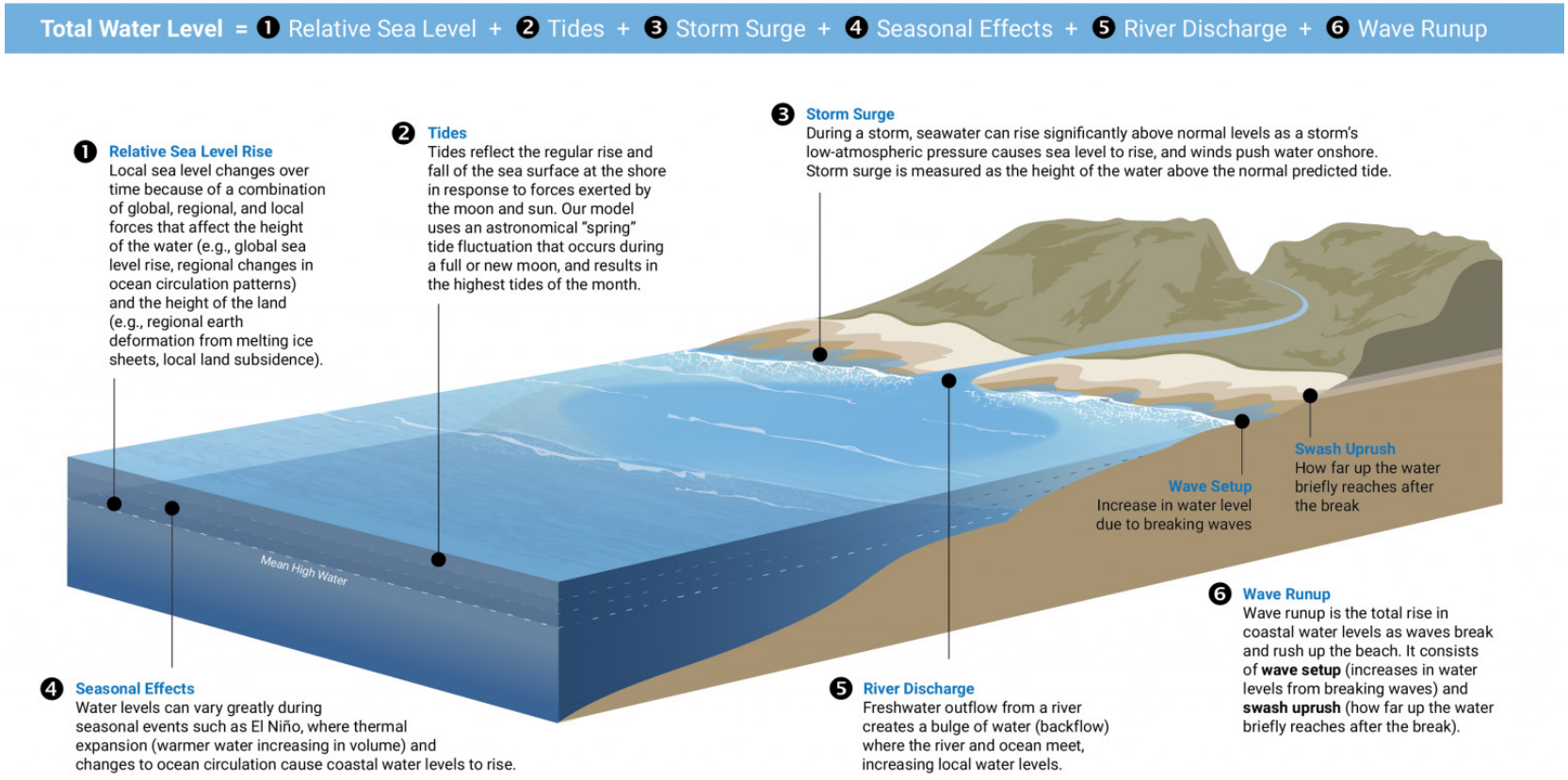

Figure 1-1. Conceptual Diagram of the Components of Total Water Level (Source: Our Coast Our Future Web Platform, Point Blue Conservation Science, and USGS[2])

[2] https://ourcoastourfuture.org/science-and-modeling/

2 INDIVIDUAL COASTAL PROCESSES

This section describes the primary coastal processes influencing shoreline response in Santa Cruz County, including tides, waves, coastal erosion, and beach width variability. These processes interact to control water levels, sediment transport, and shoreline change, and together govern the magnitude and extent of coastal hazards.

Tides establish the baseline water levels along the coast, while waves drive sediment transport and contribute to coastal flooding through wave setup and run-up. Coastal erosion, including both cliff retreat and dune erosion, reflects the combined influence of marine and terrestrial processes. Beach width varies seasonally and over longer time scales in response to wave climate, sediment supply, and SLR. Although each process is described independently in the following sections, they are closely interconnected. For example, changes in beach width can influence wave energy reaching the backshore, thereby affecting erosion rates and flood exposure. Understanding these interactions is critical for evaluating current coastal hazards and how they may evolve under future SLR conditions.

2.1 TIDES

Tides in the study area are mixed, predominantly semidiurnal, and composed of two low and two high-water levels of unequal heights per 24.8-hour tidal cycle. Typically, the largest tide ranges in a year occur from late December to early January when the moon and sun are in alignment and closest in their orbits to the Earth. These astronomically high tides are known as “king tides” and often result in coastal flooding independent of storm events.

Maximum water levels result from the combined effects of astronomical tides, storm surge, wave setup, density anomalies, long-period waves (including tsunamis), and large-scale climate variability such as El Niño and the Pacific decadal oscillation (PDO). On longer time scales, tidal elevations increase as sea levels rise. The National Oceanic and Atmospheric Administration (NOAA) Monterey tide gauge (Station 9413450) provides the closest long-term record for the Santa Cruz region, with a continuous record beginning in the early 1970s.

In addition to mean sea level trends, coastal hazards are typically evaluated using extreme water level statistics associated with specific recurrence intervals (e.g., 2-, 5-, 25-, and 100-yr events). These extreme water levels incorporate the combined effects of tides, storm surge, and other oceanographic processes, and are commonly derived from NOAA tide gauge analyses or Federal Emergency Management Agency (FEMA) coastal flood studies. Representative tidal datums and extreme water levels for the Monterey tide gauge are summarized in Table 2-1. For the Santa Cruz region, these values provide a basis for assessing coastal flood exposure and are used consistently throughout the vulnerability assessment. These elevated water levels, particularly when coinciding with wave events, are a primary driver of coastal flooding, erosion, and overtopping hazards evaluated in this study.

Table 2-1. Tidal datums and extreme water levels at NOAA Monterey tide gauge

Parameter	Elevation (ft NAVD88)	Description
MLLW	0.14	Mean lower-low water
MLW	1.23	Mean low water
MSL	2.97	Mean sea level
MHW	4.78	Mean high water
MHHW	5.48	Mean higher-high water
1-year (99%)	6.78	Extreme water level
2-year (50%)	7.18	Extreme water level
10-year (10%)	7.58	Extreme water level
100-year (1%)	7.98	Extreme water level

Regionally, sea level is influenced by the shape of the shoreline and local wind and weather patterns. For the study area, the relative rise in sea level has been 1.72 millimeters per year (mm/yr), based on monthly mean sea level data collected from the Monterey gauge from 1973 to 2025, with a 95% confidence interval of 0.65 mm/yr (Figure 2-1). This indicates that sea levels have risen ~0.3 ft since the early 1970s. These measured local relative SLR trends when compared to the global average provide a partial estimate of land motion. In this area, the land is rising but just not as fast as sea levels.

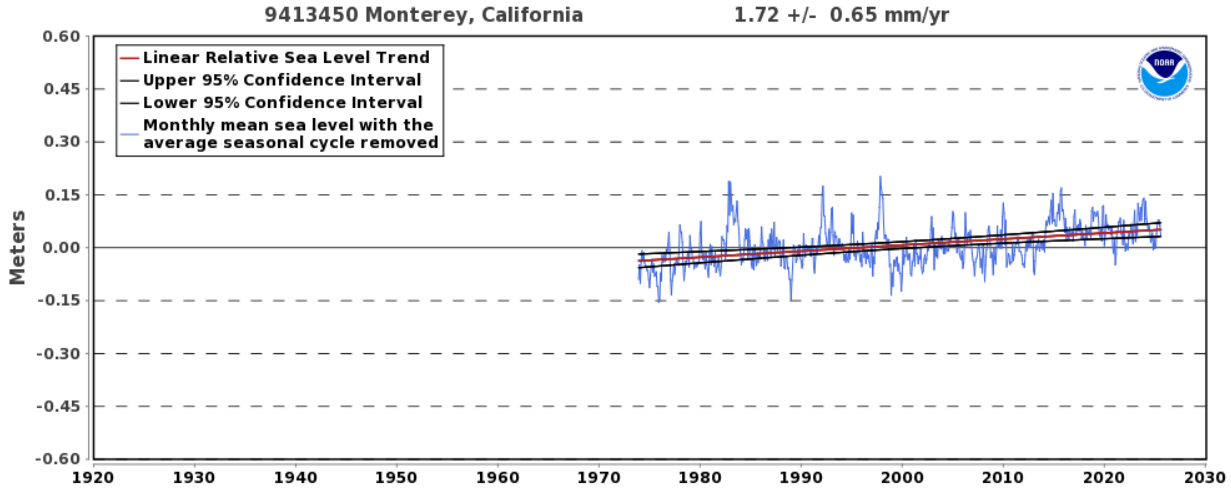

Figure 2-1. Relative Sea Level Trend for the NOAA Monterey Tide Gauge (NOAA Station 9413450[3])

[3] https://tidesandcurrents.noaa.gov/stationhome.html?id=9413450

As sea level rises, higher water levels allow waves to encroach further up on beaches and into low lying areas. Increases in tidal height may also cause localized flooding along river mouth estuaries and the agriculture and urban development located in low-lying areas, leading to periodic flooding at first, and then more permanent inundation.

2.2 WAVES

The waves that approach Santa Cruz County are characterized by three dominant types depending on their wave source and direction. Most wave energy approaches the county from the northwest and west (Storlazzi and Wingfield 2005) by waves generated by cyclones in the North Pacific and tend to peak in wave height during the winter months (up to 25 ft). During the summer, southern hemisphere waves produce smaller waves with longer wave periods (greater than 20 seconds). Between April and October, mid-sized and slightly shorter period wind waves also approach Carmel Beach from the northwest (Storlazzi and Wingfield 2005). In general, smaller waves tend to move sand volumes up the beach profile and feed the dry sand beach while larger waves tend to move sand off the dry sand beach.

The wave climate fluctuates over interannual and longer time periods with ocean-atmosphere oscillations like the El Niño southern oscillation (ENSO). These storms tend to follow a more southerly track when El Niño conditions are strongest, resulting in more erosion potential for the study area. El Niño conditions generally occur every 3 to 7 years, with particularly intense events every 10 to 20 years (Storlazzi and Griggs 1998). There are also longer-term climatic oscillations such as the PDO. PDO warm phases have been associated with periods of increased storm frequency and intensity, resulting in accelerated erosion rates (Russell and Griggs 2012).

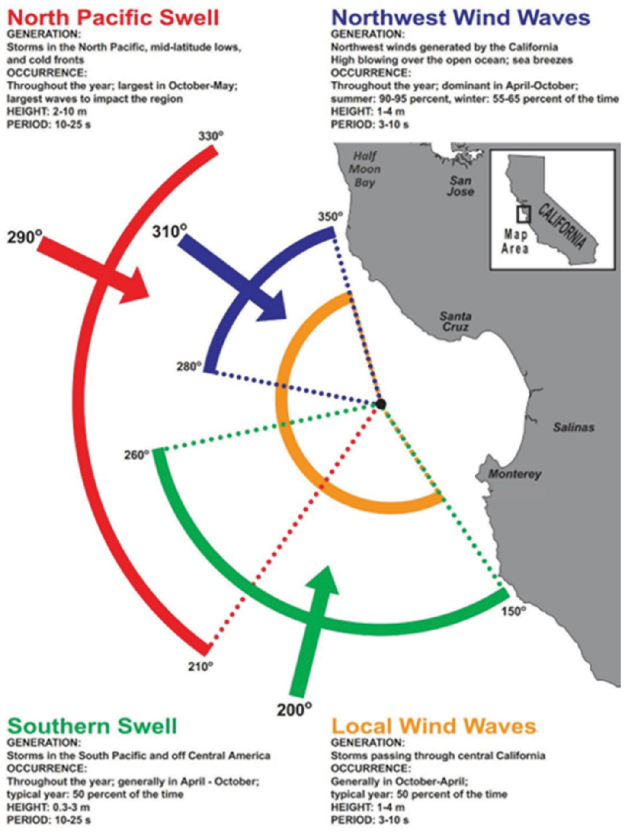

Figure 2-2. Dominant Wave Types, Directions, and Seasons for Carmel Beach and Monterey Bay (Source: Storlazzi and Wingfield 2005)

Historical observations have indicated that the northern half of Monterey Bay from Moss Landing to Santa Cruz is most susceptible to damage when storm waves approach from the west or southwest (Griggs and Johnson 1983). Waves from the northwest, which predominate along the central California coast, undergo major refraction, which results in a significant energy reduction as they bend around a point Santa Cruz to strike the beaches of the inner bay. Thus, although waves from the northwest and north–northwest dominate along this coastline and do impact the open coast northwest of Santa Cruz, their effect on the interior of Monterey Bay is considerably reduced. In contrast, storm waves approaching from the west, west–southwest, and southwest pass primarily over deep water on their way to the shoreline within the bay and, therefore, lose little energy. These waves undergo little refraction before striking the coastline directly and have produced the most consistent damage at the central and southern county coastline.

2.2.1 Nearshore Waves

Coastal storm flooding occurs when elevated water levels generated by storm surge and wave setup exceed predicted tidal levels, resulting in temporary inundation of coastal areas. Storm

surge is driven by wind stress and atmospheric pressure gradients associated with coastal storms, and its magnitude depends on storm intensity, forward speed, and size, as well as the angle of approach to the coastline.

Elevated water levels allow waves to propagate farther inland, increasing total water levels and enhancing coastal flooding, erosion, and overtopping potential. In the nearshore zone, the combined effects of storm surge, wave setup, and wave runup are critical drivers of coastal hazards. With rising sea levels, these processes will occur on an elevated baseline, increasing the frequency and extent of coastal flooding. In addition, climate change is expected to influence storm patterns and intensity, which may further increase the magnitude and impacts of nearshore water levels during extreme events.

2.2.2 Total Water Levels

For this study, total water level (TWL) calculations, conducted by BakerAECOM as part of the FEMA map updates, were used to evaluate the potential extent of coastal flooding along the Santa Cruz County coastline. Wave conditions, including significant wave height and peak period, were derived from NOAA offshore buoy 46042. The coastline was divided into subunits corresponding to FEMA transects, and empirical wave run-up formulation was applied at each transect (Stockdon et al. 2006).

Because large storm waves frequently coincide with elevated tidal conditions, the probability of high total water levels is significant and should be carefully considered in coastal planning, infrastructure design, and hazard mitigation.

2.3 COASTAL EROSION

The Santa Cruz County coastline is composed of a range of geomorphic materials that respond differently to coastal and terrestrial forcing. Backshore environments include 1) marine terraces consisting of unconsolidated sands, clays, and gravels; 2) dune systems composed of relatively mobile sand deposits; and 3) more resistant bedrock formations, primarily sandstone and mudstone. The variability in material properties results in differing erosion rates and mechanisms along the coastline.

The county shoreline includes both cliff-backed and dune-backed segments. Dune-backed areas extend approximately 5.2 miles, representing about 14% of the county's backshore, while cliff-backed shorelines account for approximately 32.3 miles, or 86% of the backshore. These geomorphic settings influence how the coastline responds to wave action, SLR, and sediment supply. The dominant erosion processes affecting cliffs and dunes are described in the following sections.

2.3.1 Cliff Erosion

The Santa Cruz County coastline is characterized by extensive sandstone cliffs, which are highly susceptible to erosion and episodic bluff failure. Along much of the central Monterey Bay coastline, including Seacliff State Beach, these cliffs consist of unconsolidated marine terrace deposits of sand and gravel overlying the Purisima Formation, a sequence of sandstone, siltstone, conglomerates, and phosphorite (Moffatt & Nichol 2024). This layered composition contributes to instability, as weaker overlying terrace materials are prone to erosion and failure when undercut or saturated.

Cliff erosion occurs through a combination of marine and terrestrial processes. Marine-driven erosion is associated with wave attack at the base of the cliff, which can lead to undercutting, sea cave formation, and eventual collapse. The extent of wave-driven erosion is strongly influenced by beach width; wider beaches dissipate wave energy and provide a protective buffer, whereas narrow or absent beaches allow waves to directly impact the cliff face. However, along much of this coastline, direct wave attack on the cliff base is typically limited to large storm events.

Terrestrial processes also play a significant role in cliff retreat. Rainfall, stormwater runoff, and groundwater flow can infiltrate and saturate bluff materials, reducing shear strength and increasing susceptibility to landslides and debris flows. Groundwater movement within the terrace and underlying formations can further weaken internal structure, leading to slope instability. These processes often manifest as rills, slumps, and debris flows along the cliff face, particularly near the bluff crest where active erosion is commonly observed (Moffatt & Nichol 2024). As a result, cliff retreat along the Santa Cruz County coastline is highly episodic, occurring through discrete failure events rather than continuous erosion. The interaction between geological composition, wave exposure, and hydrologic processes ultimately governs the rate and spatial variability of cliff retreat across the region.

2.3.2 Dune Erosion

Dunes are a common feature throughout the southern Santa Cruz County coastline, and at creek and river mouths along the mid-county and north coast. Dune erosion is primarily driven by high-energy waves that undercut the dune toe, leading to slope failure, slumping, vegetation loss, and seaward sediment transport. These processes occur when high water levels allow waves to attack the dune toe or face directly, causing erosion through scour, hydraulic action, and saturated sediment failure, often accelerated in places that lack vegetation. When dunes are allowed to function naturally, they can recover as low-energy waves return sand to the upper beach, and then wind moves this dry sand landward, where it becomes trapped by vegetation or debris.

Dunes are an import feature along the backshore and provide a sediment reserve for beach processes, protect upland habitat from storm surges, and serve as substrate for ecologically

sensitive and valuable coastal ecosystems (FitzGerald et al. 2008). In Santa Cruz County, dunes protect many agricultural areas and residential development from storm flooding and support coastal strand and dune scrub plant communities.

2.4 BEACH WIDTH CHANGES

Beach width varies over both seasonal and long-term time scales in response to wave climate, sediment supply, and sea-level conditions. During the winter months, higher-energy wave conditions, typically associated with North Pacific swell and storm events, drive offshore sediment transport and result in narrower beaches and steeper beach profiles. In contrast, lower-energy wave conditions during the summer promote onshore sediment transport, leading to wider beaches and the development of berms that provide natural protection against wave run-up and coastal flooding. Although daily wave conditions influence short-term beach variability, the majority of long-term erosion occurs during relatively infrequent, high-energy storm events.

Interannual and decadal climate variability also influences beach width. During El Niño events, more frequent and energetic storms from southerly directions increase erosion and reduce beach width, particularly along exposed portions of the Santa Cruz County coastline. Longer-term climate oscillations such as the PDO can further modulate these patterns, with warm phases generally associated with increased storm intensity and erosion, and cool phases associated with relatively milder conditions and improved beach recovery.

Over longer time scales, SLR is expected to result in a landward migration of the shoreline and a reduction in beach width where natural inland migration is constrained. This process, commonly referred to as coastal squeeze, occurs where development, coastal armoring, or steep backshore topography limits the ability of beaches to migrate landward. In addition, human activities such as shoreline armoring, reduction in sediment supply from watersheds, and changes to cliff erosion rates can further limit sediment availability and contribute to long-term beach narrowing.

2.5 SEDIMENT MOVEMENT

The Santa Cruz County coastline is part of the Santa Cruz littoral cell, a largely self-contained sediment system extending from Pillar Point in the north to the Monterey Submarine Canyon in the south, which acts as a primary sediment sink. Within this cell, sediment is transported predominantly from north to south through longshore processes, with estimated net transport rates on the order of approximately 300,000 cubic yards per year (USACE 2015). Sediment movement within the littoral cell reflects a balance between sources, including watershed inputs and cliff erosion, and sinks such as offshore transport into the canyon, resulting in spatial variability between areas of relative sediment surplus and deficit. Regional sediment management strategies have been developed to address these imbalances, including sediment

reuse, beach nourishment, and beneficial use of dredged materials to support shoreline resilience. Sediment characteristics also influence transport dynamics, with the effective littoral cutoff grain size typically around 0.18 mm, below which finer materials are more likely to be transported offshore and lost from the active beach system. Together, these processes govern sediment availability, beach width, and long-term shoreline evolution along the Santa Cruz County coastline.

3 HISTORY OF COASTAL HAZARDS AND EVENTS

The Santa Cruz County coastline is a dynamic landscape featuring a diverse range of cliff and dune formations, as well as diverse coastal development patterns that have evolved over time. The dynamics between landscape and coastal processes have ultimately shaped the coastline into its present state. This section details some of the major coastal hazard events that have occurred over recent memory (dating back to the later 1800s) and is intended to provide perspective on how coastal hazards and the human response interplay on the Santa Cruz County coastline. Large coastal storms along California's west coast often seem random from year to year, but over longer periods, clear patterns emerge that link their frequency and intensity to larger climate cycles. During El Niño events, warmer Pacific waters shift the jet stream southward, bringing more frequent and powerful storms to the California coast. Over decades, the PDO also influences storminess, with its warm phase amplifying El Niño-like conditions and its cool phase generally reducing storm activity. Together with other atmospheric patterns, these ocean–climate interactions create recurring periods of heightened coastal storm activity, even though individual events may appear unpredictable in the short term.

Since the 1910s, there have been at least 20–25 storms that have caused significant and documented damage to coastal assets in this reach. For this 110 year period, this amounts to a large storm every 4 to 6 years on the average. Although no major storms were recorded for some intervals as long as 7 years (1916–1923), in another case, five significant storms hit the coast in a single year (1931) (Griggs and Johnson 1983).

Storm-driven waves have destroyed seawalls, roads, buildings, parking lots, sewer lines, and recreational facilities such as camping sites (USACE et al. 2014). In Santa Cruz County, the winter of 1982–1983 stands out as the storm of record, marking one of the most damaging coastal storm seasons in local history. Driven by a powerful El Niño, that winter brought relentless waves, record rainfall, and widespread coastal erosion that reshaped beaches, bluffs, and infrastructure. However, because the region's instrumental record of water levels and storm impacts is relatively short, it is difficult to accurately estimate the probability of recurrence for storms of similar or greater magnitude, leaving uncertainty about how often Santa Cruz County might experience comparable coastal hazards in the future.

Table 3-1. Major coastal hazard events in Santa Cruz County, 1861–present (Griggs, G, and R.E. Johnson. 1983, Russell, N., and G. Griggs, 2012, and G. Griggs 2024)

Date	Description of Damage
Pre-1861	No verifiable sources have been found dating and estimating damage for floods prior to 1861, although noticeable floods likely occurred within the City of Santa Cruz.

Table 3-1. Major coastal hazard events in Santa Cruz County, 1861–present (Griggs, G, and R.E. Johnson. 1983, Russell, N., and G. Griggs, 2012, and G. Griggs 2024)

Date	Description of Damage
Winter 1861–1862	Bridges and mills upstream of the City of Santa Cruz were destroyed, buildings built on the banks of the San Lorenzo River within the city were washed out to sea, and water eroded 30 ft of soil away from the base of Mission Hill. The upper River Street area flooded. Water levels were approximately 16 ft. After the flood, it was claimed that the river was "several hundred feet nearer to the town" than it had been before. A bulkhead was built to stabilize the riverbank near the plaza (site of Bulkhead Street today). Townspeople began to change the river channel so it would run past Mission Hill rather than straight at it and property owners on what is now Pacific Street began to raise the grade in their lots. No bridges yet spanned the San Lorenzo River, so there were no structures to trap debris and raise the water level behind them. The year 1862 became the legendary flood for late 19th and early 20th century for Santa Cruz locals.
November 1865	A stretch of 500 ft of the Soquel Landing (now Capitola) wharf was lost and the remaining 600 ft was deemed "useless." Pilings were deposited in a potato field beyond the beach. Waves were described as "mountain high."
Winter 1871	This was the first mention of bridge damage from flooding on the San Lorenzo River. Water levels were comparable to 1862, but the damage was estimated at half as much. The bulkhead area was covered by about a foot of water. Flooding was 1–3 ft on east bank area of Broadway/Barson Tract/Riverside/May Street. Basements of buildings on Pacific Avenue flooded. Water level was 16.03 ft at Water Street bridge.
January 1878	Damage caused by heavy winds and rain occurred throughout much of the state. The San Lorenzo River rose 5 ft. An island in the San Lorenzo River had houses on it that had to be evacuated by boat (approximately the location of present day of San Lorenzo Park Plaza Shopping Center).
1880	Flooding occurred along the San Lorenzo River. The bulkhead area was covered by about a foot of water. An island in the San Lorenzo River had houses on it, which were evacuated by boat (approximately the location of present day of San Lorenzo Park Plaza Shopping Center). Water level was 15.11 ft.
1881	San Lorenzo River caused debris flow and storm water floods. Bridges across the river were damaged by flooding. Water level was 15.41 ft.
December 1889–February 1890	Severe flooding occurred, the "highest yet known." The rail bridge pilings at the mouth of the San Lorenzo River are believed to have created a debris dam which made the flood much worse. The rail bridge's failure allowed flood waters to drop. The practice of using pilings to span the river was stopped after this flood. The flood was well remembered for 50–60 years. The bulkhead area was covered by about a foot of water. The Pajaro River Basin also overflowed near Watsonville; water levels were 16.35 ft.
1894	Flooding near Watsonville was caused by overflow of the Pajaro River Basin.
1895	Estimated water level was 16 ft.

Table 3-1. Major coastal hazard events in Santa Cruz County, 1861–present (Griggs, G, and R.E. Johnson. 1983, Russell, N., and G. Griggs, 2012, and G. Griggs 2024)

Date	Description of Damage
March 1905	What was headlined as the worst storm for 27 years visited Monterey Bay. Capitola paid for its advantageous location on the sea beach Sunday night with broken porches, flooded cottages and general wreckage of many of its summer homes. The hotel (which was at the downcoast end of the beach where the Esplanade Park is today) suffered especially from the storm. About 4 ft of water stood in the hotel on Monday morning.
March 1911	More than 2,000 acres of farmland was destroyed along the Salinas River; electric plant and pumping plant were both impacted; oil tanks were half submerged; buildings along river were underwater; debris.
December 1912	Headline “huge breakers rolled over port Watsonville flooding Capalco,” a planned subdivision located north of the current Pajaro Dunes.
November 1913	A severe storm with “monster” waves arriving at high tide washed across the beach at Capitola to the Esplanade and spread “clear to the railroad tracks.” Water reached the Hihn Superintendent’s Building (at Capitola and Monterey avenues).
January 1914	Bridges were damaged; some bridges carried away; torrential rains.
February 1926	Along with the highest tide of the season, a huge 20-ft wave broke. The two bandstands collapsed almost simultaneously, and the Capitola bathhouse and boathouses were washed away by the waves along with beach concessions. High tides reached a block up the main streets and downtown Capitola was under a foot of water. The Venetian Court apartments, which had just been completed and replaced the old Italian fishing village, were flooded and their seawall promenade was broken. Wave run-up reached the second floor of the Hotel Capitola.
December 1931	A violent storm affected much of the California coast. In Capitola, damage was confined to the waterfront area as “waves smashed in several doors and windows in the first row of the Venetian Court apartments, drenching the furnishings and compelling a hasty exodus of residents there.” The casino suffered considerable damage. Timber bulkhead at Seacliff were destroyed and the concession building and bathing pavilion at Seacliff were wrecked.
December 1937	The San Lorenzo River flooded due to heavy rainfall; Soquel Creek flooded the main street of Soquel including houses on Porter Avenue.
January 1939	Capitola seemed to have taken the brunt of this storm as the ocean swept over the Esplanade during the night and brought sand and seawater into the dance floor and up to the bandstand.

Table 3-1. Major coastal hazard events in Santa Cruz County, 1861–present (Griggs, G, and R.E. Johnson. 1983, Russell, N., and G. Griggs, 2012, and G. Griggs 2024)

Date	Description of Damage
January and February 1940	The Capitola waterfront was lashed by one of worst storms in recent years in the morning leaving a trail of havoc. A log jam at Soquel Bridge at Soquel Drive was eventually flooded by Soquel Creek; bridges were damaged; flooding of 1–3 ft of water occurred on east bank area of Broadway/Barson Tract/Riverside/May Street; bridges were damaged by floods; 17.41 ft flood level at Water Street, with 24,000 cfs at Felton.
December 1940–January 1941	Floods of 15.3 and 17.41 ft occurred in the City of Santa Cruz by the San Lorenzo River. Flooding of 1–3 ft of water occurred on east bank area of Broadway/ Barson Tract/Riverside/May Street. Bridges were damaged by floods. At Seacliff, logs up to 10 ft were tossed onto road, houses were damaged, 80 ft of state park was lost, and two sections of bulkhead were ripped out. Later that winter, residents in Seacliff were cut off by slides.
November 1950	Soquel business district suffered damage because a log jam forced water from Soquel Creek into businesses and houses.
December 1955	The costliest, deadliest and most well-known flood occurred in the history of Santa Cruz. Soquel Drive Bridge was destroyed, 40-year flood levels were observed, water reached maximum possible at Riverside Avenue bridge and began to back up (luckily not at high tide); seven people were killed and 390 were displaced in Santa Cruz County; damages were approximately $1 million (in 1955 dollars) in Santa Cruz County. Flooding of 1–3 ft of water occurred on east bank area of Broadway/Barson Tract/Riverside/May Street. Footings of unfinished Highway 1 bridge and Riverside Avenue bridge were damaged; the older half of Soquel Avenue bridge was undermined. Water level at Water Street bridge was measured at 20.8 ft. Basements of buildings on Pacific Avenue were flooded by a few feet. Flows were 30,400 cfs at Felton and 39,000 cfs below Branciforte Creek; 410 acres of land was inundated. Pajaro River severely flooded.
April 1958	Headline: “Spectacular Waves- Damage is Heavy.” In Capitola, waves were surging under the pile-supported businesses along the Esplanade. Boulder Creek Dam was overtopped by flood waters; 250 people in northern Santa Cruz County were evacuated; damage in San Lorenzo River Basin was estimated at $170,000 due to erosion of houses and sediments and bank sloughing. Greater than 14 ft flood stage occurred at Water Street. Flows were 17,200 cfs at Felton and 18,500 cfs in Santa Cruz. Pajaro River was severely flooded.
February 1960	Headline: “Capitola and Rio Del Mar Hit Hard by Gale Winds and Heavy Seas.” Along the Capitola Esplanade, huge waves smashed the beach restaurants and amusement concessions and destroyed the picturesque merry-go-round. Waves rammed against the beach-level Venetian Courts, causing extensive damage to at least 12 of the apartments. Camping sites were destroyed, and the restroom was nearly destroyed at Seacliff.

Table 3-1. Major coastal hazard events in Santa Cruz County, 1861–present (Griggs, G, and R.E. Johnson. 1983, Russell, N., and G. Griggs, 2012, and G. Griggs 2024)

Date	Description of Damage
February 1976	At Seacliff, high waves washed completely over new seawall, carrying debris back to cliff. Portions of the seawall were undercut and caved in.
January 1978	A series of storms emanated from a more southerly direction than normally occurs. These had the greatest effects on west and southwest-facing beaches, and flooded houses and businesses between Capitola and Rio del Mar. Capitola, Rio del Mar and Potbelly Beach were the hardest hit. Jetties and breakwater barriers were overtopped and, in some cases, undermined. Accelerated erosion coupled with rain and saturated ground conditions weakened the foundations of beach-bluff top homes in Santa Cruz County. Seawalls and temporary barriers failed to protect beachfront properties. Capitola Wharf was damaged as pilings were broken loose and the end of the wharf was torn off.
February 1980	Damage totaled $1.1 million at Seacliff. The storm destroyed the entire lower beach portion of park, taking roads, parking lots for 324 cars, and a 2,672 ft seawall.
January 1982	Twenty-two were people killed; Soquel Avenue bridge cracked and partially fell into river; damages to homes and private property were estimated at > $56M; most eastside telephone lines were destroyed. The San Lorenzo River came close to topping the levees in Santa Cruz. Flooding occurred along Branciforte Creek. Water level was measured at Water St. bridge was 18 ft above sea level. Flows were 29,700 cfs in Felton and 33,000 cfs in Santa Cruz below Branciforte Creek. This was a 30-yr event. Some flooding occurred along the southeastern perimeter of Watsonville.
Winter 1982–1983	Several storms during this El Niño winter caused an estimated $200M in damage to houses, businesses, parks, harbors, and public infrastructure in California, and approximately $14M (in 1983 dollars) in damage to the County. Beaches were eroded, Highway 1 eroded at Waddell Bluffs, oceanfront properties and public facilities were damaged by waves and erosion at Seacliff State Beach; Pajaro Dunes foredunes eroded inland up to 40 ft; waves broke through windows, sliding glass doors, and walls in Seascape; beaches scoured and large logs from San Lorenzo river deposited on the beach, which caused damage as waves drove the logs into timber seawalls and oceanfront properties. Several million dollars of emergency rock was brought in and piled against eroding dune faces to protect the Pajaro Dunes development.
January–February 1995	Severe rains led to flooding of low-lying river valley in Santa Cruz County, especially the Pajaro River Valley. The area was declared a disaster area.

Table 3-1. Major coastal hazard events in Santa Cruz County, 1861–present (Griggs, G, and R.E. Johnson. 1983, Russell, N., and G. Griggs, 2012, and G. Griggs 2024)

Date	Description of Damage
Winter 1997–1998	Structures and homes, roads, and bike paths were damaged. Damage was estimated at approximately $6M; damage was not as severe because of better infrastructure built after 1982–1983 El Niño flooding. Flooding was severe, and Santa Cruz County was declared a disaster area due to El Niño. Pajaro River severely flooded. Flooding caused one death and more than $95M of total economic loss, including $67M in damage to agricultural fields and $28M in non-agricultural damage to the Town of Pajaro.
April 2006	Flooding was severe; Santa Cruz County was declared a disaster area.
March 2011	Santa Cruz County was among 19 counties proclaimed by the Governor to be in a state of emergency due to storms between March 15 and 27. In addition, the county experienced severe tsunami damage, causing approximately $20M in damage to the Santa Cruz Harbor.
2014–2016	A marine heat wave event, known as “the Blob,” formed off the coast. This resulted in the largest marine heat wave on record for the North Pacific, and had significant marine ecosystem impacts to kelp, crabs, mussels, sea lions, and many other species.
January and February 2017	Heavy winter rainstorms caused severe damage. There was more than $10M in damage to the city of Santa Cruz from flooding and mudslides, causing road and water system damage (in 2017 dollars). Watsonville slough also experienced failures.
December 2023	A series of significant atmospheric river storms starting in late December of 2023 impacted coastal communities throughout Santa Cruz County, causing widespread damage to homes. President Biden visited the area to survey storm damage, and it was declared a federal disaster.
March 2023	A levee holding back the Pajaro River burst on the Monterey County side of the level, sending floodwaters through the Pajaro community.
December 2024	Large winter storms created heavy impacts on the county coastline. Notably, the end of the City of Santa Cruz Municipal Wharf broke apart and debris was scattered downcoast.

4 COASTAL PROTECTION

Shoreline protective structures are used to protect development and infrastructure from wave action, to avoid erosion and to retain soil adjacent to development. Impacts of constructing and maintaining coastal protection structures include visual degradation of coastal vistas, loss of beach area, restrictions to public access, loss of sand supply from eroding beaches and cliffs, and passive and active down-shore erosion. The most common forms of coastal armoring found on the Santa Cruz County coastline are shore-parallel structures, such as seawalls and revetments, and shore perpendicular structures, such as breakwaters, and groins:

Shore Parallel Structures

- **Seawall:** A seawall is a vertical wall parallel to the shoreline that protects land behind it from wave action, erosion, and flooding. There is approximately 3 miles of vertical seawalls in the county.
- **Revetment:** Also known as riprap, a revetment is a protective structure designed to maintain a slope and is constructed parallel to a shoreline of a sturdy material such as stone. Riprap is the most common form of coastal armoring protection on the Santa Cruz County coastline (Stamski 2005). The longest stretching revetment from the Pajaro Dunes Resort to the Pajaro River mouth in Couth County is approximately 1.7 miles long.
- **Others:** Additional forms of shore-parallel protection include bulkheads, retaining walls, and surface armoring, which are typically constructed to provide localized stabilization and erosion control.

Shore Perpendicular Structures

- **Groin and Jetty:** A groin or a jetty is a rigid linear structure that extends out into the nearshore zone perpendicular to the shoreline and interrupts water flow and limits the down-shore movement of sediment. The primary difference between the two is that jetties completely interrupt or redirect the longshore currents. Groins may be constructed in a series, known as a groin field, to trap sand in between-groin sections along a coast. Unlike seawalls, revetments, and breakwaters, which are constructed to prevent erosion in order to protect buildings and infrastructure, groins are constructed to expand beaches but often reduce beach width down coast of the structures. Locally, there is a groin at Capitola Bech, and there is a jetty at the Santa Cruz harbor.

Much of California's oceanfront development took place between the mid-1940s and the mid-1970s, a period of below-average rainfall and storm frequency that characterizes La Niña periods. Ignorance, coupled with La Niña conditions, created a developed coast that is vulnerable to the more severe and frequent El Niño events of the PDO (Griggs 2005).

Following the destructive winter storms of 1982/1983, local, state, and federal governments as well as private landowners ramped up the construction of hard structures to protect development throughout the county. Between 1983 and 1993, 47 shoreline armoring projects were permitted in the Santa Cruz County Local Coastal Program jurisdiction, with another 13 in the City of Santa Cruz and 4 in Capitola's jurisdictions (CCC 1995). These projects were granted through both regular and emergency permits by the CCC.

Table 4-1. Inventory of existing coastal protection and water control structures in Santa Cruz County

Structure Location	Type of Structure (approximate length)
Davenport / North Coast	Isolated riprap (1,016 ft)
Twin Lakes / Corcoran and Pleasure Point / Opal Cliffs	East Cliff seawall, extensive riprap (13,073 ft)
Seacliff / Rio del Mar / Aptos	Extensive riprap and wood piling structures (15,466 ft)
Pajaro Dunes / Pajaro Valley	Extensive riprap (9,008 ft)

5 SEA LEVEL RISE PROJECTIONS

5.1 GLOBAL PROJECTIONS

The combination of melting land ice and the thermal expansion of seawater due to ocean warming has resulted in global SLR. According to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report, from 1971 to 2018, thermal expansion contributed approximately 50% of observed global SLR, with melting glaciers and ice sheets contributing most of the remainder. Since 1901, the global mean sea level has risen by about 0.20 m (8 in.), with the rate of rise accelerating from 1.3 mm per year (1901–1971) to 3.7 mm per year (2006–2018) (IPCC 2021).

Projections from IPCC indicate that global mean sea level will continue to rise throughout the 21st century and for centuries beyond, even if global warming is limited to 1.5°C. By 2100, relative to 1995–2014 levels, global mean sea level is projected to increase by 0.28 to 0.55 m (11 to 22 in.) under a low greenhouse gas emissions scenario (SSP1-1.9), and by 0.63 to 1.01 m (25 to 40 in.) under a very high emissions scenario (SSP5-8.5). Beyond 2100, SLR will continue for centuries to millennia due to ongoing ocean warming and ice sheet loss, with potential increases of 1 to 3 m (3 to 10 ft) by 2300 under high-emissions pathways.

5.2 REGIONAL PROJECTIONS

Globally, SLR is driven by two primary factors—global ice melt and thermal expansion of seawater—but locally, other factors can alter the rate, extent, and duration of changes in sea level. These processes include "steric variations, wind-driven differences in ocean heights, gravitational and deformational effects, and vertical land motions along the coast," and in California, are additionally affected by movement along the San Andreas Fault and climate patterns in the Pacific Ocean, including the ENSO, PDO, and interdecadal Pacific oscillation (USACE et al. 2014). Large El Niño events can temporarily raise the sea level as much as 3 to 12 in. (10–30 cm) for several winter months (Committee on Sea Level Rise 2012). Because of these variations, accurately predicting sea level over the coming centuries for specific locations is challenging but it is likely that sea level will rise in more than 95% of the ocean by 2100 (IPCC 2014).

Mean sea level on the California Coast rose approximately 8 in. (17–20 cm) over the past century (1900–2005) (Cayan et al. 2008). Since 1993, altimetry data suggest that the global mean SLR rate has increased and is currently 0.17 in./yr (or 0.44 cm/yr),[4] but during this time, data from altimetry and tide gauges show that the mean sea level along the Pacific coast has been more stable due to wind stress (Willis et al. 2025; Bromirski et al. 2011). When the regional climate patterns that drive local sea level trends shift, however, the Central Coast will

[4] https://zenodo.org/records/7702315

likely experience a rate of SLR that will correspond to or exceed the mean global rate of SLR (Bromirski et al. 2011).

5.3 STATE SEA LEVEL RISE GUIDANCE FOR MONTEREY BAY

This study utilizes updated guidance from the California Ocean Protection Council (OPC 2024) and CCC for evaluating future SLR under a range of time horizons and scenarios. The OPC (2024) guidance provides scenario-based projections that support risk-informed planning by linking SLR scenarios to the potential consequences of coastal hazards (Table 5-1).

For general planning purposes, including residential and commercial development, the State recommends evaluating the Intermediate–High scenario, which corresponds to approximately 4.6 ft of SLR by 2100 at the Monterey tide gauge. For critical infrastructure and facilities with high consequences of failure, the State recommends evaluating the High scenario, which corresponds to approximately 6.4 ft of SLR by 2100 (Table 5-1).

The OPC (2024) guidance presents SLR projections using a probabilistic framework that incorporates uncertainty in future greenhouse gas emissions and ice sheet dynamics. For both low- and high-emissions pathways, a “likely range” is defined, representing a 67% probability that SLR will fall within that range. By 2100, the likely range for the low-emissions scenario is approximately 0.9 to 2.3 ft, while the high-emissions scenario yields a likely range of approximately 1.5 to 3.3 ft.

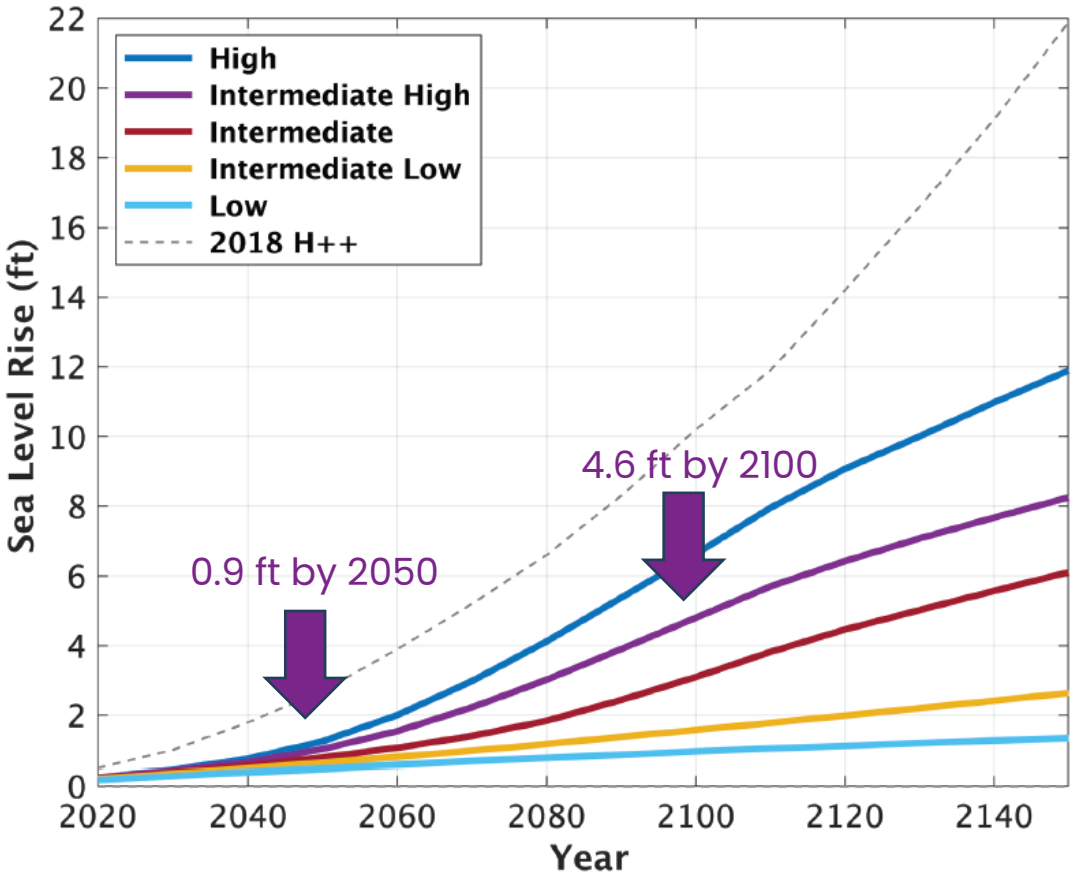

Figure 5-1. The Five Sea Level Rise Scenarios Developed by the California Ocean Protection Council in 2024 (OPC 2024)

Sea-level rise projections for the Monterey tide gauge are summarized in Table 5-1. Under the Intermediate–High scenario, sea level is projected to rise by approximately 0.4 ft by 2030, 0.9 ft by 2050, and 4.6 ft by 2100 relative to year 2000 conditions. Projections under the High scenario reach up to 6.4 ft by 2100, illustrating both the accelerating rate of SLR and increasing uncertainty over longer time horizons.

Table 5-1. Ocean Protection Council 2024 sea level rise table for the Monterey tide gage (OPC 2024)

Year	Intermediate Scenario (ft)	Intermediate–High Scenario (ft)	High Scenario (ft)
2000	0	0	0
2010	0.1	0.1	0.1
2020	0.2	0.2	0.2
2030	0.3	0.4	0.4
2040	0.5	0.6	0.7
2050	0.7	0.9	1.2
2060	1.0	1.4	1.9
2070	1.3	2.1	2.8
2080	1.7	2.9	3.9
2090	2.3	3.7	5.2
2100	2.9	4.6	6.4
2110	3.6	5.5	7.7
2120	4.2	6.2	8.8
2130	4.7	6.8	9.7

The SLR scenarios used for reporting in this vulnerability assessment are summarized in Appendix D. Discrete SLR ranges are grouped into planning horizons to provide a consistent framework for evaluating coastal hazards across time. Existing conditions represent present-day water levels (0 ft SLR), while the near-term (0–1 ft), mid-term (1–3 ft), and long-term (3–5 ft) horizons capture progressively greater changes in coastal processes and flood risk. These horizons correspond approximately to early-, mid-, and late-century conditions and provide a practical basis for comparing results across scenarios and communicating future risk.

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Appendix D

Technical Methodology

Appendix D
Technical Methodology

Sea Level Rise Vulnerability Assessment Report
Santa Cruz County

Prepared for
County of Santa Cruz
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Santa Cruz, CA 95060

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October 5, 2026

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ACRONYMS AND ABBREVIATIONS

BFE	base floor elevation
BRV	building replacement value
CCC	California Coastal Commission
CoNED	Coastal National Elevation Database
CoSMoS	Coastal Storm Modeling System
CPAD	California Protected Areas Database
DDF	depth-damage functions
ESA/PWA	Environmental Science Associates–Philip Williams & Associates
FEMA	Federal Emergency Management Agency
FEMA AE	low velocity flood zone
FEMA VE	high wave velocity flood zone
FIRM	Flood Insurance Rate Map
GIS	geographic information system
Integral	Integral Consulting Inc.
LCP	Local Coastal Program
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NPV	net present value
NRC	National Research Council
OSM	Open Street Map
SLR	sea level rise
TNC	The Nature Conservancy
TWL	total water level
USGS	U.S. Geological Survey

1 INTRODUCTION

This appendix summarizes the technical methods employed in the sea level rise (SLR) vulnerability assessment for Santa Cruz County. Described herein are the sectors evaluated, the assets and data sources evaluated, the coastal hazard models used in the assessment, and the methods used in the vulnerability assessment and economic valuation of the study area's market and nonmarket coastal assets.

2 SECTORS EVALUATED

Reporting of vulnerabilities was organized by the following sectors: land use and structures, utilities and infrastructure, recreation and coastal access, and transportation. Demographic and social vulnerability data are not evaluated explicitly but are summarized in the reporting of neighborhood characteristics.

- **Land use and structures:** Parcels and buildings including residences, commercial, farms, and critical facilities
- **Utilities and infrastructure:** Wastewater, stormwater, and water supply
- **Recreation and coastal access:** Beach recreation, surfing, coastal access, parks, and trails
- **Transportation:** Roads, rail, and bridges
- **Others considered:** Demographics and social vulnerability.

Table 2-1. Inventory of coastal resources and data sources

Asset or Resource	**Source**
Land Use and Structures	
Building Footprints and Building Value	County of Santa Cruz (County), Cotality
Parcels and Parcel Value	County, Cotality
Beach Visitation	Placer.ai
Critical Facilities	County
Utilities and Infrastructure	
Wastewater	County (Pajaro Valley data not available)
Stormwater	County
Water Supply	County (Pajaro Valley data not available)
Recreation and Coastal Access	
Coastal Access	California Coastal Commission (CCC)
Coastal Access Parking	Open Street Maps (OSM)
Parkland	California Protected Areas Database (CPAD), State Parks, County

Asset or Resource	**Source**
Beach Widths	CoastSat and Integral Consulting Inc.
Coastal Trail	OSM
Bike Trail	County, OSM
Restrooms and Park Facilities	County Building Footprints, State Parks
Transportation	
Road Centerlines	County
Rail Centerlines	County
Bridges	County
Demographics and Disadvantaged Communities	
U.S. Census Block Groups	American Community Service, U.S. Census
Disadvantaged Communities	State (CalEnviroScreen 4.0)
Coastal Armoring	
Coastal Armoring	County, CCC

Critical public infrastructure encompasses a range of data from the sectors defined above. As defined in Senate Bill 272, it includes but is not limited to: "...transit, roads, airports, ports, water storage, and conveyance, wastewater treatment facilities, landfills, power plants, and railroads." Other critical infrastructure types that are considered in this study include wastewater pump stations and lines, stormwater facilities, and other utility infrastructure[1].

Land use and structures' market value projections were sourced from Cotality (formerly CoreLogic), a company that provides data on home values for the real estate market. Other data used were the County's Assessor's Parcel data reports assessed values, which is determined by the County to calculate property taxes, and are not reflective of how much a property would sell for in the real estate market. This study utilized the higher of the two values, either the market values from Cotality or assessed value from the County. For each property, values were distributed between the structure(s) on the parcel and land area of the parcel based on the land-improvement ratio in the assessor's parcel data set.

[1] https://legiscan.com/CA/text/SB272/id/2844425

3 HAZARD MODELING FRAMEWORK

3.1 CHOICE OF COASTAL HAZARD MODELS

This study relied on a combination of hazard models, including The Nature Conservancy (TNC) Santa Cruz County Coastal Resilience model (ESA and PWA 2014), Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) maps, and long-term beach change modeling from Integral Consulting Inc. (Integral). The TNC Santa Cruz County Coastal Resilience model is the backbone of the hazard data, and it was chosen over other available hazard models such as U.S. Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) as it provides more refined spatial resolution for cliff and dune erosion and is consistent with the previous County vulnerability assessment from 2017, as well as other assessments conducted by local jurisdictions including the City of Santa Cruz and Capitola.

3.1.1 Coastal Hazard Models

- **Rising Tides**—TNC Coastal Resilience[2]
- **Coastal Erosion (Dune and Cliff)**—TNC Coastal Resilience and the County of Santa Cruz's Coastal Hazard Screening Area[3]
- **Coastal Wave Flooding**—FEMA VE Zone[4] and TNC Coastal Resilience
  - **Recurrence Intervals**—Recurrence intervals and total water levels were sourced from FEMA's Intermediate Data Submittal (BakerAECOM 2014).
  - **Other Parameters**—Beach parameters relied on CoastSat[5] shoreline positions and beach slope, and offshore topobathy from the California Coastal National Elevation Database (CoNED)[6].
- **Low-Lying Flood Prone Areas**—FEMA AE Zone and TNC Coastal Resilience
- **Beach Narrowing**—Integral used CoastSat to document historical beach trends since 1984. Long-term beach widths projections relied on average maximum summer and minimum winter positions from 2019 to 2024 as a baseline. Projections were made for 0, 1, 2, 3, 4, and 5 ft of SLR. This analysis was only conducted for areas where CoastSat

[2] https://maps.coastalresilience.org/
[3] This mapping includes areas with 100 ft of a coastal bluff where a geologic hazards assessment or geologic report is automatically required for all development activities as required by General Plan/Local Coastal Plan Policy 6.2.11 – This layer is available to view on Santa Cruz County's hosted Web Map Service available at: https://www.santacruzcountyca.gov/departments/geographicinformationsystems(gis).aspx
[4] FEMA's Flood Hazards Zones are available at Flood Map Service Center: https://msc.fema.gov/portal/search
[5] CoastSat is a global shoreline mapping toolbox from publicly available satellite imagery: http://coastsat.wrl.unsw.edu.au/
[6] CoNED data can be found on the NOAA Digital Coast Data Access Viewer: https://coast.noaa.gov/dataviewer/#/

transects occurred and omits areas of the coast with cliff-backed shorelines and some of the small pocket beaches.

3.1.2 Model Descriptions

3.1.2.1 The Nature Conservancy Coastal Resilience Hazard Layers for Monterey Bay (2014)

The TNC Santa Cruz County Coastal Resilience hazard model was published in 2014 by Environmental Science Associates (ESA) and Philip Williams & Associates (PWA) and was funded by TNC and prepared for the Monterey Bay Sanctuary Foundation to cover southern Monterey Bay and all of Santa Cruz County.[7] The TNC model did not account for coastal armoring when predicting future cliff erosion rates. Integral, working with the County of Santa Cruz coastal armoring geographic information systems (GIS) layer (which was built on and improved upon the CCC layer), determined areas of the coastline that were either protected or unprotected by coastal armoring. These areas were then used to amend the TNC model to include areas that are either "with" or "without" coastal armoring.

The TNC model relied on prior sea level rise guidance from the 2012 National Research Council (NRC). Due to the difference between this prior scientific guidance, and most current 2024 California Ocean Protection Council guidance, a crosswalk was formed to link the SLR elevations to the most up-to-date guidance.

The original TNC work evaluated three SLR scenarios—Low, Medium, and High—with up to 5.2 ft of SLR by 2100. Results were available in four time steps: Existing conditions (2010), Near-term (2030), Mid-term (2060), and Long-term (2100). As time has passed since this model was created, the timing assumptions from this model were translated into existing conditions of 2020 and a near-term of 2040. This change incorporates the fact that SLR in the near-term has not been as high as the assumptions used in this model. In addition, three other horizons were evaluated including a mid-term of 2060, mid- to long-term of 2080, and a long-term of 2100.

Table 3-1 links the two studies' assumptions.

[7] At the time of writing, these layers are no longer hosted on the TNC Coastal Resilience Mapping Portal: https://maps.coastalresilience.org/. These data may available online in the future either on the TNC website or another location.

Table 3-1. SLR scenarios for this study vs. 2014 TNC model scenarios

THIS STUDY (2024)		TNC MODEL (2014)		
Year	SLR Assumption (ft)	Year	SLR Assumption (ft)	Scenario
2020	0	2010	0	N/A
2045–2060	1	2030	0.7	High
2060–2085	2	2060	2.4	High
2075–2100	3	2100	2.9	Mid
2090–2100+	5	2100	5.2	High

The TNC model also included a range of assumptions on future storminess. For this study, the "with storm" scenario was used, and the "stormier" scenarios were used for 2080 (approximately 3 ft of SLR) and 2100 (approximately 5 ft of SLR). The stormier scenarios assumed an increase in storm intensity due to climate change.

3.1.2.2 Coastal Erosion Hazard Area Supplement—Santa Cruz County Coastal Hazard Screening Area

The TNC model's coastal erosion hazard layer was projected inland from a bluff or dune crest line that was manually digitized by the scientific team at ESA and PWA. The bluff or dune crest delineation process relied on the interpretation in the change in slope from elevation data in 2010 and ultimately came down to analyst decisions.

The County of Santa Cruz also maintains an erosion hazard layer known as the Hazard Screening Area, which is used to determine if a geologic hazards assessment or geologic report is automatically required for development activities as required by General Plan–Local Coastal Plan Policy 6.2.11.[8] This layer relies on a different interpretation for the location of the bluff top edge and is projected backward 100 ft from that location. To maintain consistency with the County hazard screening areas and to account for better present-day cliff edge delineations, the County's hazard screening layer was amended to the TNC model results for the 2100 coastal erosion hazard zone. While the County's coastal hazard screening area is an overlay and not a projection of anticipated coastal erosion, it does pick up areas where future coastal erosion may be a concern and thus incorporated to create a more conservative erosion hazard

[8] The General Plan 2030 and Local Coastal Program is available at: https://www.santacruzca.gov/Government/City-Departments/Community-Development/Long-Range-Policy-Planning/Ordinance-Policy-Updates/Downtown-Plan-Expansion/General-Plan

area. These amendments to the hazard layer primarily extended the zone along the County's rural coastline and had limited impact on the develop coastline.

3.1.2.3 FEMA Flood Zones

The National Flood Insurance Program, administered by FEMA, generates regulatory FIRMs that are used to identify base flood elevations according to a 1%-annual-chance total water level (TWL) elevation at the coast. FEMA updated the Pacific Coastal flood maps through the California Coastal Analysis and Mapping Project in 2018. Supplemental and supporting data related to this mapping project was provided by AECOM.[9]

3.1.2.4 CoastSat

CoastSat data were used for seasonal and long-term beach width change analysis, as well as serving as a baseline for projecting long-term beach narrowing due to SLR.

The CoastSat project is an open-source and joint development effort between the Water Research Laboratory of the University of New South Wales in Sydney and USGS (Vos et al. 2019).[10] CoastSat extracts shoreline positions from Landsat 5, Landsat 7, Landsat 8, Landsat 9, and Sentinel-2 satellite images with a horizontal accuracy of ±10 m (33 ft) and provides the largest repository of historical shoreline positions for the County.

CoastSat delineates the shoreline as the wet/dry line in each satellite image. Beach widths represent the visible dry sand beach and are representative of the distribution of sand across the entire nearshore profile. This wet/dry line was determined at every time step where there was a non-obscured image (unblurred by cloudy or foggy weather) available; about monthly or bimonthly.

CoastSat transects occur approximately every 100 m for all the major beach-backed shorelines in the county; however, these transects do not always capture the full geometric complexity of the coastline, and may omit ephemeral and small pocket beaches. In total, the unincorporated County study area encompasses 297 transects and 197,599 observation records.

3.2 APPLICATION OF MODELS TO COASTAL HAZARDS

Due to the specialized nature of the models and the unique needs of each hazard reviewed in this report (storm wave flooding, coastal erosion for both cliffs and dunes, beach narrowing, compound flooding, rising tides and other hazards), each hazard layer is a patchwork of models

[9] FEMA Region IX California Coastal Analysis and Mapping Project / Open Pacific Coast Study Intermediate Data Submittal
[10] CoastSat Live provides a location to view the data: http://coastsat.space/

and modeling decisions tailored to the unique attributes of the county shoreline and each hazard. A description of that decision-making process is outlined below.

3.2.1 Storm Wave Flooding

Flooding along the Santa Cruz County coastline is dominated by various processes depending on location and geomorphology. Within the TNC model, the shoreline was divided into regions based on two major dominant processes and included storm wave run-up and flooding associated with beach berm closure of seasonal lagoons. The major flood processes that were not considered included flooding from large precipitation events and riverine flooding.[11] When combined with high tides and SLR, these processes significantly contribute to flooding along major creeks and rivers in the study area. To account for this, the FEMA low velocity (AE) flood zone was used to supplement the TNC model in the low-lying Rio del Mar Flats area of neighborhood the Seacliff / Aptos / Rio del Mar neighborhood, a location where pluvial and fluvial flood processes lead to significant flood hazards.

The storm wave flood hazard extent included the furthest extent of storm wave flood waters from the TNC model and existing conditions FEMA flooding (100-year storm wave event, or a 1% annual chance storm) high wave velocity (VE) zone. For the TNC modeling, hazard extents were mapped as the 100-year storm wave run-up extent, and flood recurrence relied on wave and tide data up until the time of study (2014), with the storm of record based on the worst-case storm (1982–1983 El Niño). The storm wave hazard zone excluded wave flooding in areas that are low-lying but hydraulically disconnected from the ocean.

For cliff-backed shoreline areas, wave run-up did not extend into areas that were projected to be eroded in the future. For the dune-backed shoreline, coastal wave flooding was assumed to move inland along with dune erosion and migration in response to SLR. No armoring scenarios were considered for storm wave flooding. The only location where increased wave overtopping with SLR was made was at Via Gaviota along the Aptos coastline. The wave overtopping analysis was based on desktop review of the BakerAECOM TWL elevations and the height of the recurved seawall. It was assumed the seawall would be effective at preventing wave overtopping from a 100-yr storm until 2 ft of SLR and thereafter would experience overtopping.

3.2.2 Coastal Erosion (Cliff and Dune Erosion)

Two types of coastal erosion hazard zones were used for this study, coastal cliff and coastal dune erosion. This separation was used to provide a distinction between the type of erosional processes that could occur. For coastal cliff erosion, the coastal erosion hazard areas represent the potential maximum retreat of the bluff at any given SLR horizon. For coastal dune erosion,

[11] Climate change may also increase rainfall intensity, which would increase flood extents along creeks and rivers; however, this was not modeled in the TNC study.

the coastal erosion hazard areas represent the potential retreat of the of the dune crest at any given SLR horizon.

The TNC model assumes a spatially variable long-term erosion rate for the entire coastline and adds the erosion extent that could be caused by a large storm event (100-yr) as an additional offset to account for the episodic nature of coastal erosion. The potential erosion extent due to a large storm event was estimated using a geometric model originally proposed by Komar et al. (1999) and applied with different slopes to make the model more applicable to SLR (Revell et al. 2011). Following FEMA guidelines, the erosion extent was limited by a duration factor of 50% for cases of activated backshore erosion to account for material that would be provided to the beach from the backshore.

As an added factor of safety, for the 5-ft SLR scenario, the county's coastal hazard screening areas were blended with the TNC hazard extent. For most of the developed county shoreline, this had marginal to no impact on the projected erosion extents at 5 ft of SLR; however, for some rural areas of the north and south coasts, this extended the hazard area by up to 80 ft.

This study evaluated coastal erosion scenarios that consider a with coastal armoring ("hold the line") scenario and a without coastal armoring, or natural erosion ("let it go") scenario. "Hold the line" was developed for 0, 1, 2, and 3 ft of SLR horizons and assumed that backshore erosion is halted at the location of coastal armoring. "Let it go" was developed for 0, 1, 2, 3, and 5 ft of SLR horizons and assumed natural erosion. By 5 ft of SLR, only the "let it go" scenario was run for the vulnerability assessment.

To build the "hold the line" model, a line was cast perpendicular to the coastline from all coastal armoring structures, and the area behind this line was used to develop the "with armoring" coastal erosion hazard scenario. If a property or structure lies completely within this area, the property or structure is considered completely protected. However, if any portion of the property or structure are partially protected and partially exposed to erosion, then the property or structure is considered to be impacted by erosion hazards.

3.2.3 Beach Narrowing

Along the Santa Cruz County coastline, short-term (day-to-day to seasonal duration) shoreline position changes are driven primarily by wave conditions. Long-term shoreline changes (multi-year) are influenced by the balance of sediment supply, high-energy wave events (especially during El Niño events), SLR, and human interventions such as sand bypassing at the harbor.

To provide a greater understanding of these changes, short- and long-term shoreline positions were derived from CoastSat, which provides bimonthly satellite-derived shoreline positions, delineated as the wet/dry line, from 1984 to the present. The CoastSat data set provided high spatial and temporal resolutions to give an understanding of both seasonal and long-term beach width change. This allowed the study team to develop beach width narrowing projections for both average summer and winter conditions, as well projections at a spatial

scale and level of precision that is greater than what existing beach width narrowing models could provide.[12]

Long-term beach narrowing projections were modeled by Integral in 2025 and represent the projected average width for both winter and summer shoreline positions for all SLR horizons. Average winter and summer beach positions were projected using the Bruun rule slope,[13] which was used to estimate beach width change by assuming the conservation of sediment and an equilibrium profile shape. This procedure was done for each of the following two scenarios: 1) "hold the line," where it is assumed that the current armored backshore does not retreat inland with SLR, and 2) "let it go," where the beach is unrestricted by the backshore, but still constrained by the extent of cliff and dune erosion. Only the "hold the line" scenario is reported in the vulnerability assessment findings as it reflects the expected near to mid-term future, but both scenarios are used in the evaluation of adaptation alternatives.

Average beach widths with SLR were derived by calculating the distance from the projected shoreline position to the back of the beach, or backshore line. The backshore line was manually digitized and defined by the toe of coastal armoring or the toe of the cliff or dune as defined by a slope breakpoint from the County's GIS slope layer. The backshore line was then ground-truthed using high-resolution aerial photographs and adjusted as needed.

Beach narrowing was projected from both peak summer and winter positions, represented as the average August beach and average February beach for the past 5 years (2019–2024). These months were chosen as benchmarks as across the entire data range, as August was most often the widest beach, and February was most often the narrowest.

3.2.4 Flooding in Low-Lying Areas Including Lagoons and Waterways

The TNC model molded flooding-associated beach berm closure of seasonal lagoons for low-lying areas along the county coastline using a "bathtub" type model, which simulates flooding by identifying all low-lying areas below a certain water surface elevation. For Pajaro Valley, to estimate the potential worst-case scenario of a closed Pajaro Lagoon flooding, a maximum beach berm elevation of 16 ft North American Vertical Datum of 1988 (NAVD88) was considered for the Pajaro River mouth. For the rest of the county's lagoons, a flood elevation of 14 ft NAVD88 was considered. This elevation represents the flood risk associated with an unmanaged river mouth that is allowed to naturally aggrade and close under existing conditions. The chosen elevation was based on geomorphic interpretation of sediment grain size characteristics, beach slopes, and wave exposure. For future conditions with SLR, the

[12] CoSMoS Coast data was considered; however, the spatial resolution and accuracy was not well suited for this study, and there appeared to be some issues with the model. For instance, even at 10 ft of SLR, the CoSMoS Coast model still showed hundreds of feet of beach width remaining along many sections of the county coastline, which does not align with reasonable inferences for beach response to 10 ft of SLR.

[13] The Bruun (1962) Rule provides a mathematical model to estimate coastal retreat due to SLR. It assumes a linear relationship between SLR and shoreline recession based on equilibrium profile theory, and shifts the beach profile upward and landward by a distance determined by SLR and the geometry of the profile.

beach berm elevation was assumed to rise with sea level to project future flooding extents associated with a seasonally closed lagoon.

As described in the storm wave flooding section above, the TNC model did *not* consider contributions from upland fluvial (river) flooding and local rain/run-off drainage, which likely play a large part in coastal flooding, especially around coastal confluences where a creek meets the ocean. To better account for these processes, the FEMA AE Flood Hazard Zone was supplemented with the TNC Coastal Resilience hazard layers in Rio del Mar Flats.

3.2.5 Rising Tides

This hazard represents daily high tide flooding and was sourced from the TNC Coastal Resilience model. This includes both topographically connected and disconnected areas to account for groundwater connectivity.

3.2.6 Other Hazards

For emergent groundwater with SLR, the study team relied on the USGS CoSMoS groundwater model. Overlay analysis of emergent grounder areas with asset sectors was not conducted in the vulnerability assessment. Instead, these data were used to inform qualitative discussions of where emergent groundwater hazards may be present with SLR.

Tsunamis were not evaluated as part of this study and are considered as part of the County's Local Hazard Mitigation Plan.

3.2.7 Model Uncertainty

There are inherent uncertainties in a coastal hazard model that stem from complex interconnected factors, including natural variability in climate patterns, coastal systems, and geomorphic response, as well as limitations in inputs to modeling data. To account for uncertainty, the study team utilized projections that are weighted towards more conservative assumptions and probabilistic methods to report potential impacts to structures along the county coastline (see Section 3.5).

The coastal erosion hazard zones are not predictions of a future cliff top or dune crest, but rather envelopes of potential erosion extents areas. It is highly unlikely that all of this erosion would occur simultaneously; rather, multiple cliff failures would occur along the coast in different locations. This means that cliff failure distances could extend within the limits of this area in any location, but may extend further, due to the high uncertainty associated with coastal erosion processes and the regional scale of analysis. For instance, the cliff erosion models used in this study do not account for the evolution of nearshore slopes over time, including the beach and shore platform, which are likely to evolve as sea levels rise and erosion forcing conditions change.

Within the TNC model, these factors and others that lead to uncertainty in erosion distance are partially addressed within each analysis block by including an uncertainty buffer that is calculated based on the alongshore range in erosion rates per block, but significant variations in the range of erosion extents exist in the historical data, and future erosion may also vary substantially by location. Therefore, these hazard zones do not define boundaries between inherently risky and risk-free areas, but rather provide a conservative hazard extent that are intended for planning purposes only.

In some cases, coastal erosion hazard zones may vary significantly between two adjacent areas. This is due to the variability in factors that can influence erosion modeling such as slope, geology, wave exposure, and historical erosion rates. These differences are most pronounced at the transitions between cliff-backed vs. dune-back shorelines. This is due to the difference in the modeling approach that was employed between these two different backshore typologies.

3.2.8 Coastal Armoring Assumptions

There are more than 10 miles (54,300 ft) of coastal protective structures (seawalls and riprap) covering 8.6 miles of linear coastline in unincorporated Santa Cruz County.[14] These structures resist wave-induced erosive forces, protecting properties and buildings from damage or loss. For the vulnerability assessment, this study assumed that properties located behind these structures were protected from coastal erosion.

One of the controversies in the previous County Local Coastal Program (LCP) policy effort and CCC directives has revolved around coastal armoring to protect private residential property. The goal of this study is to provide a comparison between armored and unarmored adaptation approaches and to evaluate potential impacts to beaches and recreation, assuming coastal armoring is to remain in place. Specifically, assumptions are made around existing coastal armoring (i.e., whether they will continue to be maintained, rebuilt, or removed) and when in the future the removal will happen. As a site-by-site decision on when this would occur would be onerous at a County-wide scale, the assumption around coastal armoring was made for the entire coastline and was based on discussions with County staff. This study settled on the assumption of a “with” and “without” coastal armoring scenario for 0, 1, 2, and 3 ft of SLR. By 5 ft of SLR, all armoring was assumed to have been removed or no longer effective.

Because the life span of coastal infrastructure is not finite, this assessment assumes that unless significantly redesigned, all existing coastal protection infrastructure will be removed or no longer effective at some point in the future. The study team does not assume that all coastal armoring will no longer be present on the coastline by 5ft of SLR, but this scenario was

[14] Because some of these coastal armoring layers overlap, this 10 miles of armoring extends over 8.6 miles of linear coastline.

developed to illustrate what long-term removal of armoring could look like as TWLs exceed the design parameters of current coastal armoring.

The study team acknowledges that the armoring condition and effectiveness over time are highly uncertain, and coastal erosion hazard exposure areas likely exists somewhere in the middle between the with and without armoring scenarios. For vulnerability assessment reporting purposes, this assessment reports both the with and without armoring scenarios by neighborhood area, and these figures can be seen as representative of a low-end and a high-end estimate of vulnerability.

3.3 DETERMINATION OF ASSET EXPOSURE

Each asset feature was analyzed using a slightly different procedure to address the unique characteristics of the various data geometries. Each vector type was evaluated as follows (Figure 3-1):

- **Points Features:** A single point feature (e.g., stormwater outfalls or manhole locations) was categorized as "exposed" if it intersected a hazard zone.
- **Lines:** Line assets (i.e., roads or water pipelines) that are bisected by a hazard zone were split along the bisecting boundary of the hazard zone. The segments inside the hazard zone are then categorized as "exposed." The asset line lengths were tabulated and reported.
- **Polygons:** Polygon assets were processed in two ways. For large contiguous areas such as parcels, the asset is bisected by a hazard and split along the bisecting boundary of the hazard zone. The area inside the hazard zone is then categorized as "exposed." For smaller areas, such as buildings, the feature is categorized as "exposed" as soon as it is intersected with a hazard zone. For reporting purposes, the asset polygon area (in acres or square feet) and the number of assets within the hazard zone are tabulated.

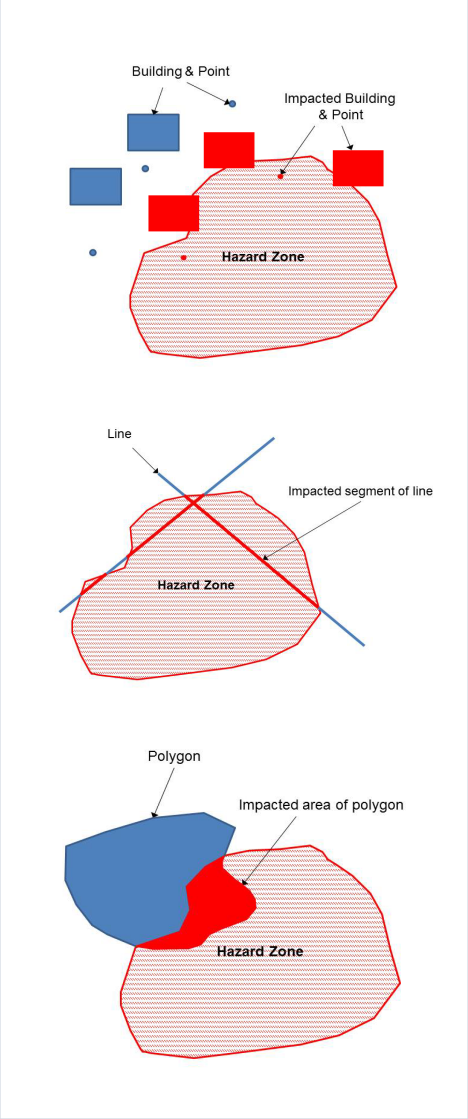

Figure 3-1. GIS Vulnerability Analysis Methodology for Point, Line, and Polygon Features

3.4 EXPOSURE ASSUMPTIONS FOR PARCELS AND STRUCTURES

Tables displaying the number, length, or area, and value of damages by type of feature are reported by SLR horizon and armoring scenario. The valuation of infrastructure assets relies on information from the County and other studies. Valuation of parcels and structures relies on CoreLogic's market values and the County's Assessor's Parcel Database, and projects damage to both built assets and land. This section will provide a description of the assumptions made in the reporting of damages to parcels and structures.

3.4.1 Physical and Monetary Damages Due to Coastal Erosion

Erosion is evaluated as an impact on both land and structures. A structure is considered fully lost once the building footprint is intersected by the extent of the coastal erosion hazard zone. For land and assets such as parking lots, damages are estimated based on the percentage of land eroded at the assessed SLR horizon. When the hazard area for both dune and cliff erosion bisect a structure, the first of the two hazard instances (typically dune erosion) is used, and the structure is not counted as being at risk to both hazards. For properties with parcel boundaries that extend seaward of their coastal armoring, the cliff top edge, or into the ocean, the "overhanging" area has been removed from consideration in the economic analysis.

3.4.2 Physical and Monetary Damages Due to Flooding

Flood damages were determined using FEMA's Depth-Damage Functions (DDFs), also known as damage curves, from Hazus 5.1.[15] DDFs are mathematical relationships that estimate the damage to buildings from flood inundations and are based on the depth of flooding and reported damage amounts for different locations across the county. As no DDFs existed for Santa Cruz County or any similar west coast counterparts, the existing DDFs from the U.S. East Coast were adapted for Santa Cruz County by increasing the DDF to account for a more energetic wave environment.

DDFs are calculated based on structure types, and as specific structure types as they would relate to FEMA's Hazus 5.1 were not available for the study area, this study grouped structures by backshore development locations, as the backshore condition is closely associated with a structure's sensitivity to hazards. For instance, developments on high cliffs are more likely to be slab on grade and to be impacted by wave overtopping and wave splash, whereas beachfront development is often armored or raised on pilings and more likely to be impacted by storm wave flooding and wave overtopping. The backshore categories utilized in the DDFs are the following:

- **Development on low dunes or bluffs**: These structures are generally slab-on-grade construction and not exposed to storm wave flooding unless it is a large storm. An example of these structures is at Pajaro Dunes.
- **Beachfront development with armoring:** These structures are typically located behind armoring or are raised above on pilings or above a garage, and are typically exposed to flooding from less severe storm events. The determination as to whether a beachfront structure was armored was made if more than 50% of the structure is located behind coastal armor. The location of a structure was also factored into this category, and if a structure is located along the second line of homes from the coast, a

[15] More information on HAZUS can be found here: https://www.fema.gov/flood-maps/tools-resources/flood-map-products/hazus/documentation

reduction factor was used relative to first-line ocean-fronting homes. An example would be Las Olas Drive.

- **Beachfront development with no armoring:** These structures are typically raised on pilings. An example would be the Corcoran Lagoon Condos.
- **Low-lying development:** These structures are typically slab-on-grade construction and exposed to flooding without wave velocity. Examples include development in low-lying areas such as Rio del Mar Flats and the Pajaro Valley.
- **Development on high cliffs:** These structures are slab-on-grade construction and are generally less exposed to wave bore, and more exposed to wave splash. This includes structures at places such as Black Point.

The DDF utilized for this study employed a mathematical relationship between the depth of flood water above or below the base floor elevation (BFE) and the amount of damage associated with flooding. Figure 3-2 illustrates damage as a function of water depth (the first-floor elevation is equivalent to 0 ft water height). In some cases, negative numbers indicate heights below the first-floor threshold, which indicates that damage may occur due to scouring around the building foundation or cleanup below the first-floor elevation (which may include exposure to debris and cleanup of the property or scouring around pilings). Depth-damage relationships are computed separately for structure and contents.

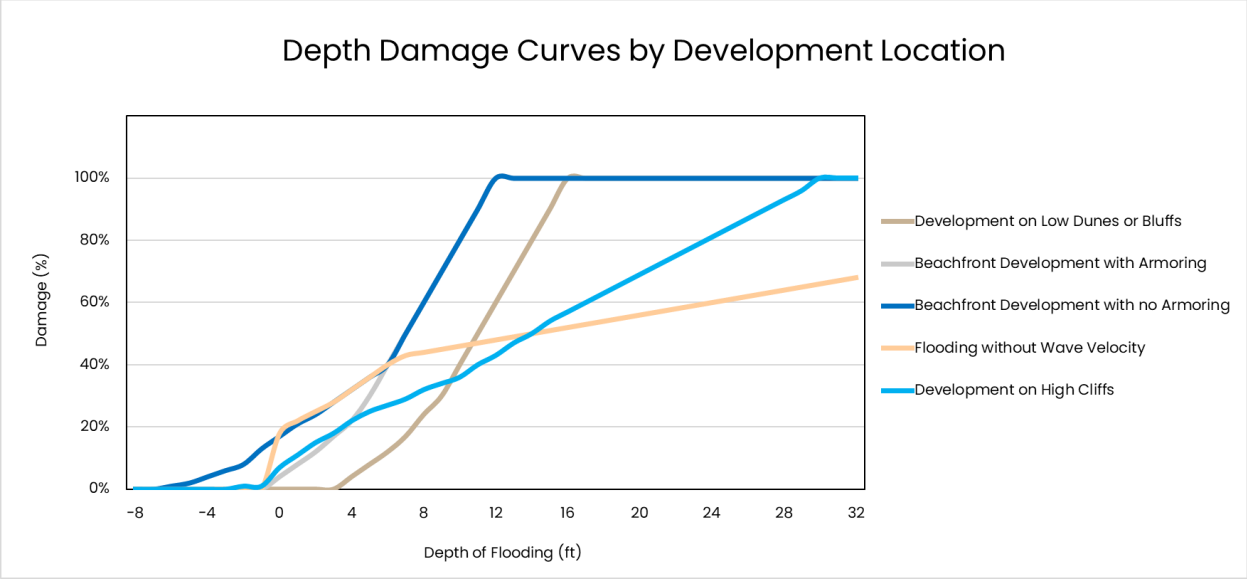

Figure 3-2. Depth Damage Function with Respect to Structural Location

In order to apply the DDF for each structure in the flood hazard zone, a BFE was applied to each structure. For most coastal structures in the County, the BFE was determined through

visual inspection of each structure using the California Coastal Records Project's[16] oblique angle views in concert with known ground elevations from the 2018 FEMA/USGS[17] digital elevation model. In addition, a small number of properties had listed BFEs in County permits.

For coastal properties where the BFE is raised above ground elevation, a determination was based on manual interpretation, and the height of one residential garage or first story was assumed to be 8–10 ft, depending on the structure. For all inland properties outside of the storm wave velocity zone (FEAM VE zone), the elevation of the property was assumed to be the same as ground elevation, rounded up to the nearest foot (i.e., the building was assumed to be slab on grade).

3.4.2.1 Flood Damage Reporting

For each structure in the study area, three damage range estimates were tabulated by SLR horizon, divided into five 20-yr windows, including a low, middle, and high range damage estimates. The "low" range assumes calm conditions and is associated with multiple small storms (5-yr recurrence or less) over a 20-yr window. The "middle" range assumes average conditions and is associated with one 25-yr storm and multiple smaller storms over a 20-yr window. And the "high" range assumes stormier conditions and represents multiple large storms over a 20-yr window (one 100-yr, one 25-yr, and multiple smaller storms). The high- and low-end ranges are unlikely, but for the purposes of this study, these higher and lower ranges can be seen as accounting for the uncertainty in the flood depth-to-damage relationships. For all projections, it is assumed that no adaptation strategies are adopted in the future.

3.4.2.2 Temporal Bounds to Flood Damages

A structure can only experience wave action damage up to the point that it is lost to erosion. Once the property is subject to erosion, the full building value (improvement value) is incorporated into the damage loss function for that SLR horizon, and no further wave action damages are included in future SLR horizons. In this study, it is assumed that so long as a structure is not eroded, it would be repaired or rebuilt following any damage at the same location. In reality, repeated flood damage would make affected structures a complete loss; however, this was not accounted for in this study.

[16] https://www.californiacoastline.org/
[17] Available at: https://coast.noaa.gov/dataviewer/#/

3.4.3 Inundation Depth and Frequency

3.4.3.1 Depths and Damages for Storm Wave Flooding

For open coast areas of the County, this study relied on BakerAECOM's FEMA Region IX California Coastal Analysis and Mapping Project / Open Pacific Coast Study Intermediate Data Submittal, which provided transect-by-transect TWLs for a range of storm recurrence intervals for the entire County coastline. This study evaluated three storm recurrence intervals, a 100-yr, a 25-yr, and 5-yr storm. The total water levels from these storms was evaluated relative to the BFE of each structure to derive depths of inundation. These depths were used to determine the percentage of damage, using the adapted DDFs, which were multiplied by estimates of the building's value to scale damage estimates.

3.4.3.2 Depths and Damages in Low-Lying Flood-Prone Areas

For low-lying coastal areas that are not exposed to wave flooding with velocity, this study could not rely on the open Pacific Coast Study Intermediate Data Submittal. For these areas, this study set the 100-yr flood elevation according to TNC model, and then scaled the 25-yr and 5-yr storm flood elevations based on a flood elevation to recurrence relationship. In the TNC model, a 100-yr flood elevation of 16 ft was used for the Pajaro Valley, and 14 ft for other locations such as the coastal lagoons. The TWLs from these storms were evaluated relative to the BFE of each structure to derive depths of inundation. These depths were used to determine the percentage of damage, using the adapted DDFs, which were multiplied by estimates of the building's value to scale damage estimates.

3.5 ASSIGNING PROBABILITY OF DAMAGE CATEGORIES

To provide a more nuanced perspective on the relative risk to existing structures from coastal hazards and SLR, each structure in the study area was a assigned a probability of experiencing damage across each of the SLR horizons (0, 1, 2, 3, and 5 ft of SLR), and an evaluation of the temporal risks was assigned on a scale from none, very low, low, medium, high, to very high. This evaluation employed a risk-averse methodology and identified all structures with the potential to be impacted during a 500-year storm event. This risk-averse method assumes that statistical records and FEMA VA and AE elevations might underestimate current and future risks, providing a more robust reporting of potentially impacted structures.

The study team ran a spatial overlay analysis to inform when a given structure would be impacted by a given hazard, including storm wave run-up and overtopping, coastal erosion, rising tides, and fluvial flooding, and then used additional metrics described below to determine the probability of a structure experiencing damage over a 20-yr window. For flood hazards, this probability was related to the BFE relative to the FEMA VE and AE elevations for various storm recurrence intervals, and for erosion, this was related the structure's proximity to

the cliff-top or dune-crest, the length of time (expressed as number of SLR horizons) that the structure was located within an erosion hazard zone, and if the structure is protected by coastal armoring. The hazard having the highest likelihood of leading to impacts took precedence, and in the handful of cases where both coastal erosion and flooding were equally likely to cause damage at a specific SLR horizon, the overall damage probability classification was elevated by one category.

To maintain consistency with a neighborhood-scale approach to adaptation planning, and to ensure that the study was not calling attention to any one structure among its neighbors, all structures along a neighborhood block were grouped and assigned the same impact category. The probability of impact category for all structures was determined through a unimodal analysis of all damage probability categories for the group of structures. In a small number of cases, exceptions were made, including when individual structures were either lower lying than their neighbors, or located a significant distance away. This grouping method also accounted for some of the uncertainty in both asset, environmental, and modeling uncertainty, and all probability of damage categories were spot checked with County staff. Table 3-2 and Table 3-3 show how probability of impact categories were decided.

Table 3-2. Probability of impact due to flooding

Structures at Risk from Flood Hazards	Flooding Recurrence Interval
Very Low	1 in 100 to 1 in 500
Low	1 in 20 to 1 in 100
Medium	1 in 10 to 1 in 20
High	1 in 5 to 1 in 10
Very High	< 1 in 5

Note: Includes storm wave and inland flooding

Table 3-3. Probability of impact due to erosion

Structures at Risk from Erosion Hazards	Category Description	
	Structures With Coastal Armoring	Structures Without Coastal Armoring
Very Low	Between 50 and 150 ft from the coastal bluff edge or armor, and still within a coastal erosion hazard zone by 5 ft of SLR	Over 100 ft from the projected coastal bluff edge, but still within a coastal erosion hazard zone by 5 ft of SLR
Low	Between 20 and 50 ft the coastal bluff edge or armor, but still within a coastal erosion hazard zone by 5 ft of SLR	Between 50 and 100 ft from the projected bluff edge, but still within a coastal erosion hazard zone by 5 ft of SLR
Medium	Less than 20 ft from the bluff edge or armor	The first instance a structure is within a coastal erosion hazard zone
High	The second instance a structure is within is less than 20 ft from the coastal bluff edge or armor	The second instance a structure is within a coastal erosion hazard zone
Very High	The third instance a structure is less than 20 ft from the coastal bluff edge or armor	The third instance a structure is within a coastal erosion hazard zone.

Note: Includes cliff and dune erosion

4 ECONOMIC VALUATION METHODS

This section provides a brief overview of the economic valuation methods of both the study area's market and nonmarket coastal assets.

4.1 LAND USE AND STRUCTURES

Property value data were sourced from CoreLogic, a data and analytics firm now operating under the name Cotality, which specializes in real estate market intelligence. The analysis utilized CoreLogic's THVx 2024 price estimates, specifically drawing on the "high" market value projections to establish property valuations. The improvement-to-land value ratio was derived from the County Assessors' roll.

4.1.1 Types of Properties

This analysis assesses multiple structure types, each requiring distinct valuation approaches. Condominium structures were valued as the sum of all individual properties within the structure, while apartment values were already structured this way and did not require adjustments. Overall, the average structure value for all residences in the study area was approximately $1,000,000, and the average value of a single-family parcel of land was just under $2,000,000 (2024 dollars).

Structures that lacked individual market assessments, such as garages, barns, and other outbuildings, were identified and assigned a nominal value depending on the size and use classification (either $5,000, $20,000, or $50,000). Facilities like State Parks vault toilets represented the lower end of this range, while structures such as large barns or storage sheds represented the higher end of this range.

The values for institutional structures such as community buildings, libraries, or fire stations were not valued in the CoreLogic value estimate, and were therefore assigned by the study team to better reflect structure value. An example of these value estimates is shown in Table 4-1.

Table 4-1 Examples of structure value estimates

Structure	Assigned Value
Live Oak Library	$2,000,000
Pajaro Dunes Fire Station(Cal Fire Station 42)	$380,000 per structure
Watsonville Water Treatment Plant [a]	$20K–$100K per building within the complex

[a] Individual buildings were assigned values based on type, or if type was unknown, size.

4.1.2 Calculating Monetary Damages

Building values in Santa Cruz County far exceed those used by FEMA for other places in the country to calculate building replacement values (BRV). BRVs are used by FEMA to estimate the damage reductions due to interventions that reduce exposure to flood hazards. These costs are independent of the building's market or taxable value, as the cleanup actions do not differ greatly for homes with similar construction materials.

FEMA estimates of BRV use a default value of $100 per square foot. Given the high cost of construction in Santa Cruz, the potential for increased repair costs after an event, and the limited supply of licensed contractors, a value of $200 per square foot was used in calculations of repair and cleanup costs.

Improvement values were converted to a dollar value per square foot using building footprint areas. The cost of repairs was estimated as the minimum of the improvement value per square foot estimate and the $200 building replacement value. Multiplying the cost of repairs by the building footprint gives a conservative estimate of the total BRV. This was multiplied by the percentage damage estimate from the DDFs to arrive at a per event replacement value.

Depth-damage relationships are generally expressed with content damage as a percentage of structure value. For simplicity, a standard 20% of structure value was then added to account for contents.

Many factors influence the amount of damage arising from a flood event that cannot be accounted for in this study, including time of year (with holiday season being busier for the coast), warning time, and site-specific floodproofing improvements.

4.2 INFRASTRUCTURE

Another component of this economic valuation was determining the value of infrastructure vulnerable to present and future coastal hazards. To do this, the study team used a simple cumulative property loss estimate. In other words, the estimated average replacement costs of

infrastructure were multiplied by the total number of each asset found within the various time horizons to generate a combined value of resources within future hazard zones.

Several assumptions and generalizations were made to complete this infrastructure and property loss estimates. For municipal buildings and urban infrastructure, data from several local economic analyses were used to estimate costs to replace or move critical infrastructure. For water and wastewater systems, replacement cost estimates for each wastewater pump station, provided by the County, were used to calculate the value of these stations.

Table 4-2. Property and asset valuation data sources for economic analysis

Asset	Valuation	Source
Roads /ft	$280	TNC 2016
Rail /ft	$237	Fresno business plan
Storm drain conduit /ft	$1,080	TNC 2016
Wastewater conduit /ft	$1,080	TNC 2016
Drinking water conduit /ft	$189	TNC 2016
Abandonment and relocation of a wastewater pump station / unit	$7 million	County 2024
Raising critical equipment and sealing wet well at a wastewater pump station / unit	$2 million–$3 million	County 2024

4.3 DISCOUNTING, INFLATION, AND MARKET CHANGES

This study calculates all damages in 2024 dollars (the year of the County Assessor data) and does not calculate the net present value (NPV) of these damages, nor does it adjust future damages for inflation.

4.3.1 Discounting and Inflation

NPV is a method used to calculate the present value of future payments for a project and is used to understand the rate of return on an investment by considering the time value of money. In other words, an investment in a project will have an expected rate of return; however, so would an investment in securities or, alternatively, other projects on which the money could be invested. While calculating the NPV is a common practice in public policy cost–benefit analysis, the appropriate discount rate to apply to climate mitigation investment projects over long-time

horizons is controversial (Li and Pizer 2021). Because of the uncertainty surrounding how to appropriately set this influential parameter, this calculation was omitted from this analysis.

Future costs do not adjust for inflation for a similar reason: uncertainty surrounding the future inflation projections.

4.3.2 Market Changes

This analysis makes the underlying assumption that the market environment in which damage occurs is static. In other words, it assumes that, save for the damages and repairs occurring to structures and land, their base valuation does not change throughout the analysis period. For example, if a 1,000 square foot parcel starts out in 2024 at a value of $100 per square foot, this model assumes that by SLR 5, it will still be worth $100 per square foot even if there are only 10 square feet left due to erosion. The per foot value of the parcel does not respond to predicted growth or decline in the property market nor with the predicted change in size of the parcel.

4.4 TAX REVENUE LOSS CALCULATION

To calculate the lost revenue due to erosion exposure over all SLR periods, the following method was deployed: an annual price per square foot adjustment was applied to the cumulative erosion in any given SLR horizon and summed over the years in that horizon to reach lost revenue for that horizon. Table 4-3 outlines the parameters specified to make this calculation.

Table 4-3. Parameters used in tax revenue loss projection

Parameter	Value	Description
Tax rate	1.26%	Proposition 13 rate (1%) plus average voter-approved measures from Ownwell[18].
Annual property value adjustment	2%	Proposition 13[19] allows the evaluated property to increase at a maximum of 2% year over year. It is assumed the County makes the maximum adjustment each year.
Start year	0	Present day—value adjustments begin at this value
End year	100	Year by which SLR 5 occurs
Erosion assessment frequency	10 years	Property reassessment occurs after a transfer of ownership or a large renovation. Data from the most recent U.S. Census Bureau American Housing Survey[20] for California reports a median home tenure of 10 years. The area of the parcel is assessed at this frequency.

The assessment was by parcel, on an annual basis, using the net taxable parcel value such that each evaluation incorporated the components shown in Figure 4-1 below.

[18] https://www.ownwell.com/trends/california/santa-cruz-county
[19] https://www.santacruzcountyca.gov/tax/assrpam.htm
[20] https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=00006&s_year=2023&s_tablename=TABLE8A&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup2=1

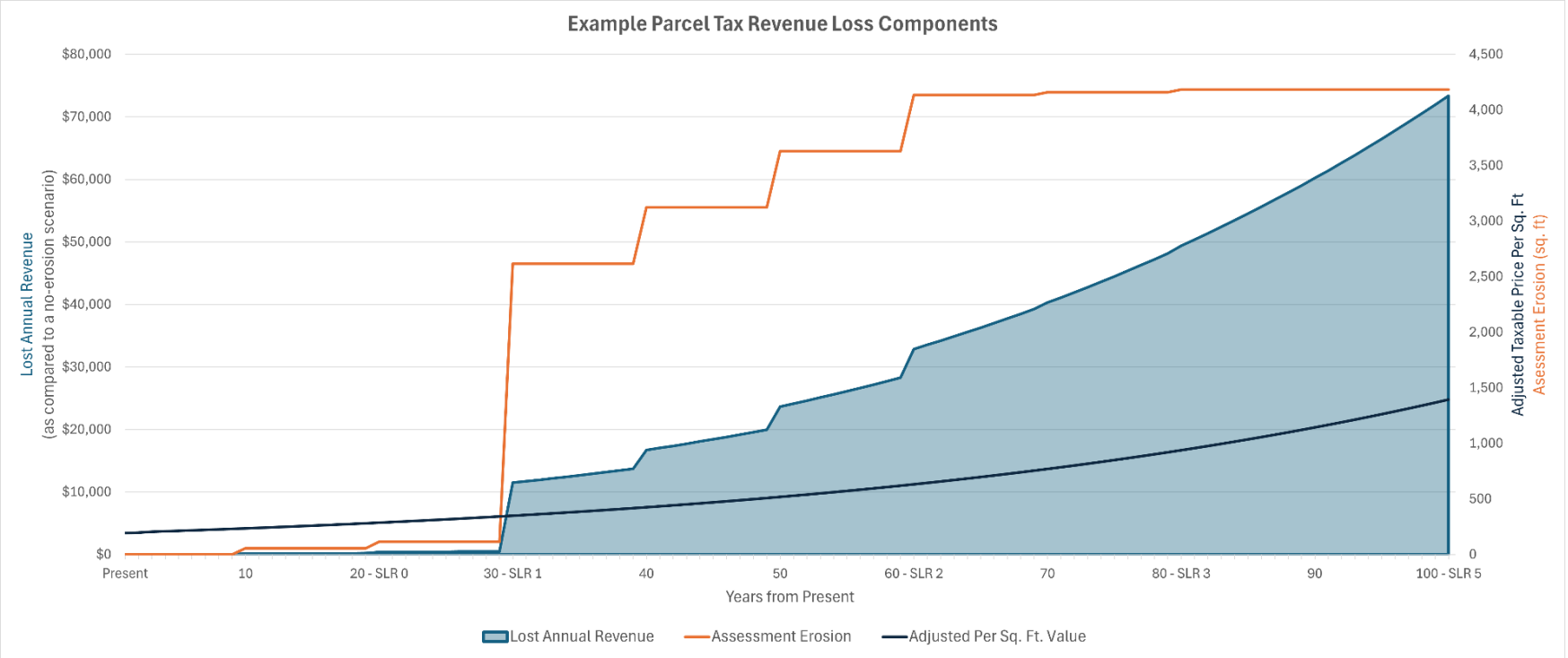

Figure 4-1. Annual Lost Revenue, Assessment Erosion and Property Value for an Example Parcel

For the example parcel in Figure 4-1 and all other parcels, no matter the erosion that occurs in Years 0 through 19, there is no tax loss in Years 0 through 9 because the land has not been reassessed by the assessor, and so the parcel is still taxed at its original size. This "retroactive" erosion applies to all decades such that the erosion level of the previous period is the erosion level of the assessment window until a reassessment occurs. In reality, the orange assessment line would be continuous, but this "retroactive assessment" causes a stepwise erosion to emerge. For example, an annual assessment occurring in year 49 must rely on what the erosion level was in year 40, an assessment year, thus the retroactive nature of assessment. This results in the County losing less than if an area assessment happened every year because the periodic assessments artificially keep erosion lower than it is predicted to be in most years.

Though assessed erosion is stepwise, the price per square foot is adjusted annually, which results in a smooth, exponential increase in the price-per-square-foot net taxable value of the parcel. This blue line is multiplied by the orange line, and then by the tax rate, to arrive at the annual loss, the light blue line (note the separate *y*-axes). The lost annual revenue is shaded underneath to show the total loss of revenue from that parcel over 100 years.

The exponential shape of the adjusted price, along with erosion rates countywide, influences the overall curved shape of the cumulative tax revenue loss calculations. Two main components are missing from this simplified calculation: 1) a separation of parcel from building, and 2) market adjustments.

In the real world, property value would not be linearized in ratio to erosion like we have designed above. What is likely to happen is a stagnant property value as erosion progresses, and then a drop to very low or zero value once the building on the property has been compromised or cannot be redeveloped. It is unclear without doing the separate analysis on each property in the county whether this "all-or-nothing" version of the model would produce higher or lower tax losses for the county.

Secondly, market forces were in large part ignored to avoid unhelpful and distracting speculation. However, there are three aspects that would be important areas of focus should further analysis be required and have been discussed in the context of the lost property value analysis: inflation, market forces, and discounting. The increase year over year of 2% of the net taxable value is, in a way, already making assumptions about inflation and market forces. Currently, the county reassesses properties regularly on this basis and regularly assigns the maximum increase due to increasing market prices, which in turn are a reflection of the market and of inflation.

Another aspect of erosion is the market value *increase* it may pose to "second row" homes (homes that are one street behind the oceanfront home). The idea being, once the "front-row" home erodes and the lot is vacated, the "second row" home then becomes oceanfront property with a view (assuming timely demolition), thus potentially increasing the property's value. This "second row" effect could potentially offset a large portion of the expected tax loss, but this analysis did not attempt to fully define and predict the magnitude of price changes that

a home may incur. The assessment increase was set at 2% while acknowledging that it is not a guarantee that inflation and home prices will produce this outcome each year for the next 100 years for each parcel.

Discounting was also not included in this analysis to remain consistent with the other property value analysis elsewhere in this study. Section 4.3 provides a more detailed discussion of discounting.

4.5 VISITATION DATA

To estimate beach visitation within unincorporated Santa Cruz County, this analysis uses mobility data from the location analytics platform Placer.ai. These mobility data, also known as advanced cell phone data, are aggregated anonymous location information from cell phone user application data collected and reported on by phone providers and cell towers.[21] These visitation data consist of the sandy beach areas and exclude all upland areas.

4.5.1 Visits and Visitors

An important distinction in the mobility data is the difference between total beach "visits" relative to total beach "visitors." Many times, they are used synonymously as a proxy for changes in crowd numbers or recreation trends, but their interpretations differ. Visits are the larger of the two metrics, and this is the total number of beach trips taken to a given beach within unincorporated Santa Cruz County, irrespective of the person taking them. On the other hand, visitors are the total number of people who visited the beach, without regard to the number of times they visited.

4.5.2 Filter Parameters

All visitation data used in this analysis were restricted to those collected in the year 2024 and with a duration of more than 45 minutes on the beach. This is because visits of under 45 minutes may represent individuals passing through multiple beach locations during a single outing, and including these shorter duration visits could artificially inflate total visitation counts. This methodology thus aims to produce estimates that mitigate double counting visitors, and filter out those who may be passing by for very short periods of time.

4.5.3 Privacy Concerns with Mobility Data

Mobility data are anonymous sources of information and pose no risk of individual identification. Mobility data provide an additional layer of privacy alongside de-identification in that the origin, destination, and day of visitation are all aggregated to the total population level.

[21] Placer.ai : https://www.placer.ai/

This is standard practice to alleviate challenges that might arise in scenarios where the counts of origin, destination, or day of visit are extremely low. For instance, a beachgoer from a remote area visiting a beach in Santa Cruz County on a rainy day might very well be the only one with a mobile device from that origin in the area on that day, but because of de-identification and aggregation, there is no ability to pinpoint the end device user/beachgoer.

4.5.4 Limitations

Total beach visitation numbers are estimated from actual cell phone detections on the beach areas and do not equal the total number of cell phones that are detected on the beach. Due to factors such as what mobile phone applications people use, what location service opt-ins are elected or rejected, or whether a visitor chooses to bring their cell phone with them to the beach or leave it in the car or at home, these data are unable to capture every person on the beach. These limitations highlight the importance of ground-truthing beach recreational activities, and future work could involve developing a beach monitoring system that can count the number of people on the beach and the in water.

4.5.4.1 Insufficient Visitation Count

Beach areas for which visitation data were not available were instead interpolated to estimate average values. This was common on very small or very narrow beaches, which includes many cliff-backed beaches, pocket beaches, and areas where armoring and development reduce beach widths. This approach involved identifying the lowest recorded visitation value across the neighborhood beach areas and reducing it by 50% to establish a conservative baseline. This adjusted figure served as the estimated average for locations without direct measurements. Applying this method produced an estimated average of approximately 600 visitors per year to beaches with missing data. These conservative estimates ensure that beaches without available mobility data are not excluded from the adaptation planning analysis while avoiding potential overestimation of their usage levels.

4.5.4.2 Sensitive Locations

Visitation data were not available for certain beach locations due to their proximity to or overlapping with sensitive areas. Placer.ai maintains strict data privacy policies that prohibit the sharing of location information for specific categories of facilities and sites, such as places of worship and pre-K–12 schools. For the small number of beaches where this was the case, the methods described above were used to interpolate visitor counts.

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Appendix E

Supplemental Tables and Figures

Appendix E
Supplemental Tables and Figures

Sea Level Rise Vulnerability Assessment Report
Santa Cruz County

Prepared for
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Countywide Summaries of Land Use and Coastal Recreation Vulnerabilities

Table 1. Summary of Countywide Vulnerabilities

SLR	**Land Use and Structures**						**Coastal Recreation**		
	Coastal Erosion		**Flooding**		**Combined Hazards (Flooding + Erosion)**		**Beach Loss**		**Surf Break Loss**
					With Armoring through 3 ft of SLR, then Without Armoring				
	No. of Structures exposed (With – Without Armoring)	*Value of the Loss of Land and Structures (With – Without Armoring)*	*No. of Structures (vulnerable to a 100-yr storm, with armoring)*	*Flood Damages*	*Damages and Losses*		*Assuming Hold the Backshore Line*	Winter Beach Loss Locations	*Names of Surf Spots that Rarely Function*
				Estimates (low – mid – high)			*Winter – Summer*	*Names of Beaches Lost*	
0	51 – 489	$292M – $1.64B	903	$9 – 64 – 155M	943	$356M	207 – 283		The Harbor, Drainpipes
1	113 – 852	$457M – $2.55B	916	$24 – 170 – 350M	988	$624M	110 – 183	North Coast Cliff-Backed, 26th Ave, Pleasure Point, Seacliff	Above + Murph Bar, Jacks, Sunny Cove
2	160 – 1,054	$559M – $3.10B	974	$48 – 315 – 600M	1,080	$869M	46 – 102	Above + Rio del Mar, Aptos, La Selva, Pajaro Dunes	Above + Black's Beach, 26th Ave, Wind and Sea, Privates, Trees
3	269 – 1,404	$798M – $3.98B	993	$93 – 502 – 910M	1,193	$1.29B	29 – 52	Above + Twin Lakes at Schwan, Blacks, Sunset	Above + Santa Moes, Sharks Cove
5	1,892	$5.06B	1,129	$213 – 809M – 1.38B	2,209	$5.72B	15 – 24	All except beaches at coastal waterway outlets	All

Flooding: Cumulative assuming flooding on its own, from depth damages, includes cleanup, repair, and contents of structure only, high estimate in combined. Damages rounded to nearest 100K. Number of structures included in the 1% annual chance flood hazard area. High end is equivalent to one 100-yr storm, one 25-yr storm, and multiple smaller storms in 20 years, and low end is two 5-yr storms in 20 years.

Erosion: Cumulative, with armoring through 3ft, then w/o armoring, adjusts for double counting of erosion and flooding

Combined includes middle estimate for flooding (approximately ten 25-yr storms in 100 years)

Names of surf breaks that break less than 20% of the time

Table 2. Summary of North Coast / Davenport Vulnerabilities

SLR	**Land Use and Structures**						**Coastal Recreation**	
	Coastal Erosion		**Flooding**		**Combined Hazards (Flooding + Erosion)**		**Beach Loss**	
					With Armoring until 3 ft of SLR, then Without Armoring			
	No. of Structures exposed (With – Without Armoring)	*Value of the Loss of Land and Structures (With – Without Armoring)*	*No. of Structures (vulnerable to a 100-yr storm, with armoring)*	*Flood Damages*	*Damages and Losses*		*Assuming Hold the Backshore Line*	*Winter Beach Loss Locations*
				Estimates (low – high)			*Winter – Summer*	*Names of Beaches Lost*
0	0 – 1	$1.16 – 1.25M	7	$0 – <100K	7	$1.2M	285 – 342	
1	5 – 8	$6.30 – 6.6M	8	$0 – <$100K	8	$6.3M	238 – 296	All cliff-backed beaches
2	8 – 12	$9.41 – 10.2M	12	$0 – <$100K	12	$9.4M	197 – 253	Same as above
3	11 – 16	$12.5 – 14.2M	13	$0 – $100K	14	$12.5M	166 – 215	Above + Davenport Landing
5	20	$17.3M	16	$0 – $200K	20	$17.6M	114 – 159	All except beaches at coastal waterway outlets

Table 3. Summary of Twin Lakes / Corcoran Vulnerabilities

SLR	Land Use and Structures						Coastal Recreation		
	Coastal Erosion		Flooding		Combined Hazards (Flooding + Erosion) *With Armoring until 3 ft of SLR, then Without Armoring*		Beach Loss		Surf Break Loss Locations
	No. of Structures exposed (With – Without Armoring)	*Value of the Loss of Land and Structures (With – Without Armoring)*	*No. of Structures (vulnerable to a 100-yr storm, with armoring)*	*Flood Damages Estimates (low – mid – high)*	*Damages and Losses*		*Assuming Hold the Backshore Line Winter – Summer*	*Winter Beach Loss Locations Names of Beaches Lost*	*Names of Surf Spots that Rarely Function*
0	7 – 14	$26.9 – 123M	121	>$100 – 600K – 2.7M	124	$27.5M	229 – 289		
1	11 – 88	$33.7 – 217M	127	$200K – 1.7M – 7.9M	131	$35.2M	121 – 178	26th Ave	The Harbor
2	16 – 112	$40.7 – 283M	142	$300K – 3.3M – 15.6M	149	$43.5M	48 – 95	Above + Moran Lake	Above + Murph Bar & Blacks Beach
3	34 – 167	$78.6 – 426M	149	$500K – 6.9M – 26.4M	169	$84.6M	16 – 37	Above + Twin Lakes & Blacks	Above + Sunny Cove
5	256	$583M	212	$1.2 – 16.0M – 47.3M	275	$592.6M	0 – 5	All Beaches	All

Table 4. Summary of Pleasure Point / Opal Cliffs Vulnerabilities

SLR	**Land Use and Structures**					Coastal Recreation			
	Coastal Erosion		**Flooding**		**Combined Hazards (Flooding + Erosion)**	**Beach Loss**			**Surf Break Loss Locations**
					With Armoring until 3 ft of SLR, then Without Armoring				*Names of Surf Spots that Rarely Function*
	No. of Structures exposed (With – Without Armoring)	*Value of the Loss of Land and Structures (With – Without Armoring)*	*No. of Structures (vulnerable to a 100-yr storm, with armoring)*	*Flood Damages*	*Damages and Losses*	*Assuming Hold the Backshore Line*	*Winter Beach Loss Locations*		
				Estimates (low – mid – high)		*Winter – Summer*	*Names of Beaches Lost*		
0	4 – 31	$18.2 – 133M	28	$1.0 – 11.7 – 17.2M	31	$29.5M	43 – 43		Drainpipes
1	5 – 57	$22.2 – 203M	28	$2.5 – 25.5 – 36.5M	32	$47.1M	0 – 0	All **but** a small pocket beach at the 38th Stairs	Above
2	7 – 69	$29.2 – 258M	28	$4.7 – 41.0 – 57.5M	34	$69.7M	0 – 0	All	Above
3	18 – 101	$50.9 – 384M	28	$8.1 – 58.2 – 80.6M	45	$108.5M	0 – 0	All	Above + 26th Ave, Wind and Sea, Jacks/38th, Privates, Trees
5	127	$464M	28	$14.5 – 79.2 – 107.7M	127	$531.5M	0 – 0	All	All

Table 5. Summary of Seacliff / Rio del Mar / Aptos Vulnerabilities

SLR	**Land Use and Structures**						Coastal Recreation	
	Coastal Erosion		**Flooding**		**Combined Hazards (Flooding + Erosion)** *With Armoring until 3ft of SLR, then Without Armoring*		**Beach Loss**	
	No. of Structures exposed (With – Without Armoring)	*Value of the Loss of Land and Structures (With – Without Armoring)*	*No. of Structures (vulnerable to a 100-yr storm, with armoring)*	*Flood Damages* *Estimates (low – mid – high)*	*Damages and Losses*		*Assuming Hold the Backshore Line* *Winter – Summer*	*Winter Beach Loss Locations* *Names of Beaches Lost*
0	7 – 370	$26.0M – 1.11B	449	$600K – 24.4M –97.1M	450	$50.3M	231 – 302	
1	15 – 476	$41.7M – 1.38B	449	$2.5 – 78.9 – 218.5M	457	$119.0M	81 – 144	Potbelly to State Park Dr. West
2	18 – 542	$51.1M – 1.57B	471	$8.8 – 160.6 – 372.1M	482	$210.6M	23 – 54	Potbelly to Beer Can Beach (Via Gaviota)
3	40 – 710	$134M – 1.98B	477	$30.0 – 270.1 – 560.0M	510	$402.1M	7 – 17	All
5	987	$2.56B	477	$103.4 – 450.6 – 831.3M	1,173	$2.93B	0 – 0	All

Table 6. Summary of La Selva / Manresa / Sunset Vulnerabilities

SLR	**Land Use and Structures**						Coastal Recreation	
	Coastal Erosion		**Flooding**		**Combined Hazards (Flooding + Erosion)** *With Armoring until 3 ft of SLR, then Without Armoring*		**Beach Loss**	**Surf Break Loss Locations**
	No. of Structures exposed (With – Without Armoring)	*Value of the Loss of Land and Structures (With – Without Armoring)*	*No. of Structures (vulnerable to a 100-yr storm, with armoring)*	*Flood Damages*	*Damages and Losses*		*Assuming Hold the Backshore Line*	*Winter Beach Loss Locations*
				Estimates (low – mid – high)			*Winter – Summer*	*Names of Beaches Lost*
0	33 – 40	$160.8 – 188.0M	5	$0 – 100K	38	$161.0M	234 – 322	
1	56 – 65	$217.7 – 270.7M	5	$>100K – 200K	61	$217.8M	109 – 198	
2	82 – 90	$271.5 – 323.2M	5	$100 – 300K	87	$271.7M	18 – 75	La Selva Beach to Sunset Beach Rd (Port Watsonville)
3	130 – 147	$357.0 – 425.8M	5	$200 – 400K	134	$357.3M	7 – 22	La Selva Beach to Sunset Beach Parking Lot
5	220	$570.0M	5	$300 – 600K	223	$570.5M	0 – 1	All

Table 7. Summary of Pajaro Dunes / Pajaro Valley Vulnerabilities

SLR	**Land Use and Structures**						Coastal Recreation	
	Coastal Erosion		**Flooding**		**Combined Hazards (Flooding + Erosion)** *With Armoring until 3ft of SLR, then Without Armoring*		**Beach Loss**	
	No. of Structures exposed (With – Without Armoring)	*Value of the Loss of Land and Structures (With – Without Armoring)*	*No. of Structures (vulnerable to a 100-yr storm, with armoring)*	*Flood Damages* *Estimates (low – mid – high)*	*Damages and Losses*		*Assuming Hold the Backshore Line* *Winter – Summer*	*Winter Beach Loss Locations* *Names of Beaches Lost*
0	0 – 6	$58.8 – 84.9M	293	$7.6 – 27.5 – 38.3M	293	$86.3M	210 – 320	
1	21 – 158	$135 – 472M	299	$19.2 – 63.8 – 86.9M	299	$198.0M	116 – 228	
2	29 – 229	$156 – 652M	316	$34.0 –109.8 – 153.8M	316	$264.6M	40 – 136	All **but** Palm Beach State Park Beach
3	36 – 263	$165 – 753M	321	$55.5 – 165.9 – 242.7M	321	$327.3M	17 – 50	All **but** small pocket beaches
5	282	$869M	391	$93.7 – 262.5 – 386.7M	391	$1.08B	0 – 3	All

Table 8. Summary of Countywide Backshore Characteristics and Recreation

Neighborhood	Backshore Characteristics			Average Summer Beach Width (ft)					Visitation (2024)				
	Average Beach Development Width (ft)	Length of Beaches (mi)	Armored Beach Length (%)	0ft of SLR	1ft of SLR	2ft of SLR	3ft of SLR	5ft of SLR	Yearly Visits	Yearly Visitors	Average Beach Visitor Dwell Time (min)	Average Seasonal Visitation Distribution (Summer / Winter in 2024)	Most Visited Beach (2024)
North Coast / Davenport	0	13.8	9%	260	213	171	138	92	107,235	84,384	84	65 / 35	Panther Beach
Twin Lakes / Corcoran	0	2.1	66%	241	144	84	39	2	245,527	181,385	90	81 / 19	Twin Lakes Beach at Schwan Lagoon
Pleasure Point / Opal Cliffs	0	0.8	82%	33	0	0	0	0	15,804	11,529	72	78 / 22	Privates Beach
Seacliff / Rio del Mar / Aptos	125	4.2	73%	297	143	46	7	0	339,255	243,007	106	80 / 20	Beer Can (Sumner Beach)
La Selva / Manresa / Sunset	0	5.6	3%	337	219	101	31	0	142,252	108,671	135	76 / 24	Manresa State Beach
Pajaro Dunes / Pajaro Valley	0	1.7	71%	300	208	116	32	2	64,868	46,492	91	75 / 25	Palm Beach State Beach
Grand Total	**22**	**28.3**	**28%**	**283**	**183**	**101**	**52**	**24**	**914,940**	**675,467**	**95**		**Twin Lakes Beach at Schwan Lagoon**

Combined Hazard Exposure Tables for Assets, Infrastructure, and Utilities

Acronyms & Explanations

FMMP	Farmland Mapping and Monitoring Program. Maps farmland areas.
CPAD	California Protected Areas Database. Includes all open space, park, and conserved lands owned in fee by public agencies.

Notes

Reporting includes cumulative exposure to coastal erosion, coastal wave flooding, and tidal inundation, and are reported assuming the **without** armoring scenario. All data are non-cumulative across sea level rise horizons. Reporting of utilities does not include assets that are privately managed.

Table 9. Summary of North Coast / Davenport Assets, Infrastructure, and Utility Exposure to Coastal Hazards by Sea Level Rise Horizon

North Coast / Davenport							
Assets	**Unit**	**Total**	**0**	**1**	**2**	**3**	**5**
Land Use							
FMMP	Acres	860.0	490.0	51.0	74.0	101.0	144.0
Williamson Act	Acres	0.0	0.0	0.0	0.0	0.0	0.0
Transportation							
Roads	Miles	3.5	1.3	0.1	0.3	0.7	1.1
Railroads	Miles	0.4	0.0	0.0	0.1	0.2	0.1
Bridges	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Recreation and Public Access							
CPAD	Acres	625.0	389.1	33.9	47.7	56.6	97.7
Trails	Miles	18.4	5.2	4.2	2.8	3.4	2.8
Public Access	Count	8	1	0	3	2	2
Bicycle Facilities	Miles	3.0	1.2	0.1	0.1	0.6	1.0
Parking Lots	Acres	2.9	1.3	0.1	0.2	0.5	0.8
Utilities and Infrastructure							
Sanitation Structures	Count	0	0	0	0	0	0
Sanitation Pipes	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Water Mains	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Stormwater Structures	Count	1	0	0	1	0	0
Stormwater Conduits	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Stormwater Culverts	Count	1	0	0	0	1	0

Table 10. Summary of Twin Lakes / Corcoran Assets, Infrastructure, and Utility Exposure to Coastal Hazards by Sea Level Rise Horizon

Twin Lakes / Corcoran							
Assets	**Unit**	**Total**	**0**	**1**	**2**	**3**	**5**
Land Use							
FMMP	Acres	138.0	100.0	6.0	7.0	9.0	16.0
Williamson Act	Acres	0.0	0.0	0.0	0.0	0.0	0.0
Transportation							
Roads	Miles	1.8	0.4	0.2	0.3	0.3	0.5
Railroads	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Bridges	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Recreation and Public Access							
CPAD	Acres	58.2	53.2	1.3	1.0	0.6	2.2
Trails	Miles	1.6	0.9	0.1	0.1	0.1	0.4
Public Access	Count	13	11	1	1	0	0
Bicycle Facilities	Miles	0.9	0.4	0.1	0.2	0.1	0.2
Parking Lots	Acres	0.8	0.3	0.3	0.1	0.0	0.0
Utilities and Infrastructure							
Sanitation Structures	Count	73	26	11	14	10	12
Sanitation Pipes	Miles	2.6	0.9	0.3	0.5	0.3	0.7
Water Mains	Miles	1.6	0.4	0.2	0.3	0.2	0.4
Stormwater Structures	Count	97	54	8	11	12	12
Stormwater Conduits	Miles	3.8	2.9	0.2	0.2	0.2	0.4
Stormwater Culverts	Count	1	0	0	1	0	0

Table 11. Summary of Pleasure Point / Opal Cliffs Assets, Infrastructure, and Utility Exposure to Coastal Hazards by Sea Level Rise Horizon

Pleasure Point / Opal Cliffs							
Assets	**Unit**	**Total**	**0**	**1**	**2**	**3**	**5**
Land Use							
FMMP	Acres	32.0	13.0	3.0	3.0	7.0	6.0
Williamson Act	Acres	0.0	0.0	0.0	0.0	0.0	0.0
Transportation							
Roads	Miles	1.0	0.0	0.2	0.2	0.3	0.3
Railroads	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Bridges	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Recreation and Public Access							
CPAD	Acres	2.4	1.9	0.1	0.1	0.2	0.2
Trails	Miles	1.1	0.6	0.1	0.1	0.1	0.1
Public Access	Count	9	7	1	0	0	1
Bicycle Facilities	Miles	0.5	0.1	0.2	0.1	0.1	0.0
Parking Lots	Acres	0.0	0.0	0.0	0.0	0.0	0.0
Utilities and Infrastructure							
Sanitation Structures	Count	0	0	0	0	0	0
Sanitation Pipes	Miles	1.1	0.2	0.2	0.2	0.3	0.3
Water Mains	Miles	1.1	0.1	0.1	0.2	0.3	0.3
Stormwater Structures	Count	77	17	11	9	20	20
Stormwater Conduits	Miles	1.0	0.1	0.1	0.1	0.3	0.3
Stormwater Culverts	Count	1	0	0	0	0	1

Table 12. Summary of Seacliff / Rio del Mar / Aptos Assets, Infrastructure, and Utility Exposure to Coastal Hazards by Sea Level Rise Horizon

Seacliff / Rio Del Mar / Aptos							
Assets	**Unit**	**Total**	**0**	**1**	**2**	**3**	**5**
Land Use							
FMMP	Acres	360.0	208.0	29.0	22.0	46.0	55.0
Williamson Act	Acres	0.0	0.0	0.0	0.0	0.0	0.0
Transportation							
Roads	Miles	9.0	4.8	0.5	0.4	2.1	1.3
Railroads	Miles	0.2	0.0	0.0	0.0	0.0	0.1
Bridges	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Recreation and Public Access							
CPAD	Acres	97.7	72.4	5.6	4.1	7.5	8.0
Trails	Miles	7.2	3.7	0.8	0.5	0.8	1.4
Public Access	Count	31	27	1	1	0	2
Bicycle Facilities	Miles	1.9	0.8	0.4	0.2	0.2	0.3
Parking Lots	Acres	8.1	6.0	0.3	0.3	0.7	0.8
Utilities and Infrastructure							
Sanitation Structures	Count	291	172	21	16	53	29
Sanitation Pipes	Miles	11.9	7.2	0.5	0.5	2.2	1.6
Water Mains	Miles	9.2	4.8	0.4	0.5	2.1	1.4
Stormwater Structures	Count	234	123	22	12	37	40
Stormwater Conduits	Miles	6.4	3.7	0.4	0.4	0.8	1.1
Stormwater Culverts	Count	5	2	0	0	2	1

Table 13. Summary of La Selva / Manresa / Sunset Assets, Infrastructure, and Utility Exposure to Coastal Hazards by Sea Level Rise Horizon

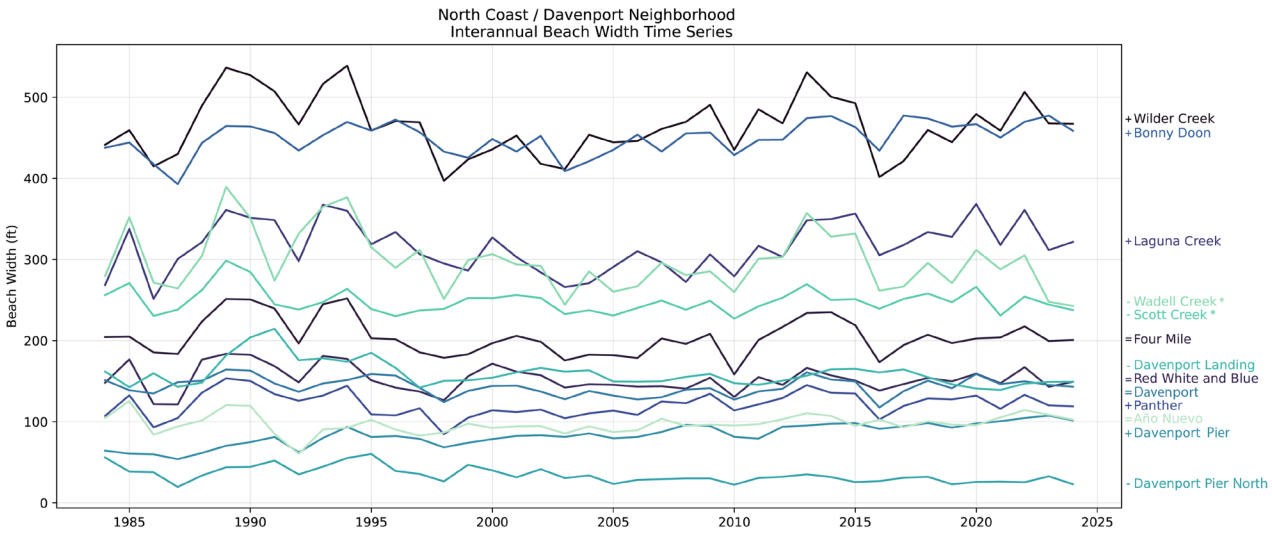
La Selva / Manresa / Sunset							
Assets	**Unit**	**Total**	**0**	**1**	**2**	**3**	**5**
Land Use							
FMMP	Acres	1135.0	845.0	37.0	46.0	65.0	142.0
Williamson Act	Acres	0.0	0.0	0.0	0.0	0.0	0.0
Transportation							
Roads	Miles	3.8	0.8	0.4	0.5	0.7	1.5
Railroads	Miles	1.5	0.8	0.2	0.1	0.2	0.2
Bridges	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Recreation and Public Access							
CPAD	Acres	644.8	514.0	13.7	21.4	20.7	75.0
Trails	Miles	4.4	1.3	1.0	0.5	0.7	0.9
Public Access	Count	15	10	1	2	1	1
Bicycle Facilities	Miles	0.2	0.1	0.0	0.0	0.0	0.1
Parking Lots	Acres	3.7	0.9	0.6	0.6	1.0	0.6
Utilities and Infrastructure							
Sanitation Structures	Count	28	4	0	0	12	12
Sanitation Pipes	Miles	0.9	0.3	0.0	0.1	0.2	0.3
Water Mains	Miles	2.8	0.7	0.1	0.1	0.5	1.4
Stormwater Structures	Count	29	5	3	3	8	10
Stormwater Conduits	Miles	1.4	1.1	0.1	0.0	0.1	0.1
Stormwater Culverts	Count	3	0	0	0	1	2

Table 14. Summary of Pajaro Dunes / Pajaro Valley Assets, Infrastructure, and Utility Exposure to Coastal Hazards by Sea Level Rise Horizon

Pajaro Dunes							
Assets	**Unit**	**Total**	**0**	**1**	**2**	**3**	**5**
Land Use							
FMMP	Acres	2161.0	1880.0	47.0	133.0	39.0	62.0
Williamson Act	Acres	0.0	0.0	0.0	0.0	0.0	0.0
Transportation							
Roads	Miles	7.8	6.4	0.4	0.5	0.2	0.4
Railroads	Miles	1.0	0.7	0.1	0.2	0.0	0.0
Bridges	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Recreation and Public Access							
CPAD	Acres	66.3	62.0	2.1	1.0	0.4	0.9
Trails	Miles	9.6	7.3	0.5	0.7	0.1	1.0
Public Access	Count	13	10	0	3	0	0
Bicycle Facilities	Miles	2.2	1.5	0.3	0.2	0.0	0.1
Parking Lots	Acres	1.0	1.0	0.0	0.0	0.0	0.0
Utilities and Infrastructure							
Sanitation Structures	Count	0	0	0	0	0	0
Sanitation Pipes	Miles	0.0	0.0	0.0	0.0	0.0	0.0
Water Mains	Miles	8.7	7.2	0.6	0.6	0.3	0.1
Stormwater Structures	Count	31	22	0	4	1	4
Stormwater Conduits	Miles	1.6	1.2	0.0	0.1	0.1	0.1
Stormwater Culverts	Count	8	8	0	0	0	0

Historical Beach Change Analysis

North Coast / Davenport



\+ Net accretion trend from 1984–2024 *partially armored

– Net erosion trend from 1984–2024 ** fully armored

Figure 1. Interannual Beach Width Trends by Beach (average width per year across all records from 1984–2024)

Lighter colors appear further north, and darker colors appear further south.

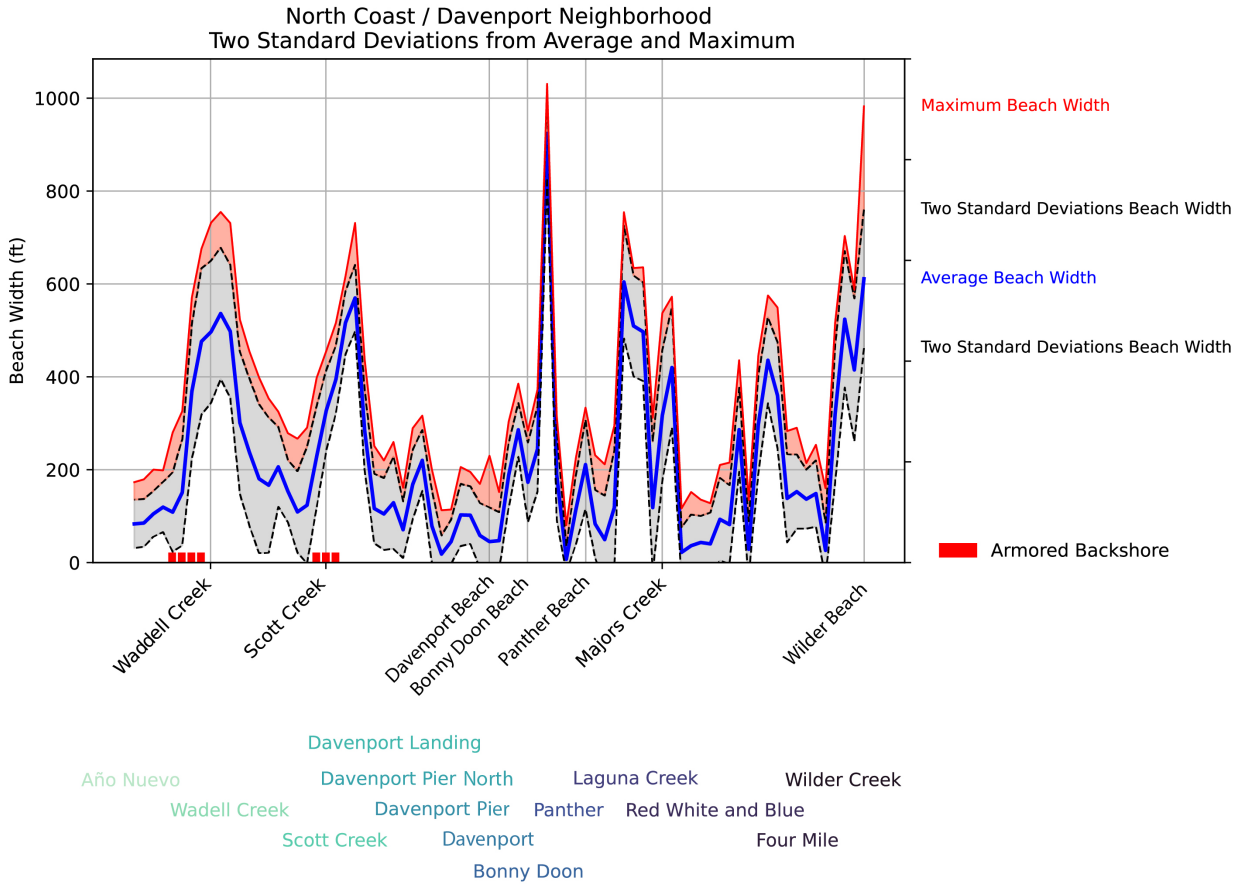
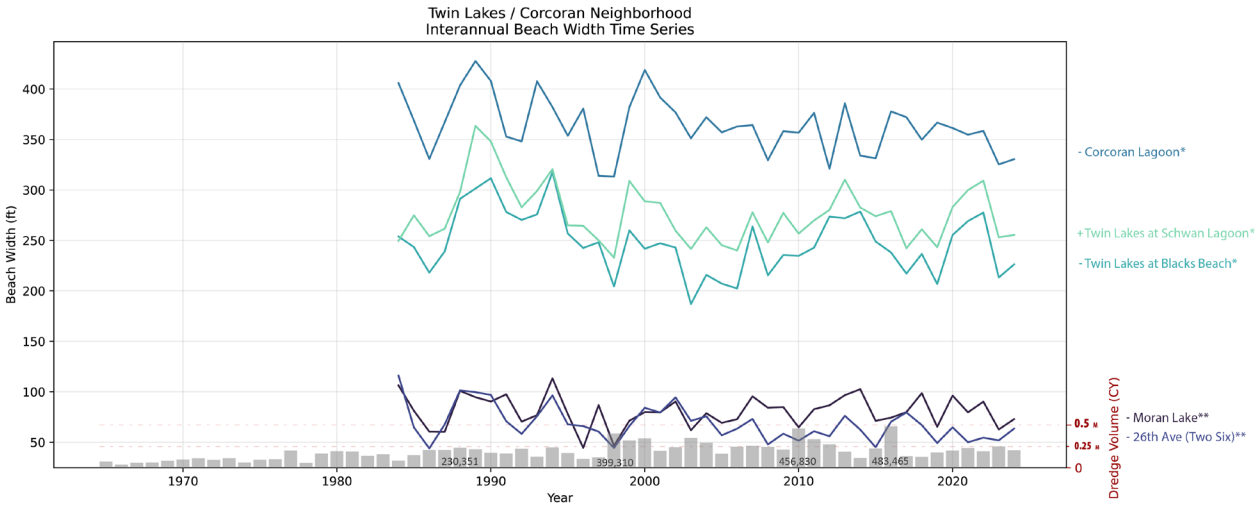


Figure 2. Beach Width Statistics and Armored Backshore Locations

Notes: Cliff-backed shorelines have been excluded from the trend line.
CoastSat has registered some artificially wide beaches in some locations, including at Bonny Doon Beach

Twin Lakes / Corcoran



\+ Net accretion trend from 1984–2024 *partially armored
– Net erosion trend from 1984–2024 ** fully armored

Figure 3. Interannual Beach Width Trends by Beach (average width per year across all records from 1984–2024) and the Santa Cruz Harbor Entrance Dredging Volumes (1965–2024)

Lighter colors appear further west, and darker colors appear further east.

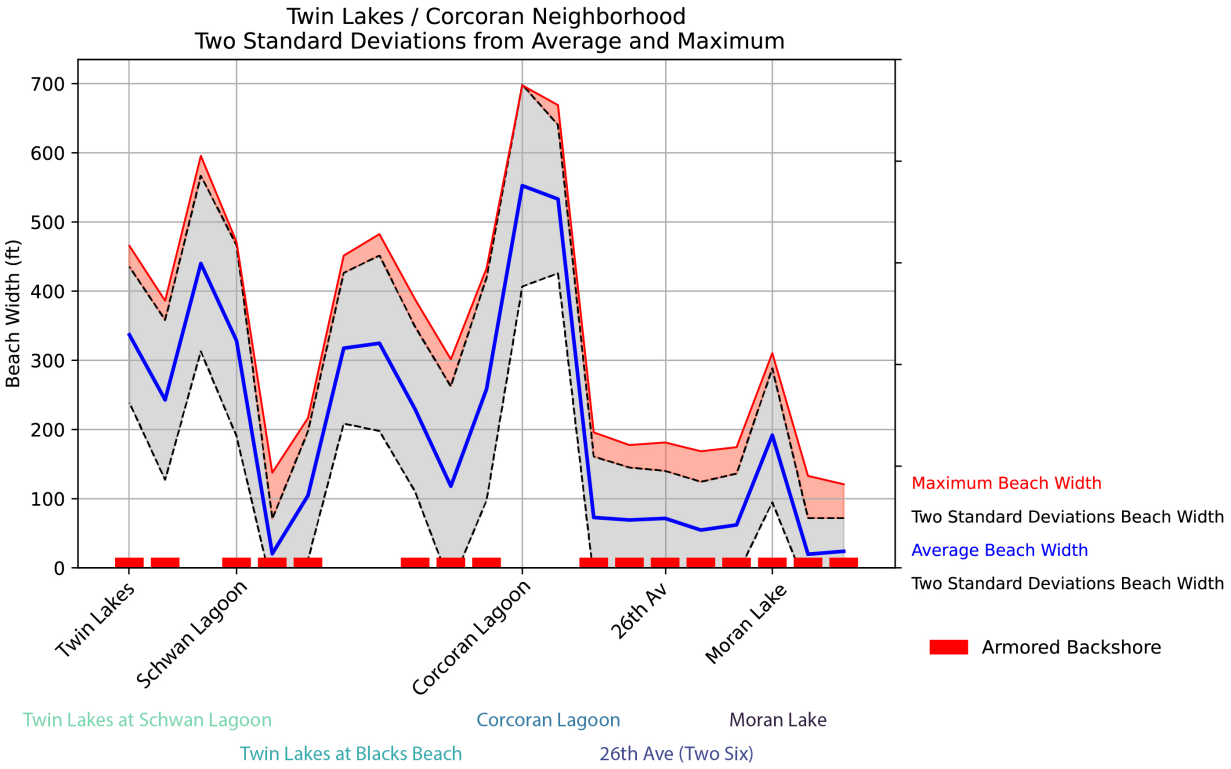
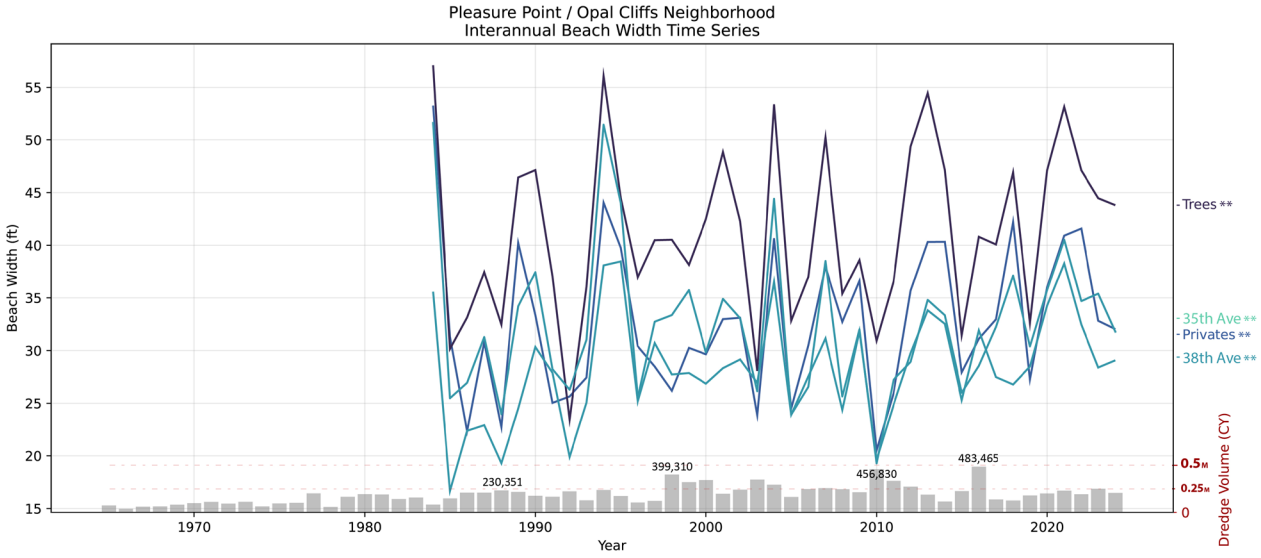


Figure 4. Beach Width Statistics and Armored Backshore Locations

Cliff-backed shorelines have been excluded from the trend line.

Pleasure Point / Opal Cliffs



\+ Net accretion trend from 1984–2024 *partially armored
– Net erosion trend from 1984–2024 ** fully armored

Figure 5. Interannual Beach Width Trends by Beach (average width per year across all records from 1984–2024) and the Santa Cruz Harbor Entrance Dredging Volumes (1965–2024)

Lighter colors appear further west, and darker colors appear further east.

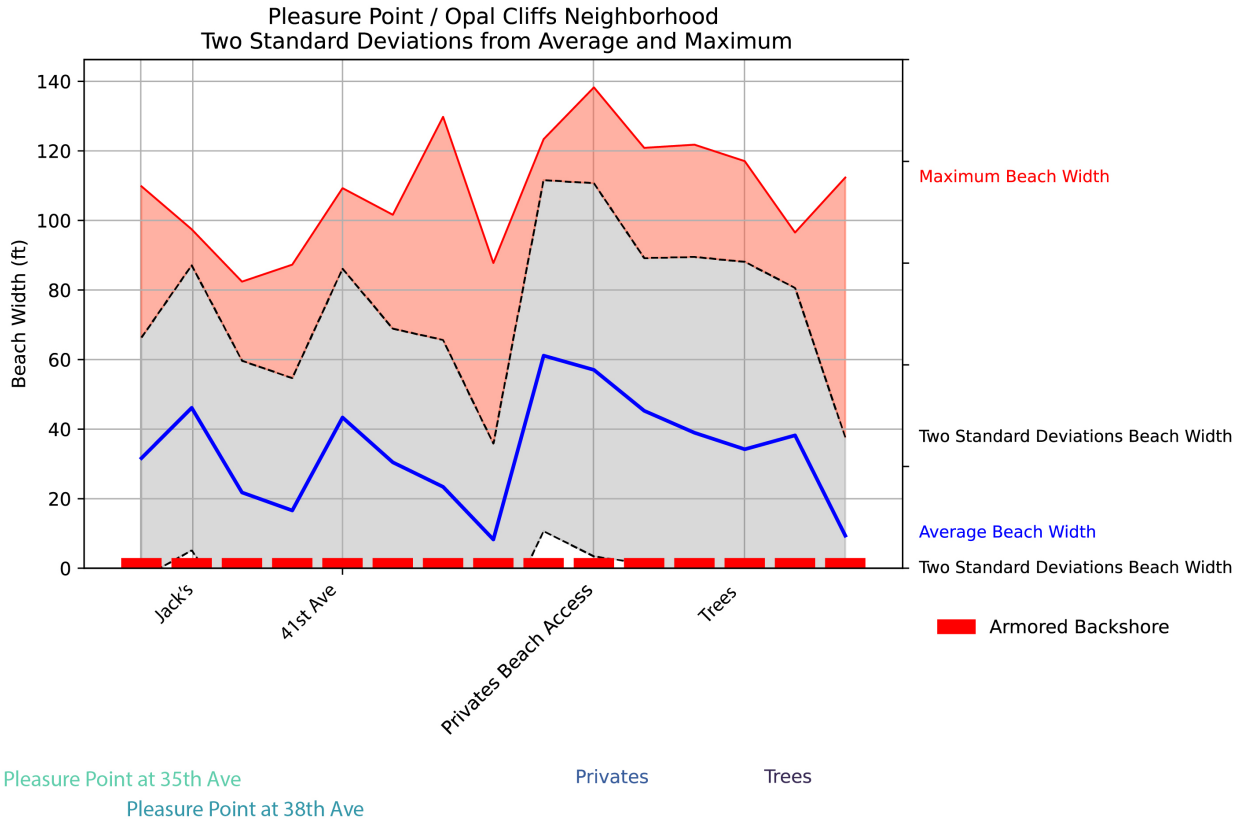
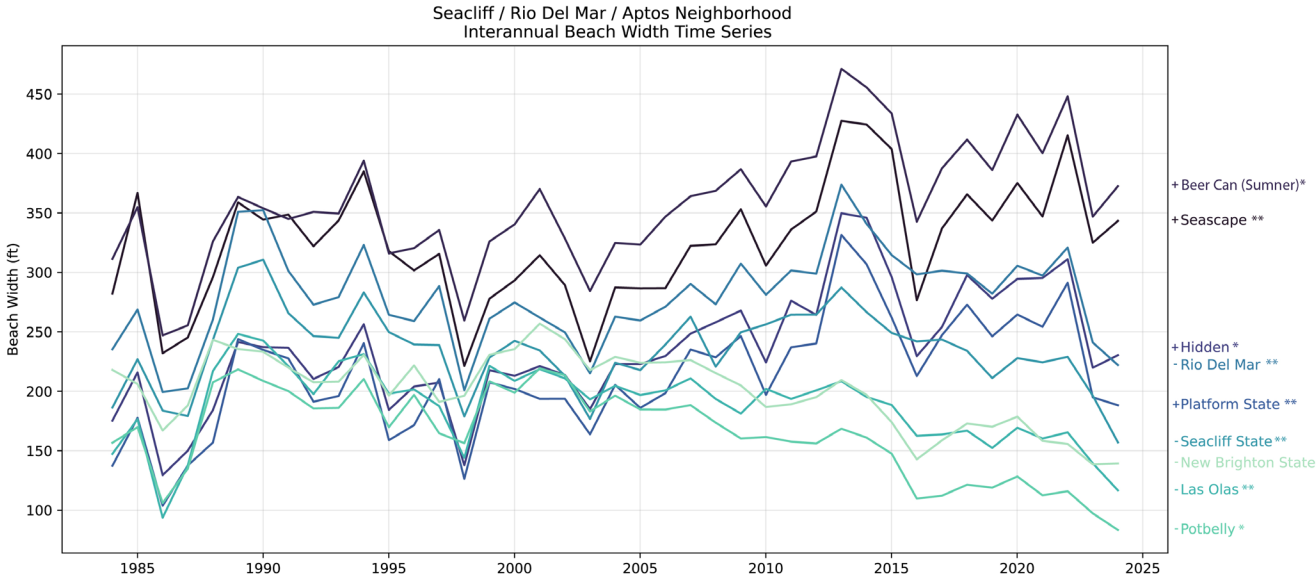


Figure 6. Beach Width Statistics and Armored Backshore Locations

Cliff-backed shorelines have been excluded from the trend line.

Seacliff / Rio del Mar / Aptos



\+ Net accretion trend from 1984–2024 *partially armored
– Net erosion trend from 1984–2024 ** fully armored

Figure 7. Interannual Beach Width Trends by Beach (average width per year across all records from 1984–2024)

Lighter colors appear further north, and darker colors appear further south.

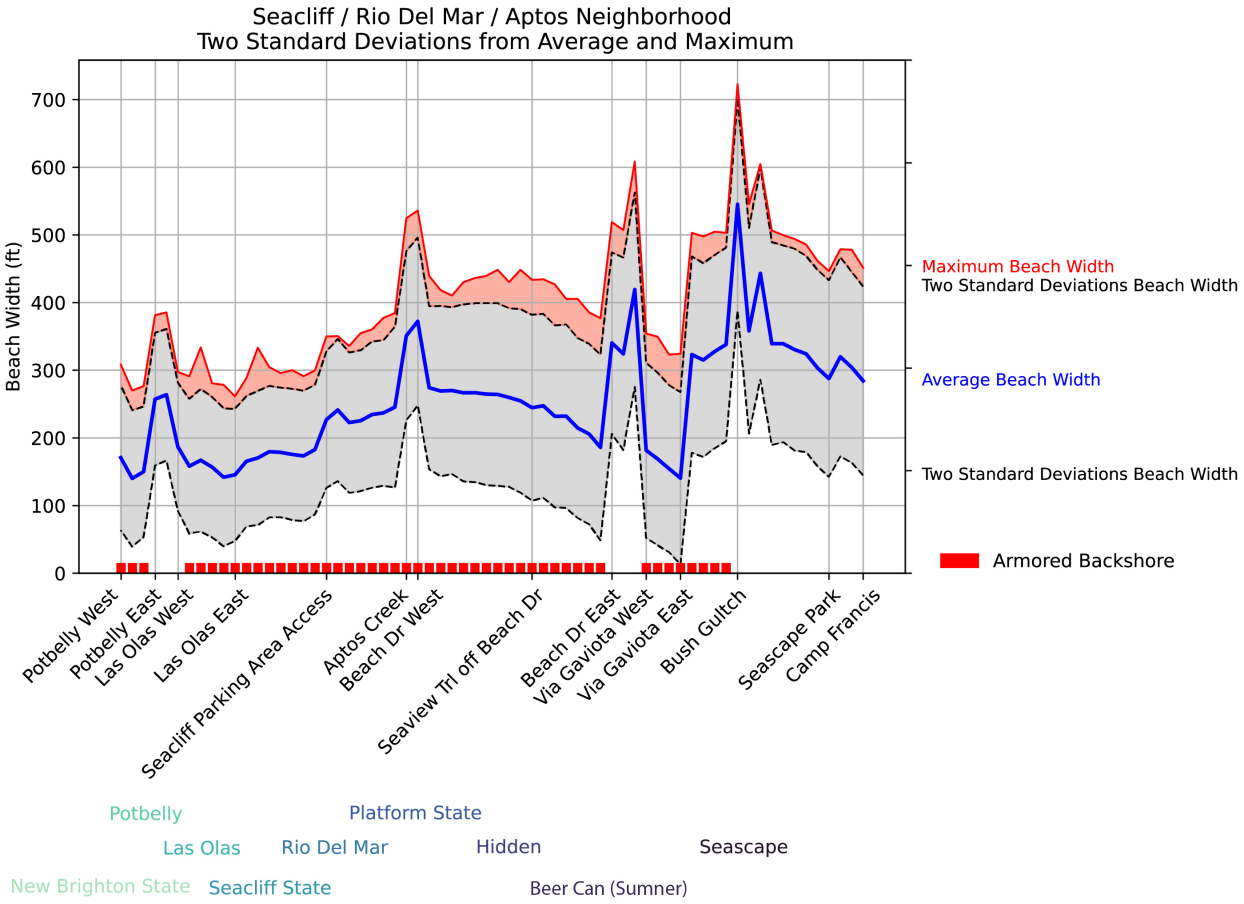
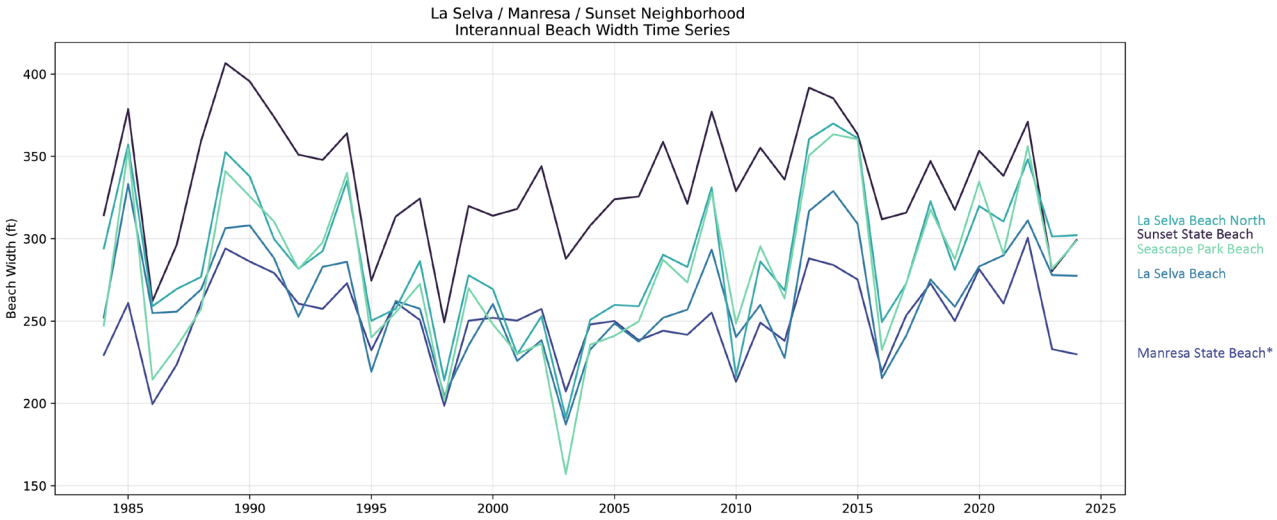


Figure 8. Beach Width Statistics and Armored Backshore Locations

La Selva / Manresa / Sunset



\+ Net accretion trend from 1984–2024 *partially armored
– Net erosion trend from 1984–2024 ** fully armored

Figure 9. Interannual Beach Width Trends by Beach (average width per year across all records from 1984–2024)

Lighter colors appear further north, and darker colors appear further south.

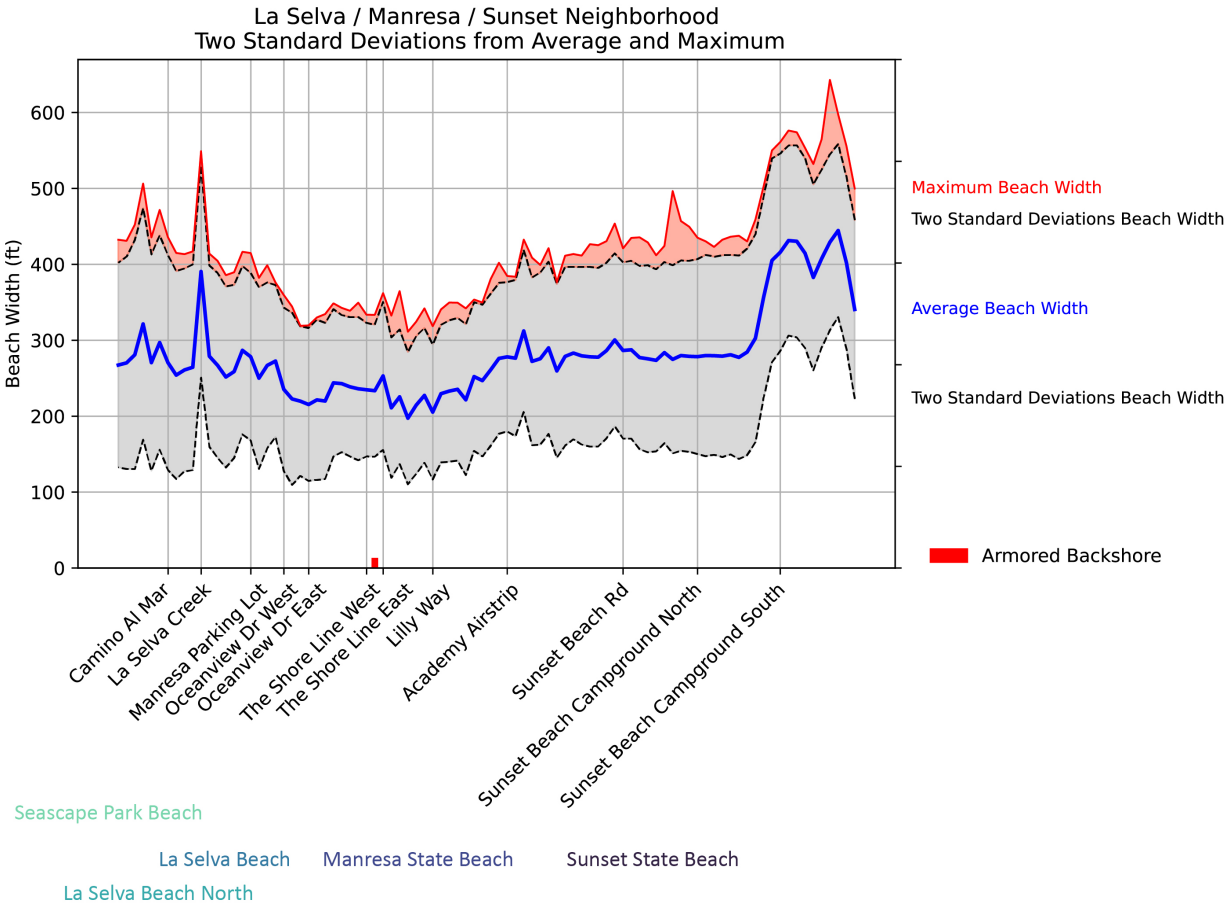
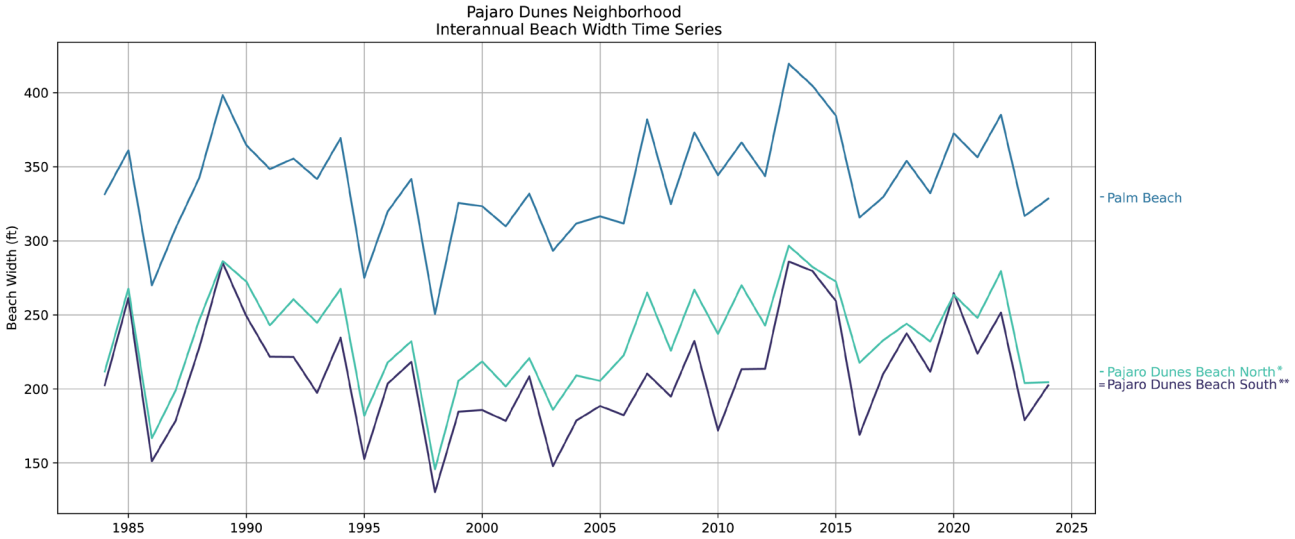


Figure 10. Beach Width Statistics and Armored Backshore Locations

Pajaro Dunes / Pajaro Valley



\+ Net accretion trend from 1984–2024 *partially armored
– Net erosion trend from 1984–2024 ** fully armored

Figure 11. Interannual Beach Width Trends by Beach (average width per year across all records from 1984–2024)

Lighter colors appear further north, and darker colors appear further south.

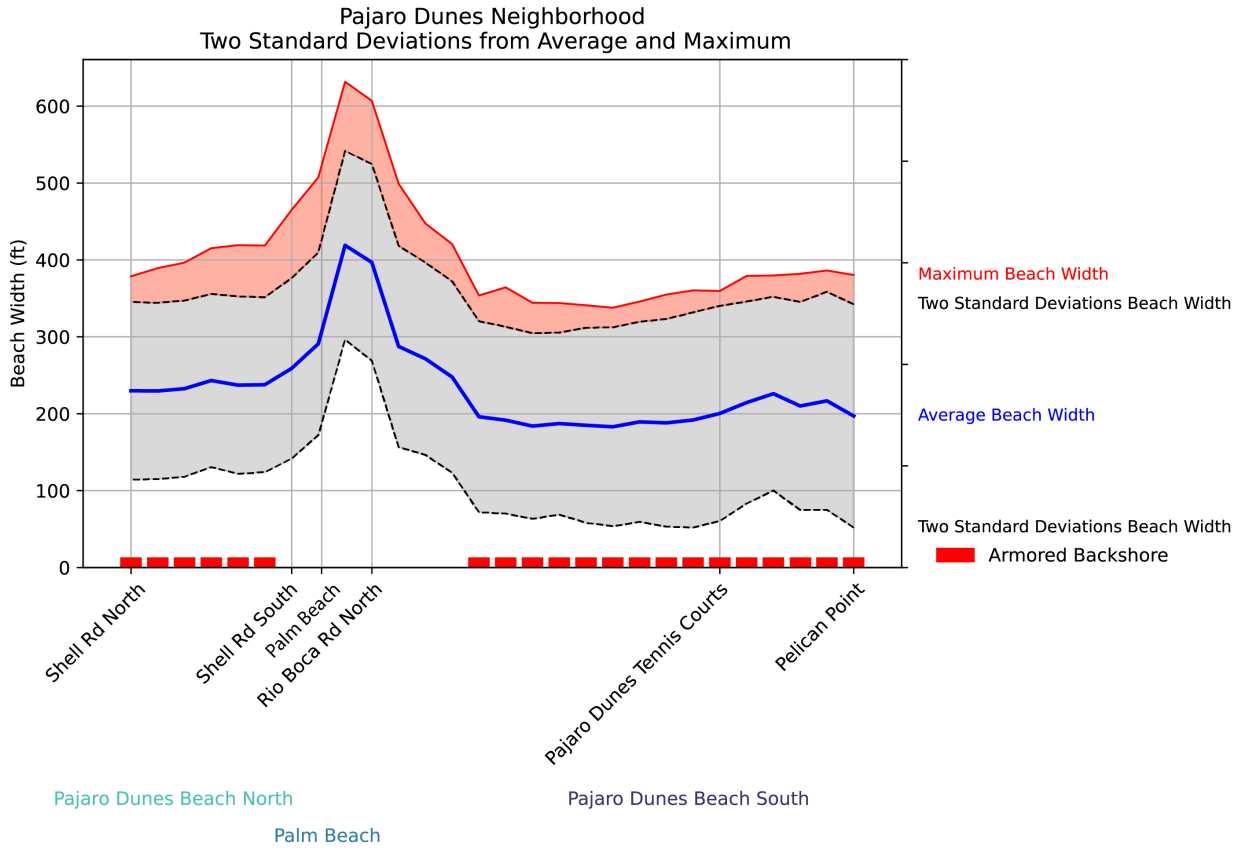


Figure 12. Beach Width Statistics and Armored Backshore Locations