Chapter 9 Coastal Erosion

9.1 Risk Assessment

9.1.1 Description of Hazards

Requirement §201.6(c)(2)(i): The risk assessment shall include a description of the type location and extent of all natural hazards that can affect the jurisdiction.

Coastal erosion is the wearing away of coastal land. It is commonly used to describe the horizontal retreat of the shoreline along the ocean. Erosion can be measured as a rate, with respect to either a linear retreat (feet of shoreline recession per year) or volumetric loss (cubic yards of eroded sediment per linear foot of shoreline frontage per year).

Erosion rates are not uniform and vary over time at any single location. Annual variations are the result of seasonal changes in wave action and water levels. Erosion is caused by coastal storms and flood events, changes in the geometry of tidal inlets and bays and human-made structures and human activities such as shore protection structures and dredging.

Coastal erosion includes both cliff or bluff erosion and beach erosion and is a result of both winter wave attack as well as constant wave action. Local residents will notice that beaches change seasonally in response to changes in wave conditions. Winter storm waves are larger, steeper and contain more energy, and typically move significant amounts of sand from the beaches to offshore bars, creating steep, narrow beaches. In the summer, lower, less energetic waves return the sand, widening beaches and creating gentle slopes. During the winter months when beaches are narrow, or absent altogether, the storm waves attack the cliffs and bluffs more frequently. There are many factors involved in coastal erosion, including human activity, sea-level rise, seasonal fluctuations and climate change, and sand movement will not be consistent year after year in the same location.

Wind, waves, and the long-shore currents are some of the driving forces behind coastal erosion. The removal and deposition of sand creates long-term changes to beach shape and structure. Sand may be transported to landside dunes, deep ocean trenches, other beaches, and deep ocean bottoms.

Coastal erosion such as cliff and bluff erosion is also a result of processes related to the land such as rainfall and runoff, weathering, and earthquakes. Santa Cruz County is bounded on one side by the Pacific Ocean. The entire coastal edge of the county is affected by coastal erosion.

On the north coast, where there are few structures near the coastline, the risk to structures and infrastructure is less than the coastline in the middle and southern portions of the County where homes and some businesses, as well as roads and related infrastructure are located very close to the shoreline.

Most of the significant cliff, bluff and dune erosion occurs in the area of the County from Live Oak to the southern County line during major winter storms at times of very high tides. The north coast area of the County also experiences coastal erosion, however, to a lesser degree. All of the cliffs along the ocean experience some degree of coastal erosion.

The north coast area of the County (from the City of Santa Cruz to the Santa Cruz/San Mateo County line) is underlain by the geologically older Santa Cruz Mudstone formation, which is less susceptible to coastal erosion than areas in the County to the south.

The bluffs in the Live Oak area and eastward to Rio Del Mar are underlain by the younger Purisima formation capped by terrace deposits which have been estimated to be retreating at a rate of six inches to one to two feet per year.

Eolian deposits that are also sensitive to coastal erosion underlie the areas south of Rio Del Mar.

Figure 19 depicts coastal flood zones as mapped by FEMA to evaluate the extent of the coastal erosion hazard.

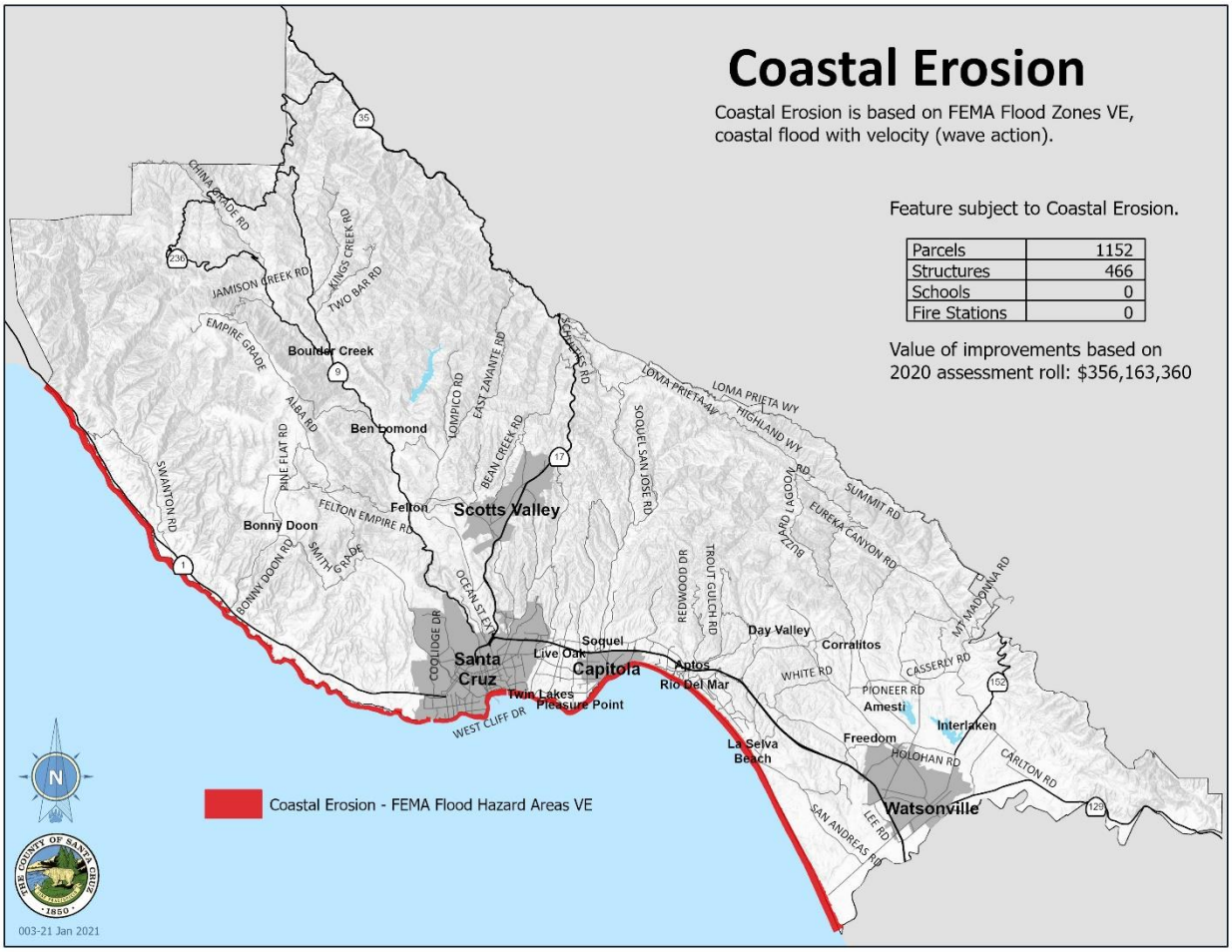

Figure 19 Coastal Erosion areas in Santa Cruz County

9.1.2 Previous Occurrences

Requirement §201.6(c)(2)(i): The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Nearly the entire California coast is actively eroding due to complex oceanographic and geologic conditions, and to human activities that affect the delivery and movement of sand along the coast.[24]

Bluff failure takes place through processes related to the sea (mainly those that affect wave action) and to the land (rainfall and runoff, weathering, earthquakes), although the terrestrial processes are less often appreciated than the marine processes. Wave attack during periods of high tides or otherwise elevated sea level (e.g. El Niño or storm surge) is one of the most common mechanisms of episodic cliff failure. El Niño increases storm frequency, elevated sea levels, wave height and rainfall. Studies have been performed on El Niño, storm frequency, and coastal erosion history for the central California coast from 1910-1995. This research indicated that the majority of documented coastal erosion occurred during El Niño storms that originated from the southwest.

During the severe El Niño winters of 1983 and 1997-98, sea levels were further elevated and storm damage along the coastal area was extensive. Wave attack combined with a global rise in sea level over the past 18,000 years has led to the continued migration of the shoreline. At the end of the last Ice Age, about 18,000 years ago, the coastline at Santa Cruz was about 10 miles offshore. As the ice sheets and glaciers melted, sea level gradually rose and continues to rise today.

Over the past several decades it has been discovered that coastal wave climate and storm frequency are related to larger scale climatic oscillations that affect the entire Pacific Ocean. During the time period from about 1945 to 1978, the California coast was characterized by a fairly calm climate, few large storms, less rainfall and less coastal erosion and storm damage. Beginning in 1978 and continuing until 1998, California experienced a period of more frequent and severe El Niño events with associated elevated sea levels, large waves, heavier rainfall and more extensive coastal storm damage and cliff and beach erosion.

While the sea level rose a little less than a foot over the past century, most scientists are concerned that due to the increase in greenhouse gases from human activity, warming will accelerate. As a result, glaciers will continue to retreat and the rate of sea level rise will increase, with the best estimate being about three feet higher by 2100. Given this estimate, the probability of future coastal erosion is very high.

In 2017 The Central Coast Wetlands Group conducted a study of future sea level rise impacts along the Santa Cruz County coast. The report titled Coastal Climate Change Vulnerability Report was funded through a grant from the Ocean Protection Council through the Local Coastal Program Sea Level Rise Adaptation Grant Program. This grant program is focused on updating Local Coastal Programs (LCPs), and other plans authorized under the Coastal Act such as Port Master Plans, Long Range Development Plans and Public Works Plans (other Coastal Act authorized plans) to address sea-level rise and climate change impacts, recognizing them as fundamental planning documents for the California coast.

The project was intended to achieve key objectives to further regional planning for the inevitable impacts associated with sea-level rise (SLR):

1. Identify what critical coastal infrastructure will be compromised due to SLR and estimate when those risks may occur; and
2. Define appropriate response strategies for these risks and discuss with regional partners the programmatic and policy options that can be adopted for LCP updates.

The project incorporated the most complete inventory of coastline revetment and seawalls for the Monterey Bay with coastal hazard GIS layers developed by Phil Williams and Associates and ESA Consulting to account for current protections from current and future coastal hazards. The project evaluated the impacts of sea level rise on municipal infrastructure, private properties, and natural resources. The project also evaluated relevant state policies and adaptation response alternatives ranging from "grey to green" for integration into municipal planning documents. The project also fostered regional discussions regarding inclusion of appropriate adaptation strategies into Local Coastal Program and other planning documents.

The study evaluated how various sea level rise scenarios would impact both coastal flooding and coastal erosion. Two examples of the results of the study for coastal erosion of particularly vulnerable locations along the coast are shown in the following two maps. Figure 20 depicts the results of the study along East Cliff Drive and Opal Cliffs Drive assuming increasing amounts of sea level rise (from 10 centimeters to 159 centimeters) by the year 2100. Figure 21 is a similar depiction of the hazard at Pajaro Dunes.

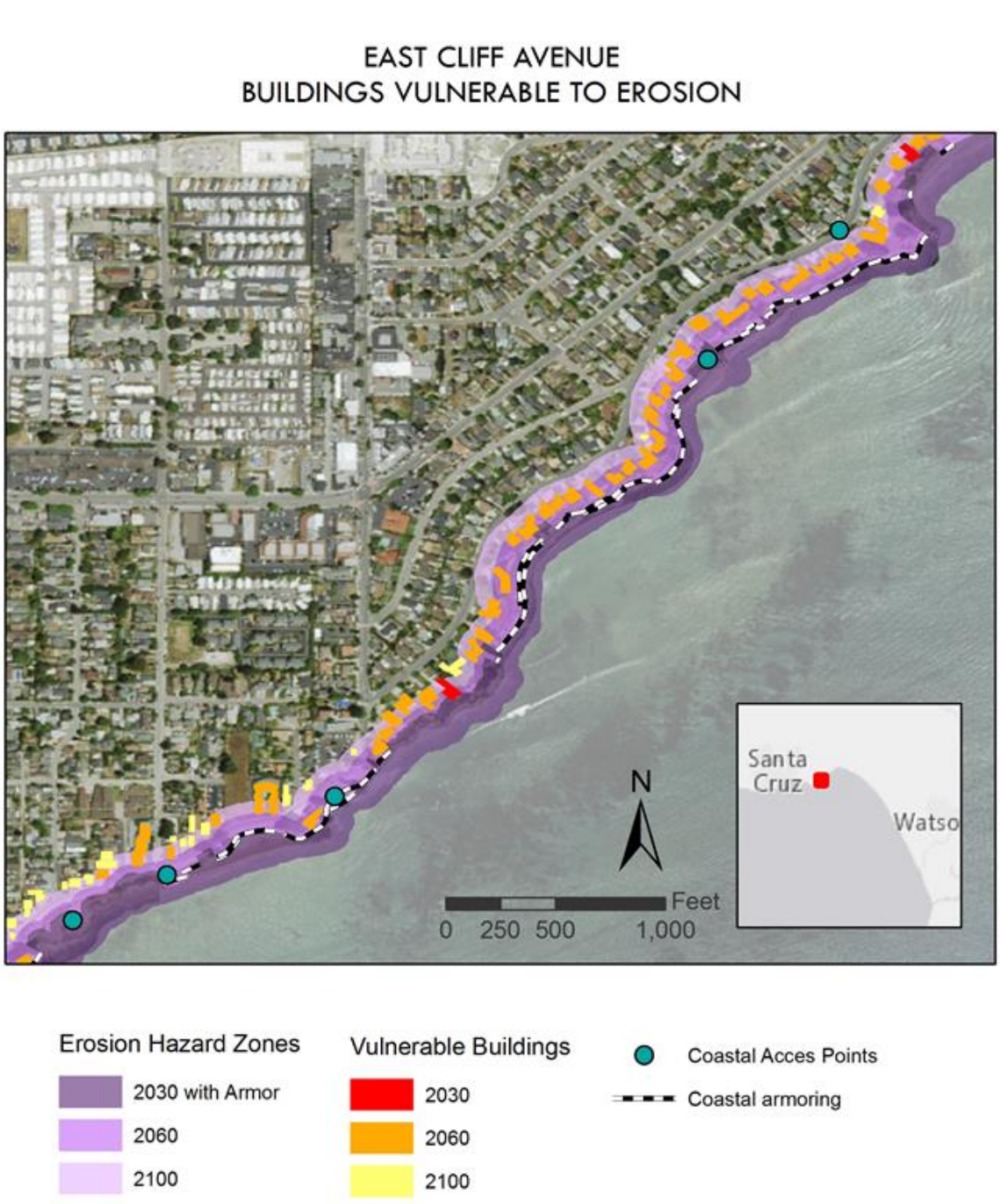

Figure 20 East Cliff Drive coastal erosion with sea level rise

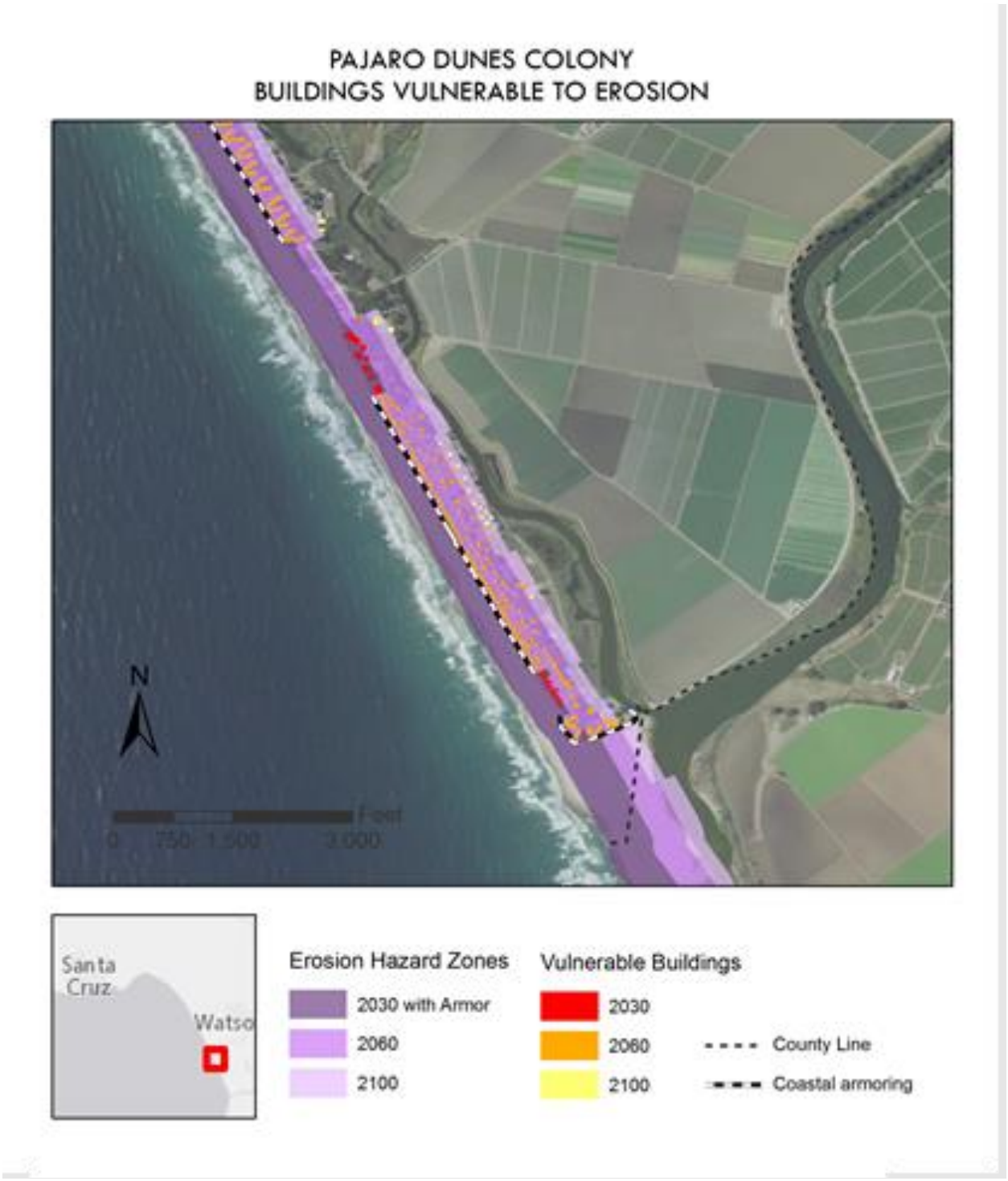

Figure 21 Pajaro Dunes coastal erosion with sea level rise

9.1.3 Assessing Vulnerability: Overview

Requirement §201.6(c)(2)(ii): The risk assessment shall include a description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.

Much of the Santa Cruz County coastline, particularly in the developed areas, has some level of armoring (walls, riprap, etc.). The majority of the protection structures have been installed within the last 40 years, and they have varying levels of adequacy and performance. While these protection structures help protect buildings and infrastructure during storms, they are still vulnerable to failure during larger storm events and may not provide full protection. Riprap structures along the coastline are particularly vulnerable to failure and require more maintenance and upgrading over time than the concrete seawalls.

While the entire Santa Cruz coast is subject to coastal erosion, the primary locations vulnerable to coastal erosion are the areas from the Santa Cruz Harbor eastward toward Pleasure Point, the area from Pleasure Point to Opal Cliffs, and the area south of New Brighton Beach to the southern Santa Cruz County line.

The area from the Santa Cruz Harbor to Pleasure Point contains numerous homes on the coastal bluff as well as roads and other infrastructure, particularly near the coastal lagoons, that are vulnerable to coastal erosion. There are also several sea caves that may affect the integrity of homes and infrastructure in this area as well. The primary type of coastal armoring in this area is riprap. It is not uncommon for East Cliff Drive to be closed or damaged where it crosses Schwann Lake, Corcoran Lagoon and Moran Lake during large winter storms. Many of the homes that exist along the coast in this area, although somewhat protected, may be subject to further coastal erosion as sea levels rise, earthquakes occur, and waves and rainfall impact the coast.

The area from Pleasure Point to Opal Cliffs also contains numerous homes on the costal bluff as well as roads and other infrastructure that are vulnerable to coastal erosion. The coastal armoring in this area is a mix of riprap, concrete seawalls, and a combination of both. A seawall has been constructed in the Pleasure Point area along East Cliff Drive that should greatly reduce potential damage from coastal erosion to East Cliff Drive as well as the homes on the other side of the road. Many of the homes that exist along the coast in this area, although somewhat protected, may be subject to further coastal erosion as sea levels rise, earthquakes occur, and waves and rainfall impact the coast.

The area south of New Brighton Beach to the southern Santa Cruz County line contains numerous homes on the bluffs, at the base of the bluffs and on the beach. There is also infrastructure and several County roads on the beach and bluffs that may be affected by coastal erosion. Many of the homes along and above both Las Olas Drive and Beach Drive will experience the continuing effects of coastal erosion. There are also several other communities (including Seascape, La Selva Beach, Sunset Beach and Pajaro Dunes) that are vulnerable to coastal erosion. Many of the homes that exist along the coast in this area, although somewhat protected, may be subject to further coastal erosion as sea levels rise, earthquakes occur, and waves and rainfall impact the coast.

Along the north coast of Santa Cruz County, regulations have limited development and structures have been constructed in very limited locations.

Although seawalls reduce or delay coastal erosion processes as long as they remain functioning, ultimately coastal erosion continues, and the best seawalls need maintenance. While seawalls remain in place, they modify coastal erosion through the reduction of wave erosion energy, or reflection or refraction of wave energy. Focused erosion can occur at the ends of the seawalls. While seawalls are helpful in protecting against coastal erosion, proper setbacks from the brow of bluffs, drainage control, and special construction are all necessary to protect structures, roadways, and utilities from damage. Modern seawall construction, such as the recently constructed structures in the Pleasure Point area, can also be designed to improve coastal access by incorporating stairways and viewing platforms, and removal of debris from previous attempts at coastal protection that block lateral access along the shoreline.

9.1.4 Assessing Vulnerability: Identifying Structures

Requirement §201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

As shown in Table 21 there are a total of approximately 1,152 parcels affected by coastal erosion containing a total of 466 structures. The analysis captures only those structures that are in flood hazard zone VE, or houses at beach level. The actual number of structures subject to coastal erosion hazard would also include structures on coastal bluffs outside of the flood hazard zone, but still subject to coastal erosion hazards. Based on a staff analysis of County Assessors records, this would bring the total number of structures vulnerable to coastal erosion hazards to over 1,000 structures. The potential loss value of the 466 structures is over $356 million; therefore, actual potential loss value is more than twice that amount and well over $700 million.

9.1.5 Assessing Vulnerability: Estimating Potential Losses

Requirement §201.6(c)(2)(ii)(B): The plan should describe vulnerability in terms of an estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate.

Land Use	Parcels	Structures	Total Assessed Value 2020
Agricultural	4		$282,777
Commercial	3		$2,374,321
Government	95	20	$0
Industrial			$0
Institutional	3		$2,049,384
Miscellaneous	37	3	$13,231,635
Residential	1,008	443	$338,225,243

Land Use	Parcels	Structures	Total Assessed Value 2020
Utilities	2		$0
Total	**1,152**	**466**	**$356,163,360**
Population	2,752		
Population is based on the number of residential parcels x 2.73 (See Table 3)			

Table 21 Coastal erosion potential loss inventory

The 2017 Santa Cruz County Coastal Climate Change Vulnerability Report provides similar estimates for coastal flood hazard areas subject to future sea level rise. Regarding the areas of Rio Del Mar and Pajaro Dunes, for example, coastal access, parking and 80 commercial and residential buildings are vulnerable to wave damage and coastal flooding by 2030 (10 cm of sea level rise) within the low-lying sections of Rio del Mar. More than 130 buildings within the Pajaro Dunes Colony (many comprised of multiple residences) are also vulnerable to flooding during winter storms.

By 2060 more than 800 additional buildings are at risk of impact from a predicted 2.4 ft. rise in sea levels as coastal protective structures begin to fail. If current structures are replaced, it is estimated that 500 of the vulnerable buildings would be protected, 400 of which are private residence. By 2100, more than 1,800 residential properties within the unincorporated county are vulnerable to coastal climate change hazards.

9.1.6 Assessing Vulnerability: Analyzing Development Trends

Requirement §201.6(c)(2)(ii)(C): The plan should describe vulnerability in terms of providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

Every coastal community in California is dealing with the issues of sea level rise and shoreline retreat armoring is becoming an increasingly controversial and contentious issue. Since seawalls now protect so much of the developed portion of Santa Cruz County coastline, the controversy now centers on improving these walls and their impacts. Coastal erosion poses many problems to coastal communities in that valuable property is frequently lost to this dynamic beach-ocean system. Additionally, human activity may modify the process of coastal erosion with uncertain results. Thus, issues of beach restoration and erosion control are at the forefront in coastal communities. Santa Cruz County's shoreline is now part of the Monterey Bay Marine Sanctuary, which will also influence development trends along the Santa Cruz coast.

The majority of the undeveloped areas along the coastline are farmland or other areas currently protected from development. The current trend in development along the coastline in Santa Cruz County is in-fill within the developed areas and reconstruction of existing structures and infrastructure. The County of Santa Cruz's Geologic Hazards Ordinance Section 16.10.070(h) requires development on coastal bluffs and beaches to be reviewed by the County Geologist. The ordinance requires

development to be setback at least 25 feet from the top of a coastal bluff, or the distance required to provide 100-year stability, whichever is greater. Shoreline protection structures are also subject to the County's Geologic Hazards Ordinance and review by the County Geologist. Most current seawall permits are for maintenance and improvement of existing walls, which allows the County of Santa Cruz to require modifications that reduce the walls' impacts.

No changes in these development regulations or patterns occurred that would affect the County's overall vulnerability since the LHMP was adopted in 2016. While the County does not track the number of residential and commercial structures that have been built in coastal erosion hazard areas since the last update, it is a subset of the overall number of new structures built in the unincorporated portion of the County. According to annual Growth Management Reports, there have been 909 new residential structures built in the County since 2010 (Table 11).

As stated above, growth management policies prevent new development from occurring where hazards are present. Development on existing lots of record is required to avoid hazards and incorporate appropriate setbacks and other requirements to mitigate potential impacts from coastal erosion hazards. The Environmental Planning Section of the Planning Department, staffed by Resource Planners, specialize in reviewing each application for new residential and commercial structures to ensure that new development does not occur in hazard zones and that development on existing lots of record avoid, minimize, and mitigate potential impacts from identified coastal erosion hazards.

9.2 Mitigation Strategy

Requirement §201.6(c)(3): The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

The Santa Cruz County General Plan and Local Coastal Program Safety Element, the Geologic Hazards Ordinance and Coastal Zone Regulations provide a framework for protecting and preserving the coastline through the permit review process. County policies and regulations require careful planning and design when considering a new seawall, and maintenance of existing seawalls. Restoration efforts can help to mitigate damage from coastal storms by increasing natural resilience to coastal hazards.

An assessment of this mitigation strategy as part of this 5-year plan update indicates the strategy is effective for reducing potential losses identified in the risk assessment. The coastal erosion risk has not changed since the previous plan was adopted. Adjustments are needed to address a change in circumstances, however. The increased risk of coastal erosion in the future as a result of sea level rise is addressed in the Climate Change chapter. There have been no coastal erosion related disasters during the five-year update period.

9.2.1 Mitigation Goals

Requirement §201.6(c)(3)(i): The hazard mitigation strategy shall include a description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

Coastal Erosion Goals

Coastal Erosion 1 - Avoid or reduce the potential for life loss, injury, property, and economic damage to Santa Cruz County from coastal erosion.

Coastal Erosion 2 - Protect and preserve natural resources.

Coastal Erosion 3 - Protect and preserve current infrastructure.

9.2.2 Identification and Analysis of Mitigation Actions

Requirement §201.6(c)(3)(ii): The mitigation strategy shall include a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

Coastal erosion mitigation strategies include the following actions. The alpha-numeric identifiers after each action are further described in Chapter 15 Mitigation Strategy.

- Protect and preserve the coastline through permit review and continue to review coastal development for conformance with the County's Geologic Hazards ordinance. (C-3)
- Encourage the replacement of existing seawalls with better-designed walls that result in less of an impact to coastal access and beach area and integrate coastal access elements. (C-4)
- Protect and preserve the coastline and infrastructure through restoration efforts (C-8)

Minimizing Hazards from Coastal Erosion

Much of the urban coastline in the County has boulder riprap or concrete seawalls to minimize the energetic wave impacts that drive cliff erosion and to protect residences and infrastructure. Because these structures have finite life spans and can have adverse effects on other parts of the coast, engineering solutions can be very expensive in both the short-term and long-term. In other cases, the solution is to leave the coastline relatively undeveloped and to allow erosion to occur naturally. This option preserves the normal input of sand into the littoral drift system, perhaps lessening erosion at neighboring beaches.

The three primary management strategies that may be used to plan for and respond to coastal erosion are hazard avoidance, relocation, and coastal protection. The maximum potential efficacy and acceptability of these strategies can best be determined with multi-disciplinary project planning, design, monitoring and evaluation.

Hazard Avoidance – A Commonsense Approach

The most logical method for preventing potential damage to new development in the coastal zone is to avoid building where coastal erosion will impact such development. This concept, known as hazard avoidance, could circumvent many subsequent permitting and legal challenges. Hazard avoidance has

proven effective when used in a number of ways including designing public infrastructure to discourage development in high geologic hazard areas along the coast.

Relocation – Moving Development Out of Harm's Way

In some instances, development is sited in unstable, erosion-prone areas that may be damaged or destroyed by natural processes acting on the coast. Relocating existing public or private development away from erosion-prone areas may be the most effective long-term option when responding to the eventual or imminent threat of damage. While relocating coastal development away from hazardous areas would be the most direct way to eliminate the risk of damage and the need for coastal protection, this response may not be technically, financially, or legally feasible. Another approach to consider under certain circumstances is the concept of "managed retreat," that is the gradual removal or abandonment of development from areas of high geologic hazard. In the context of coastal management, the concept of managed retreat acknowledges the natural erosive processes at work along the coast.

Coastal Protection

In situations where hazard avoidance and relocation are not viable options, coastal protection strategies can be used to reduce the potential for beach loss, coastal erosion, and coastal access loss. There are two general types of coastal protection, hard and soft. A "hard" protection device utilizes concrete or rock in a variety of configurations to absorb or dissipate storm wave energy, generally in the form of vertical seawalls, rock revetments or bulkheads. "Soft" protection primarily involves dune or beach restoration or enhancement to reduce the chances of storm waves from reaching the backshore. A hard protection device differs substantially from most soft erosion response alternatives in that it does not add sand to the system of sediment.

2021 Progress Report

The integration of the plan into existing planning mechanisms and the implementation of mitigation actions demonstrate progress in risk reduction. An explanation of how the mitigation plan for coastal erosion hazards has been implemented over the last five years is included in Appendix L and described below for each Mitigation Action related to coastal erosion hazard reduction.

- Planning staff is currently involved in protecting and preserving the coastline during review of development projects for conformance with the Geologic Hazards ordinance. In 2020 the Board of Supervisors adopted amendments to the Safety Element of the General Plan and Local Coastal Plan (GP/LCP) to incorporate sea level rise into policies addressing coastal bluff and beach hazards and floodplain management. The amendments will not be effective until certification by the California Coastal Commission. The amendments preserve existing policies and regulations regarding development on coastal bluffs and beaches intended to avoid coastal erosion and flooding hazards, including coastal bluff setbacks to avoid coastal erosion hazards and elevation of substantially improved structures on the beach to avoid flooding hazards. The amendments include new policies and regulations to preserve and protect the coastline including a prohibition on new seawall construction on the beach and requirements to mitigate impacts of existing seawalls as a condition of development projects. As a condition of new development, property owners would be required to acknowledge the risks of development in a hazardous area and the potential that future occupancy of structures may be prohibited as a result of coastal hazards. (C-3)

- Policies encouraging the replacement of existing seawalls with better-designed walls that result in less of an impact are incorporated in the Safety Element amendments recently adopted by the Board of Supervisors. In addition to a prohibition on new seawall construction on the beach, the new policies would encourage construction of seawalls in a defined urbanized area referred to as the Shoreline Protection Exception Area. In this area, the goal would be to continue the existing pattern of bluff protection exemplified by the County projects between 32nd and 36th Avenue and at the end of 41st Avenue. The County project resulted in improved coastal access both vertically and laterally. This project was informed by sea level rise vulnerability assessments in the Monterey Bay, and coastal regional sediment management studies. (C-4)
- Protecting and preserving infrastructure along the coast through restoration efforts is ongoing. Construction of the East Cliff Drive, 32nd Avenue to 36th Avenue and 41st, Bluff Protection Project was completed on March 21, 2011. Continued maintenance of existing coastal protection structures occurs as needed. The policy amendments described above would also result in improved maintenance of private seawalls that indirectly protect public infrastructure. Public Works continues to struggle to maintain its existing coastal protection infrastructure due to the continued shortfall of State and Federal funds and declining gas tax revenues. The lack of available funding also affects the Departments ability to plan, design, and construct new coastline protection infrastructure. (C-8)

By using these planning mechanisms to protect and preserve the coastline, encouraging the upgrade of existing coastal protection structures, and protect and preserve infrastructure along the coast, the County has demonstrated progress in reducing the risk from coastal erosion hazards. Further explanation of how the previous mitigation plan has been implemented over the last five years is included in Appendix L. The worksheets in Appendix L also describe how the current mitigation strategy, including the goals and hazard mitigation actions, will be implemented over the next five years. The projects described in Mitigation Actions C-3, C-4, and C-8 are still relevant and will continue to be implemented over the next five years.