CITY OF SANTA CRUZ
Local Hazard Mitigation Plan
Five Year Update
2017–2022

Hazard Mitigation is any action taken to reduce or eliminate the long-term risk to human life and property from hazards.
~ Title 44 Code of Federal Regulations (§206.401)

Adopted by the City Council
xxxx xx, 2017

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How to Use This Plan

FEMA has defined very specific requirements for Local Hazard Mitigation Plans and this plan follows those guidelines. The organization of the Plan follows FEMA's structural requirements and includes the following four organizational levels:

- Parts
- Chapters
- Sections
- Subsections

This LHMP Five Year Update [2017–2022] is organized into five primary Parts and fifteen Chapters (and, Appendices A–R), that track the phases of the plan's development as follows:

Risk Assessment (Part 3) is organized into specific hazards by chapter (Chapter 4 through Chapter 12). Within each of these chapters all elements required by the FEMA *Local Mitigation Review Tool* (formerly, the "crosswalk"), are addressed and the sections and subsections of each of these chapters follow the section numbering of the Local Mitigation Plan Review Tool. The Local Mitigation Plan Review Tool elements are formatted in this document as follows:

Subsection **3.1 Identifying Risk Hazards is §7.3.1** in Chapter 7 – Drought

Each of the specific hazard Risk Assessment chapters contains the following subsections:

- **3.0 Risk Assessment**
  - 3.1 Hazard Identification
  - 3.2 Hazard Profile including subsections on location, extent, previous occurrences and probability of future events.
  - 3.3 Assessing Vulnerability
  - 3.4 Identifying Structures
  - 3.5 Estimating Potential Losses
  - 3.6 Analyzing Development Trends

Mitigation Strategy (§4.0 through §4.2) is addressed briefly under each hazard chapter and covered comprehensively in Part 4. Goals and Actions specific to a particular hazard are included within each of the hazard chapters and are labeled by hazard (e.g., Earthquake Goal 1, etc.). Goals, Objectives and Actions which apply to one or more potential hazards are listed in Part 4.

Specific **Mitigation Actions** are noted throughout the hazard chapters as, for example, (A-1), and are cross-referenced to Chapter 13, Mitigation Strategy.

Goals, **Objectives** and **Action** items identified as part of the mitigation strategy were formulated in collaboration with the departments responsible for implementation of the actions. These goals and supporting actions are not new but have been taken from various plans adopted by the City Council including the General Plan Safety Element, the Capital Improvement Project list, the 2015 Urban Water Management Plan, the Emergency Operations Plan (2013) and several fire safety plans, the 2011 Climate Adaptation Plan and its update (2017; appended to this LHMP). This material was revisited and addressed during the current update process.

Local Mitigation Plan Review Tool sections that do not apply to the City of Santa Cruz, such as multi-jurisdiction plan requirements, are not included.

Compliance with the Code of Federal Regulations

Each part of the LHMP includes required elements specified under Section 201.6 of Title 44 of the Code of Federal Regulations (44 CFR). Since one of the objectives established for the LHMP is to achieve compliance for the City of Santa Cruz under the Disaster Mitigation Act (DMA), the requirements specified for program compliance are often cited at the beginning of a subsection to illustrate how that subsection attempts to comply with the requirement.

Section 44 CFR 44 CFR §201.6(d)(3) reads:

> *A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years in order to continue to be eligible for mitigation project grant funding.*

Appendices

At the end of this LHMP are Appendices A–R. These appendices include vital information or explanations to support the main content of this plan. Technical terms, acronyms, and abbreviations are used throughout this document. To aid the reader, technical terms used in the LHMP and, in emergency management in general, are defined in the glossary. The list of acronyms and abbreviations defines all shortened forms used in Hazard Mitigation planning and/or this LHMP.

Climate Adaptation

The City of Santa Cruz Climate Adaptation Plan, adopted by the City Council (Resolution NS-28,435, December 13, 2011), is referenced throughout this LHMP Update where appropriate and where it is relevant to identified vulnerabilities and risks. Additionally, the 2017 Climate Adaptation Plan Update, having been updated concurrently to this Five Year LHMP Update, is annexed in its entirety to this document in the Appendices (*see* Appendix P).

The LHMP benefited greatly from the public outreach that was undertaken in the development of the 2011 Climate Adaptation Plan. In fact, the Climate Adaptation Plan was intended to be the city's initial LHMP Five Year Update and its development was managed as such. Chapter 15 details the public outreach and Plan Update efforts undertaken by the LHMP/Climate Adaptation Project Team.

PART 1 — INTRODUCTION AND ADOPTION

Prerequisites

- Introduction
- Acknowledgements
- City Council Resolution Adopting Plan
- Summary

Introduction

THIS PLAN IS AN UPDATE

In 2007 the City of Santa Cruz completed and adopted its first Local Hazard Mitigation Plan (LHMP). Late in 2012 and early 2013 the LHMP was updated, approved by the California Office of Emergency Service (formerly CalEMA) and then by the Federal Emergency Management Agency (FEMA). The City Council formally adopted the Plan on June 24, 2014.

The Disaster Mitigation Act of 2000 (DMA, Section 201.6(c)(4)(i) requires a Plan Maintenance Process which includes periodically reviewing and updating hazard mitigation plans. FEMA requires jurisdictions to update their LHMP every five years, subject to approval by the California Office of Emergency Services (CalOES). An approved and adopted LHMP is required for the City of Santa Cruz to receive future federal and state emergency funding.

This document is the **City of Santa Cruz 2017–2022 LHMP Five Year Update**. It is the second five year update undertaken by the City. Chapter 3: The Planning Process, details how the City of Santa Cruz planned and managed this update.

The intent of the current Plan, while incorporating much of the prior LHMP versions, is to:

- Include any newly identified hazards
- Update hazard/risk data
- Update development data
- Review and revise as necessary the original document's Goals, Actions and Implementation Strategies
- Update demographic data and maps, based on current information
- Incorporate findings from the City of Santa Cruz Climate Adaptation Plan (CAP):
  - Adopted by City Council (Resolution NS-28,435, December 13, 2011)
  - The CAP is being updated concurrently with this LHMP

LOCAL HAZARDS

People and property in Santa Cruz are at risk from a variety of hazards which have the potential to precipitate wide spread loss of life, damage to property, infrastructure and the environment. Some hazards are natural, such as earthquakes, others are natural hazards exacerbated by the use of land, such as building along the cliff and development within floodplains. A natural hazard can result in damages and hardships for an entire community for many years following the event. Flooding, drought, earthquakes and cliff retreat have all occurred in the City of Santa Cruz within the last fifty years. Until 1989, flooding on the San Lorenzo River had caused the most severe damage in the City. However, the Loma Prieta earthquake in 1989 changed that history. Although subject to droughts, the City will experience flood conditions in the future. There is a very strong possibility of an earthquake equal to or larger than the Loma Prieta quake occurring in the Santa Cruz area (*see* Table 4-2).

The City of Santa Cruz is somewhat unique in that water service is provided by the Water Department to an area beyond the city limits and a significant portion of the water service infrastructure extends outside the city limits including the primary ground storage facility, Loch Lomond Reservoir.

Although Santa Cruz is a city of ± 64,632 residents (Department of Finance 2015 estimate; http://www.dof.ca.gov), this hazard mitigation plan impacts approximately 96,100 people inside *and* outside the city limits because of the city water service boundaries.

HAZARD MITIGATION

The purpose of hazard mitigation 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.

Mitigation actions include both short-term and long-term activities which reduce the impacts of hazards, reduce exposure 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.

The City of Santa Cruz developed a Local Hazard Mitigation Plan (2007–2012) and an initial Five Year Update (2012–2017), to create a safer community. The LHMP represents the city's commitment to reduce risks from natural and other hazards, and serves as a guide for decision-makers as they commit resources toward reducing the effects of potential hazards. The LHMP serves as a basis for the California Office of Emergency Services to provide technical assistance and to prioritize project funding. (Code of Federal Regulations [CFR] §201.6.).

The City of Santa Cruz must have an approved LHMP pursuant to CFR §201.6 in order to receive FEMA Pre-Disaster Mitigation (PDM) project grants or to receive post-disaster Hazard Mitigation Grant Program (HMGP) project funding. This LHMP Five Year Update (2017–2022) is written to meet the statutory requirements of the Disaster Mitigation Act 2000, enacted October 30, 2000 and Title 44 of the Code of Federal Regulations CFR Part 201 – Mitigation Planning, Interim Final Rule, published February 26, 2002.

Acknowledgements

NOTE: Many of the following individuals contributed to the original LHMP (2007–2012), its first update (2012–2017), as well as to the current document (2017–2022). This information is updated as of September 2017.

2017 City of Santa Cruz City Council		
Cynthia Chase Mayor	Sandy Brown	Cynthia Mathews
David Terrazas Vice-Mayor	Christopher Krohn	Richelle Noroyan
		Martine Watkins

2017 LHMP Project Team/Staff	**Department**	**Position**
Robert Solick (LHMP)	Fire	Mgmt. Professional and Technical Assistant
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Chris Schneiter	Public Works	Assistant Director/City Engineer
Steve Wolfman	Public Works	Senior Associate Civil Engineer
Paul Horvat	Fire	Principal Management Analyst/OES
Michele King (ret.)	Planning	Senior Planner
Maya Crelan Ray	Planning	Professional and Technical Assistant
Carol Scurich	Parks and Recreation	Recreation Superintendent
Monica Rubio	Parks and Recreation	Parks Superintendent
Leslie Keedy	Parks and Recreation	Urban Forester
Heidi Luckenbach	Water	Deputy Director/Operations Manager
Toby Goddard	Water	Water Conservation Manager
Katie Moore	Water	Associate Planner II
Taylor Roone	Water	Associate Civil Engineer
Joe Hall	Economic Development	Project Manager
Rebecca Unitt	Economic Development	Economic Development Coordinator
Richard Westfall	Information Technology	Systems Coordinator (GIS, IT, HAZUS)
2017 LHMP Technical Advisors	**Organization**	**Position**
Climate Adaptation Vulnerability Assessment		
Ross Clark	Central Coast Watershed Group	Program Director
Sarah Stoner-Duncan	Central Coast Watershed Group	Research Associate
Dr. Juliano Calil	UCSC Ocean Sciences	Research Scientist
Dr. Ben Preston	Rand Corporation	Policy Researcher, Sr.; Director, Infrastructure Resilience and Environmental Policy Program
Greg Pepping	Coastal Watershed Council	Executive Director
Dr. Bill Henry	Groundswell Coastal Ecology	Founding Dir. of Groundswell Coastal Ecology
Stakeholders		
Rosemary Anderson	Santa Cruz County OES	Emergency Services Manager

Summary

Surrounded by greenbelt and the Pacific Ocean, Santa Cruz is a compact, vibrant beach community that preserves the diversity and quality of its natural and built environments, creates a satisfying quality of life for its diverse population and workers, and attracts visitors from around the world. But every aspect of the city — its economic prosperity, social and cultural diversity, scenic beauty and historical character — could be dramatically altered by a serious earthquake, flood, tsunami or fire.

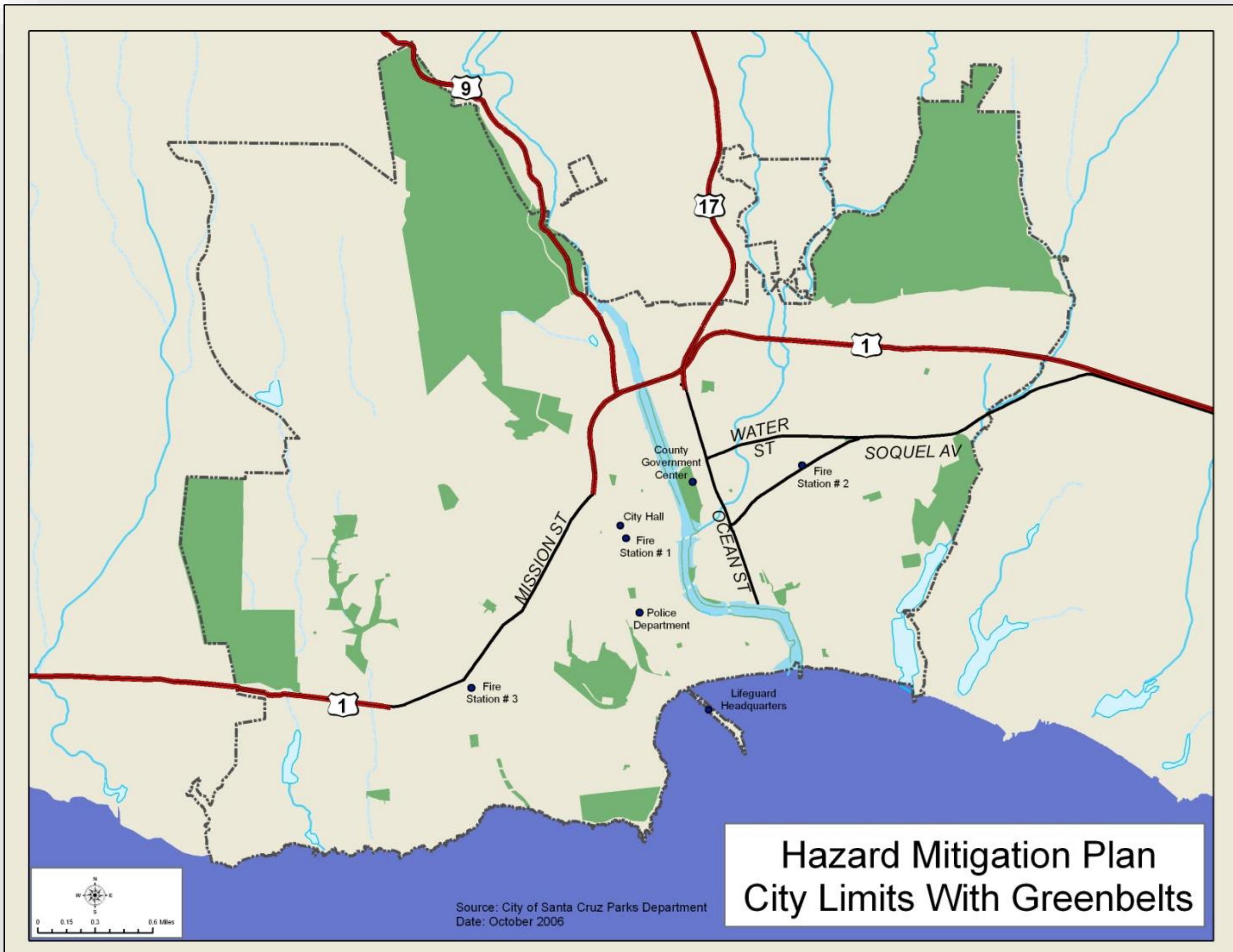


Figure 1 – City Limits of Santa Cruz with Surrounding Greenbelts

Natural hazards that have affected Santa Cruz in the past and those that may affect it in the future can be identified with a high degree of probability. However, the future extent of these hazards is unknown. Flooding, earthquakes and cliff retreat have all occurred in the city within the past forty years. The city is prone to reoccurring droughts and the city will periodically witness flood conditions in the future. Until 1989, flooding on the San Lorenzo River had caused the most severe damage in the city. However the Loma Prieta earthquake changed that history.[1]

On October 17, 1989, the Loma Prieta earthquake, the largest earthquake to hit an urban area in California since the 1906 San Francisco earthquake, struck the City of Santa Cruz. The earthquake destroyed over 50% of the downtown commercial core, displacing over 205 commercial, professional and service businesses, 5,000 employees, and hundreds of residents.[2]

While we cannot predict or protect ourselves against every possible hazard that may strike the community, we can anticipate many impacts and take steps to avoid or reduce the harm they will cause. This Local Hazard Mitigation Plan Five Year Update is part of an ongoing process to evaluate the risks that different types of hazards pose to Santa Cruz and will engage the city and the community in dialogue to identify the most important steps to pursue in order to reduce these risks.

Santa Cruz and community members have been working together during the past several years to identify and address the risks posed by earthquakes, floods, fires and other potential hazards. Many measures such as raising levees, vegetation management, a comprehensive water management plan and seismic retrofits have significantly reduced the community's vulnerability to these hazards. Over time, this focus on disaster preparation will make the city a much safer and more sustainable community.

Climate Adaptation

Following extensive public outreach and workshops the Santa Cruz completed and adopted a Climate Adaptation Plan in December, 2011, funded by CalOES' Pre-Disaster Mitigation Competitive Grant (Award #2007-1004; PDM-07 PL 02). That plan addressed the impacts our community can expect due to the continuing challenges of climate change and outlined specific adaptation strategies aimed at increasing resilience.

With new scientific data, modeling and methods available, the City is in the process of preparing the 2017 Climate Adaptation Plan Update. In 2017, the Climate Vulnerability Study was updated by city staff (non-coastal impacts) and Central Coast Wetlands Group (CCWG) was contracted to conduct the City's first Sea Level Rise Vulnerability Analysis. CCWG's three key objectives were intended to further City planning for the likely impacts associated with sea-level rise (SLR) by:

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

In a new and innovative piece to the Climate Adaptation Plan Update, the City partnered with the American Geophysicist's Union Thriving Earth Exchange to connect with Dr. Juliano Calil to assess social vulnerability to climate change. Dr. Calil worked with the City to compile social vulnerability scores and mapping for census blocks in the City. Key social vulnerability drivers in Santa Cruz include increased presence of crime, elderly, disabled, and low income populations, and populations for whom English is a secondary language. The social vulnerability scores, when overlain with the SLR impact hazard zones provide greater insight into appropriate adaptation strategies for those areas based on the drivers of social vulnerability in addition to geography.

Both the sea level rise and social vulnerability assessments offer greater detail on the temporal and geographic extent of expected climate change impacts, their economic impacts, and allow for greater customization of adaptation strategies in the Climate Adaptation Plan Update effort.

It is the intention of this LHMP Update to meet the requirements of the federal Disaster Mitigation Act of 2000 and to outline and demonstrate progress in planning and mitigation efforts. DMA 2000 §322 (Mitigation Planning) specifically addresses mitigation planning requirements at the state and local levels. Following approval of this updated LHMP by FEMA, and adoption by the City Council, the City of Santa Cruz will be eligible to apply for mitigation grants before disasters strike.

Mitigation Plan Objectives and Actions

Santa Cruz strives to be a disaster-resistant community that can avoid, mitigate, survive, recover from, and thrive after a disaster while maintaining its unique character and way of life. City government should be able to provide critical services in the immediate aftermath of a devastating event of any kind. The people, buildings and infrastructure of Santa Cruz should be resilient to disasters. The city's overall objective is to have basic government services and commercial functions resume quickly after a damaging earthquake or other significant event.

Mitigation Plan Primary Goals

This Plan has a number primary goals for reducing disaster risk in Santa Cruz:

1. Avoid or reduce the potential for loss of life, injury and economic damage to Santa Cruz residents from earthquakes, wildfires, floods, drought, tsunami, coastal erosion, landslide and dam failure.
2. Increase the ability of the city government to serve the community during and after hazard events.
3. Protect Santa Cruz' unique character, scenic beauty and values from being compromised by hazard events.
4. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and systems essential to a functioning Santa Cruz.
5. Continue to monitor effects of climate change as outlined in the City of Santa Cruz Climate Adaptation Plan.

CHAPTER 1: ADOPTION BY CITY COUNCIL

Formal City Council Adoption by Resolution (LHMP 2012–2017)
June 24, 2014

RESOLUTION NO. NS-28,796

RESOLUTION OF THE CITY COUNCIL OF THE CITY OF SANTA CRUZ ADOPTING THE CITY OF SANTA CRUZ LOCAL HAZARD MITIGATION PLAN FIVE YEAR UPDATE AS APPROVED BY THE FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

WHEREAS, the City of Santa Cruz having developed a Local Hazard Mitigation Plan Five Year Update meeting the requirements of Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, and Section 322 of the Disaster Mitigation Act of 2000; (DMA 2000) and

WHEREAS, the DMA 2000 requires all cities, counties, and special districts to adopt a Local Hazard Mitigation Plan, and to update that plan at least every five years as a condition of future funding for disaster mitigation from multiple FEMA pre- and post- disaster mitigation grant programs; and

WHEREAS, the City of Santa Cruz seeks to maintain and enhance both a disaster-resistant and resilient city reducing the potential loss of life, property damage, and environmental degradation from natural disasters, while accelerating economic recovery from those disasters.

NOW, THEREFORE, BE IT RESOLVED that the City of Santa Cruz does hereby adopt the City of Santa Cruz Local Hazard Mitigation Plan Five Year Update as an official plan in accordance with the federal Disaster Mitigation Act of 2000, thereby meeting the continued eligibility requirements for the potential receipt of hazard mitigation grant funds; and

Be it further resolved, that the City of Santa Cruz will submit this Adoption Resolution to Federal Emergency Management Agency Region IX Mitigation Division IX officials to enable the plan's final approval.

PASSED AND ADOPTED this 24th day of June, 2014, by the following vote:

AYES:	Councilmembers Bryant, Terrazas, Comstock, Mathews, Posner; Vice Mayor Lane; Mayor Robinson.
NOES:	None.
ABSENT:	None.
DISQUALIFIED:	None.

APPROVED: ______________
Mayor

ATTEST: ______________
City Clerk Administrator

Adoption

RESERVED FOR 2017–2022 LHMP COUNCIL ADOPTION RESOLUTION

CHAPTER 2: COMMUNITY PROFILE

COMMUNITY PROFILE

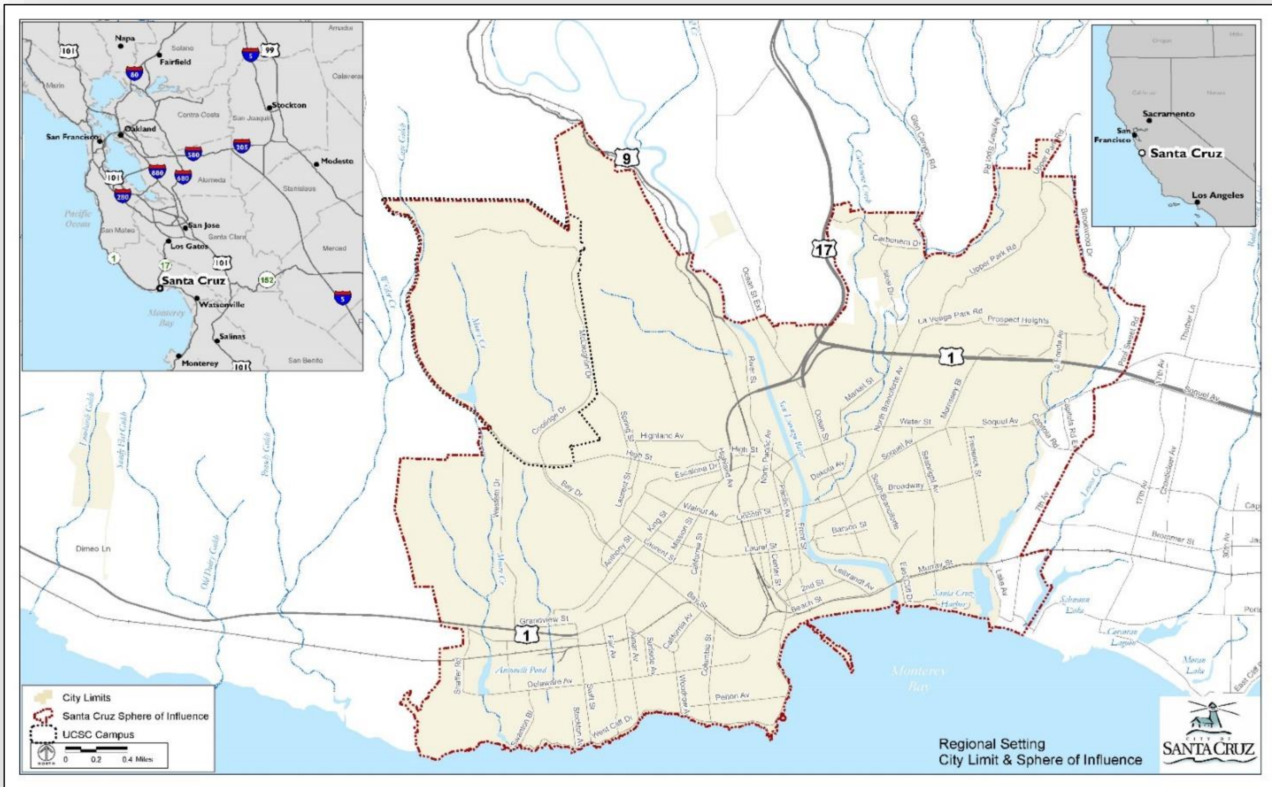


Figure 2 – City of Santa Cruz Location within the State of California

Sources: [UCSC Final Draft LRDP [2005–2020]]
[UCSC Academic Personnel Resources]

Santa Cruz may be a small city but we boast a lot of character and endless opportunities to enjoy the arts, connect with community, and explore the great outdoors. Flanked by the incredible redwood forests and the Monterey Bay National Marine Sanctuary, our city feels infused with nature. It's an incredible location with many opportunities within reach.

We're a short skip away from the San Francisco Bay Area and Silicon Valley. With easy access to major airports, sports and entertainment venues, nestled between the Santa Cruz Mountains and the Monterey Bay, our unrivalled environment creates a thriving and open culture that invites innovation, entrepreneurship, and an ethos of keeping it real.

You don't have to be a yogi or bicycle pump track superstar to appreciate how active and healthy Santa Cruz is as a community. We support all different kinds of activities, including park infrastructure that's accessible to everyone, so you can get out and live a full life. Beyond a plethora of activities, we sport one of the highest densities of specialty grocers per capita, along with several active farmers markets where we enjoy food and drink that support the whole health of our active community.

Santa Cruz' mild weather, proximity to several northern California metropolitan centers, and scenic and recreation resources make it a popular day and extended-stay recreation area. As a result, the population is subject to large seasonal variations due to an influx of visitors during summer and other peak recreational periods. Planning for potential hazards in Santa Cruz must address the safety of its visitor population as well as residents, large student population, and workers within the community.

Santa Cruz is the largest city in Santa Cruz County and serves as the County government seat. Since its founding, it has been the urban center of the County, providing employment and commercial, governmental, social, educational and cultural services to the larger area. The establishment (1964) and growth of the University of California at Santa Cruz have reinforced the city's role as a major social, cultural and scientific research center.

Santa Cruz occupies a picturesque location along the banks of the San Lorenzo River, between the Pacific Ocean on the Monterey Bay and the Santa Cruz Mountains. Public and privately owned lands along the city's western, northern and eastern boundaries form a greenbelt of open space; land uses, including agriculture and grazing lands, natural areas, parks, coastal recreation and low-density residential areas. This picturesque location also contributes to the potential hazards faced by the city. The downtown and higher density urban core is located within a flood plain. There are only four bridges across the river connecting the two sides of the community. Past experience has shown that losing even one of these bridges in a disaster presents significant problems in addition to traffic impacts.

The city's Mediterranean climate is characterized by warm, dry summers and mild, rainy winters. Warm temperatures and low precipitation are the norm from approximately April through August. November through March is dominated by cooler temperatures and heavy rains. Though winters are typically mild, colder winds from inland regions with more continental climates can result in short-term cold snaps. During the year the average temperature is approximately 58° F. The average high temperature is 69° F and the average low temperature is

47° F. Because of this temperate climate, extreme heat is rarely a threat to the community. Both summer and winter temperatures are moderated by the marine influence and summer fog is a common occurrence. Winds are generally northwesterly and seldom reach severe intensities. The Santa Cruz Mountains form a natural barrier to winds from the north and from the hot interior valleys. Rainfall averages approximately 31 inches per year. Over the past 25 years, it has ranged from 15 inches in 1989 to 59.8 inches in 1983 with an average 32 inches of rainfall annually (UCSC 2005 Long Range Development Plan [LRDP]).

Table 2-1 Temperature Averages for Santa Cruz

Average High/Low Temperature	Average Rainfall
January 63˚/41˚F (17˚/5˚C)	January 6.3 inches (160mm)
August 76˚/54˚F (24˚/12˚C)	August 0.04 inch (1mm)

Source: U.S Climate Data

Table 2-2 City of Santa Cruz Population and Household Growth — U.S. Census 2011–2015 American Community Survey 5-Year Estimates

Population(s)	Number	Percent
Total population	62,752	100.0
Sex and Age		
Male	30,895	49.2
Female	31,857	50.8
Median age (years)	28.7	
18 years and under	8,698	13.9
65 years and over	6,079	9.7
Disabled	4,639	7.4
Total households	21,657	100.0
Households with individuals under 18 years	4,817	22.2
Households with individuals 65 years and over	4,111	19.0
Average household size	2.39	
Housing Occupancy		
Total housing units	23,499	100.0
Occupied housing units	21,516	91.6
Vacant housing units	1,983	8.4
Homeowner vacancy rate (percent)		1.8
Rental vacancy rate (percent)		2.7
Owner-occupied housing units	9,459	44
Renter-occupied housing units	12,057	56
Average household size of owner-occupied unit	2.47	
Average household size of renter-occupied unit	2.51	

The population of the City of Santa Cruz grew an estimated 4.7% between 2010 and 2015, rising from an estimated 59,946 to 62,752 persons. Approximately 13.9% of households have residents under 18 years old. Approximately 9.7% of households have residents 65 or over. Approximately

7.4% of the population has some type of disability. In creating a hazard mitigation plan it is important to consider each of these special populations. It should also be noted that the city water system serves approximately 93,000 people inside and outside the city limits. Detailed census data can be found in Appendix M: Census Characteristics.

The University of California at Santa Cruz (UCSC)

The City of Santa Cruz is home to the University of California at Santa Cruz. The main campus consists of over 2,000 acres on the northwest side of the community off High and Bay Streets. Of UCSC's 10.6-mile perimeter, 1.75 miles adjoin the city. Approximately 53 percent of the campus, including most of the developed area, is located within the Santa Cruz city limits, and the remainder of the campus lies in the unincorporated area of Santa Cruz County.[3]

In addition to the main University campus, the University also has a Coastal Science Campus located on the north side of the city situated along the coast. The University owns property at 2300 Delaware Avenue on the west side of town (used as office and research space) and leases additional space in the downtown area and on the west side of Santa Cruz. The university also leases property in the nearby city of Scotts Valley.

Much of the University infrastructure and services are at least somewhat dependent on the City. UCSC receives water and sewer treatment services from the City of Santa Cruz. Water supply has been identified as a key issue for both the City and the University. While the city water supply system is essentially the same as in 1960, the service population has increased 190% and is expected to continue to increase. In normal and wet years, the water supply system is capable of meeting the needs of the current population, but even without population increases, the system is highly vulnerable to shortages in drought years.

The City and the University are also linked through mutual aid agreements in areas such as fire services. UCSC and the City recently merged their Fire Departments. On July 2, 2014 both agencies entered into a ten-year contract for fire and EMS response services (excluding prevention).

The University has a current enrollment of approximately 17,615 students supported by approximately 8,143 (April 2016) faculty and staff (per UCSC Full-Time and Part-Time Headcount).[4]

The developed area of the UC Santa Cruz campus (existing and approved) includes 3,113,000 assignable square feet (ASF) and 4,825,000 gross square feet (GSF) in 420 separate buildings within 116 building complexes. This includes existing buildings and projects approved and funded after adoption of the 1988 LRDP.[5]

The University adopted its own Emergency Plans (Hazard Vulnerability Assessment Summary Report). It also has an Emergency Operations Plan, updated in 2016 (UCSC Emergency Operations Plan). This plan provides details about hazard response, vulnerabilities and mitigation measures for the University community.

Household Income and Education

The median household income for the City of Santa Cruz in 2015 was an estimated $62,164, compared to $67,256 for the County and $61,818 for the State. Residents of the City of Santa Cruz are highly educated, with more than 51 percent of residents over age 25 having achieved a bachelor's degree or higher by 2015.

Residents' Place of Work

In addressing potential hazard, it is important to note that much of the workforce in the County of Santa Cruz is highly mobile and integrated into two separate economic ecosystems, the high technology and research and development cluster in Silicon Valley and the academic, hospitality and agricultural clusters of the greater Monterey Bay.

According to the 2014 Census "On the Map" tool (OnTheMap) there are 94,964 persons employed in the County, of which, 59,395 work and live within the County. There are 35,569 who work in the area but live outside of the area, while some 7,410 (7.8%) drive "over the hill" to Silicon Valley and Santa Clara County daily. Another 7,873 (8.3%) travel south to Monterey County. Alameda (2.3%), and San Benito (1.7%) Counties round out the top five.

Inflow/Outflow Job Counts (All Jobs)	2014	
Employed in the Selection Area	94,964	100.0%
Employed in the Selection Area but Living Outside	35,569	37.5%
Employed and Living in the Selection Area	59,395	62.5%
Living in the Selection Area	111,396	100.0%
Living in the Selection Area but Employed Outside	52,001	46.7%
Living and Employed in the Selection Area	59,395	53.3%

The City of Santa Cruz' total labor force (population 16 years or older) was estimated as 33,500 in February 2017 with an employed population of 30,900 and unemployed of 2,500. The average commute time for employed residents of the City of Santa Cruz was 22.3 minutes in 2015, indicating that most of the residents of the city are employed within the city.

Figure 3 – Key Transportation Routes to and within Santa Cruz

Santa Cruz is a compact urban community with only three major access routes into and out of town; Highway 1 (north and south) and Highway 17 (east.) Major transportation routes include Mission Street (which is also Highway 1), Bay Street, Ocean Street, Water Street, and Soquel Avenue. Primary roadways in the downtown and beach area include Pacific Avenue, Front Street, Beach Street and East and West Cliff Drive.

The Santa Cruz Metropolitan Transit District (Metro) provides bus service throughout Santa Cruz County. The Metro is a key link from the University to the other parts of the town. Metro also operates bus service between the City of Santa Cruz and San Jose. Access to and from the University is particularly vulnerable at present since there are only two streets, Bay and High which access campus. Both these streets intersect with Mission Street and according to the UCSC Long Range Development Plan Environmental Impact Report (EIR) there are unacceptable traffic service levels at several of these intersections.[4]

Santa Cruz has an extensive network of bike lanes and bike paths. Additionally, on February 28, 2017 the City Council adopted an Active Transportation Plan (ATP) that, "identifies an integrated network of walkways and bikeways that connect the City of Santa Cruz neighborhoods and communities to employment, recreation, education and destinations that meet their daily needs." The ATP will reduce traffic and increase the resilience of our transportation systems.

Most major roads have bike lanes, including bike lanes that were recently installed on Beach Street near the Santa Cruz Beach Boardwalk, the city's major tourist attraction. There are levee bike paths along the San Lorenzo River developed as part of the San Lorenzo River Levee Project, a sixty-two million dollar project which was undertaken to address flooding in the city. Additionally, the city will begin construction of the 2 mile segment of the 32 mile coastal rail corridor from Watsonville to Davenport that passes through the City of Santa Cruz. The segment will be a paved, 12–16 foot wide multi-use path running from Natural Bridges Drive to Pacific Avenue near the Municipal Wharf in 2017.

Economic Trends and Retail Sales

American Fact Finder Community Facts

2011-2013 American Community Survey 3-Year Estimates				
Subject	**Est.**	**Est. Margin of Error**	**%**	**% Margin of Error**
Civilian employed population 16 years and over	31,203	+/-1,221	57.7	(X)
Occupations				
Management, business, science, and arts	13,971	+/-1,010	44.8	+/-2.8
Service	6,292	+/-798	20.2	+/-2.5
Sales and office	7,189	+/-880	23.0	+/-2.4
Natural resources, construction, and maintenance	2,075	+/-432	6.7	+/-1.4
Production, transportation, and material moving	1,676	+/-522	5.4	+/-1.7

Industry	**Est.**	**Est. Margin of Error**	**%**	**% Margin of Error**
Civilian employed population 16 years and over	31,203	+/-1,221		(X)
Agriculture, forestry, fishing and hunting, mining	448	+/-279	1.4	+/-0.9
Construction	1,595	+/-351	5.1	+/-1.2
Manufacturing	2,176	+/-424	7.0	+/-1.3
Wholesale trade	663	+/-255	2.1	+/-0.8
Retail trade	3,910	+/-864	12.5	+/-2.6
Transportation, warehousing, utilities	578	+/-211	1.9	+/-0.7
Information	579	+/-188	1.9	+/-0.6
Finance, insurance, real estate, rental, leasing	1,555	+/-435	5.0	+/-1.4
Professional, scientific, management, administrative, waste management services	3,806	+/-613	12.2	+/-2.0
Educational services, health care, social assistance	8,504	+/-756	27.3	+/-2.6
Arts, entertainment, recreation, accommodation, food services	4,929	+/-925	15.8	+/-2.8
Other services, except public administration	1,479	+/-531	4.7	+/-1.7
Public administration	981	+/-334	3.1	+/-1.1

Of a total citywide employment base of 31,203, management, business, science and arts occupations were the most represented in the 2013 census data at 13,971. The service industry, including hotels and restaurants was the second place categorization, with sales, and construction in third and fourth respectively. Public sector administration accounts for 3.1% of the total workforce, while educational services, health care and social assistance represents 27.3% of the workforce employment.

Education represents a substantial contributor to the local economy, due to both the area's K–12 schools and UCSC. A list of public and private schools in the community are included in this plan as Appendices E–F.

Income and Benefits (in 2013 Inflation-Adjusted Dollars)				
Subject	**Est.**	**Est. Margin of Error**	**%**	**% Margin of Error**
Total households	21,154	+/-805		(X)
Less than $10,000	2,301	+/-504	10.9	+/-2.2
$10,000 to $14,999	1,129	+/-347	5.3	+/-1.6
$15,000 to $24,999	1,726	+/-394	8.2	+/-1.8
$25,000 to $34,999	1,715	+/-393	8.1	+/-1.8
$35,000 to $49,999	2,072	+/-385	9.8	+/-1.8
$50,000 to $74,999	3,683	+/-562	17.4	+/-2.7
$75,000 to $99,999	2,246	+/-355	10.6	+/-1.7
$100,000 to $149,999	3,060	+/-469	14.5	+/-2.1
$150,000 to $199,999	1,408	+/-369	6.7	+/-1.7
$200,000 or more	1,814	+/-264	8.6	+/-1.3
Median household income (dollars)	**62,580**	**+/-4,220**	(X)	(X)
Mean household income (dollars)	**83,037**	**+/-4,404**	(X)	(X)

Median household income is $62,580 while mean household income is $83,037. Just over 8% of homes report income of $200,000 or more, while households that earn between $15–24,000 a year account for 8.2% of the population, $35–49,000 households account for 9.8% and households between $50–75,000 represent 17.4% of all homes in Santa Cruz.

Like all California communities, a significant portion of Santa Cruz' General Fund and much of its downtown economy is derived from retail sales. Since the downtown and beach areas provide a large proportion of the city's economic prosperity, potential hazards in these areas make the city particularly vulnerable to economic loss in addition to physical loss. These areas are identified as being within the potential flood area, liquefaction area and tsunami risk area.

Community Vision

The City of Santa Cruz updated its General Plan (2012) including the Safety Element, which promotes public health and safety through goals, objectives and action plans addressing potential hazards such as earthquake, flood, and wildfire. The Safety Element provides a general evaluation of potential public safety hazards and also provides the direction and resources to help reduce death, injuries, property and environmental damage, and the economic and social dislocation resulting from natural hazards. The General Plan Update has informed this LHMP and this Plan has in turn informed the current update of the General Plan. Working collaboratively, both plans support the broader vision and values of the community as reflected in the vision statement for the General Plan update.

General Plan Vision Statement

Our Vision for Santa Cruz, 2030
Surrounded by greenbelt and the Pacific Ocean, Santa Cruz is a compact, vibrant city that preserves the diversity and quality of its natural and built environments, creates a satisfying quality of life for its diverse population and workers, and attracts visitors from around the world.

Guiding Principles
To achieve our vision, we will follow these principles in drafting our General Plan.

- **Natural resources**
  We will highlight and protect our unique setting, our natural and established open space, and the sustainable use of our precious natural resources.
- **Neighborhood integrity and housing**
  We will maintain the identity and vitality of our neighborhoods, actively pursuing affordable housing for a diversity of households and promoting compatible livability and high quality design in new buildings, major additions, and redevelopment.
- **The University**
  We will seek a mutually beneficial relationship with UC Santa Cruz, one where the City supports the University within the context of City responsibilities, community priorities, and the constraints of City infrastructure and resources; and one where the University reciprocally supports the City by comprehensively addressing all of its needs to the greatest extent possible on the campus itself, and by fully mitigating whatever off-campus community impacts occur.
- **Mobility**
  We will provide an accessible, comprehensive, and effective transportation system that integrates automobile use with sustainable and innovative transportation options — including enhanced public transit, bicycle, and pedestrian networks throughout the community.
- **Prosperity for all**
  We will ensure a sustainable economy for the community, actively encouraging the development of employment opportunities for residents of all levels and ages, and actively protecting from elimination our current and potential sources of sustainable employment.
- **A dependable municipal tax base**
  We will encourage diverse technology, visitor serving, industrial, home business and commercial business enterprises, and strategic redevelopment.
- **A balanced community**
  We will maintain the community's longstanding commitment to shared social and environmental responsibility, fostering a balance between employment, housing affordable to persons of all income levels, transportation, and natural resources.

- **Education**
  We will reflect our commitment to education through our schools, educational systems and programs, library system and facilities, life-long learning community programs, and our active communication/information network.
- **Arts and culture**
  We will recognize and support our vital arts community, our unique historic areas and landmarks, our cultural heritage and resources, and our recreational facilities and community programs
- **Community facilities and service.**
  We will offer excellent social services and will improve and maintain our infrastructure, community safety, and emergency preparedness.
- **An involved citizenry**
  We will welcome citizen participation in government, encourage respectful cooperation and mutual regard among residents, workers, students, and visitors, and fully accept shared responsibility for community well-being.

General Plan 2030 Adopted June 26, 2012

Critical Structures within the City of Santa Cruz and Unincorporated Surrounding Area

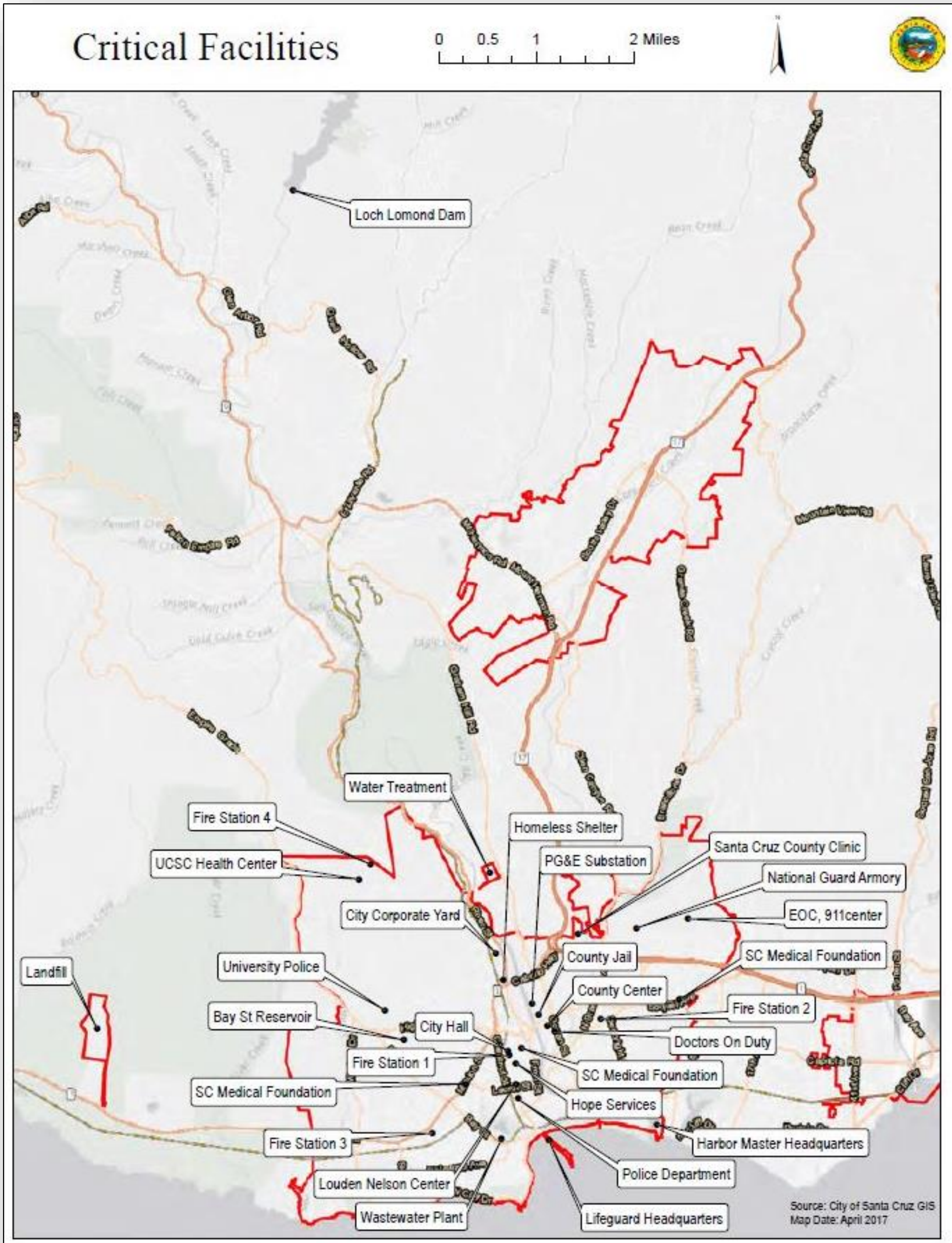


Figure 4 – Critical Structures within the City of Santa Cruz and Unincorporated Surrounding Area

COMMUNITY FACILITIES

The City of Santa Cruz owns or leases approximately forty significant buildings. These buildings are used for various purposes including government administration, providing essential and emergency services, recreation, cultural and performing arts. After the 1989 Loma Prieta earthquake, the city began examining the risks to its buildings from disasters, particularly earthquakes. A number of buildings were assessed for seismic safety and, when warranted, strengthened. Some city buildings essential for emergency response activities have been assessed and repaired or replaced.

A list of City facilities appears in Appendix I. Appendix N shows the larger Santa Cruz County area including Loch Lomond Reservoir from which Figure 4 (*above*) is extracted.

City of Santa Cruz-owned infrastructure consists of the following elements:

Water Treatment Plant
Loch Lomond Reservoir
River levees
Roads, alleys, curbs, paths
Retaining walls
Storm drains
San Lorenzo River, creeks, open channels and culverts
Wastewater Treatment Facility and sanitary sewer system
Water Street Bridge
Soquel Bridge
Laurel Street Bridge
Highway 1 Bridge (two sections)
Over 25 City parks and extensive network of street trees
Municipal Wharf including Marine Safety and Lifeguard Headquarters
Emergency Operations Center*
**leased: primary EOC site*

Critical Facilities not owned by the City

There are a number of critical facilities within the city limits that are not owned by the City. The County Government Center, the County Jail, the National Guard Armory and the U.S. Post Office are some of the buildings that are within the city but are not owned by the City. The primary Emergency Operations Center is a leased facility.

Hospitals and schools are critical facilities that are not operated or owned by city government.

Hospitals

There are no hospitals within the City of Santa Cruz. There are several rehabilitation facilities, medical clinics, senior and long term care facilities.

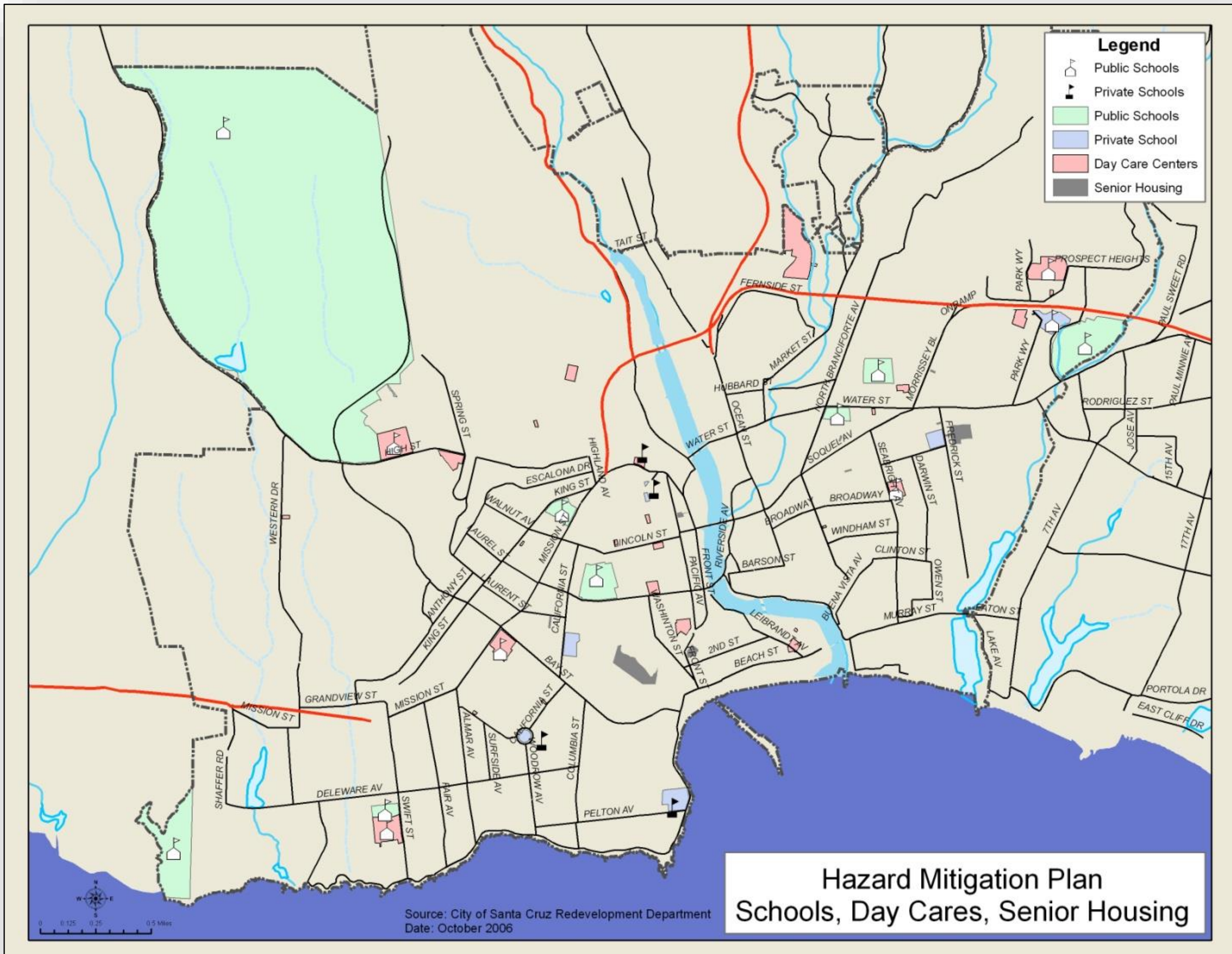


Figure 5 – Public and Private Schools, Day Care and Senior Facilities

Schools

Santa Cruz City Schools is independent from City government and manages primary and secondary education and education facilities, including all public schools in the city. The City government has no authority over these structures, but does provide police and fire services to the school district.

PART 2 — THE PLANNING PROCESS

- The Purpose of the Plan
- The Planning Process
- Documentation of the Planning Process
- Local Capabilities Assessment and Integration
- Community Participation

CHAPTER 3: THE PLANNING PROCESS

THE PURPOSE OF THE PLAN

The federal Disaster Mitigation Act of 2000 (Public Law 106-390), commonly known as the 2000 Stafford Act Amendments, was approved by Congress on October 10, 2000. To implement the DMA 2000 planning requirements, FEMA prepared an Interim Final Rule, published in the Federal Register on February 26, 2002 (44 CFR Part 201) which established mitigation planning and funding criteria for states and local communities. This act required state and local governments to develop hazard mitigation plans as a condition for federal grant assistance.

For the Pre-Disaster Mitigation (PDM) program, local jurisdictions must have an approved mitigation plan to receive a project grant. Prior to 2000, federal legislation provided funding for disaster relief, recovery, and some hazard mitigation planning. The DMA improves upon the planning process by emphasizing the importance of community planning for disasters before they occur. Using this initiative as a foundation for proactive planning, the City of Santa Cruz developed this hazard mitigation plan in an effort to reduce future loss of life, property and damage to our environment resulting from disasters. This LHMP Update continues that effort.

Hazards are difficult to predict. Through careful planning and collaboration among public agencies, stakeholders, and citizens, it is possible to avoid or minimize losses that can occur from disasters. Hazard mitigation is defined as any action taken to permanently eliminate or reduce long-term risks to human life and property from natural hazards. Along with preparedness, response, and recovery, mitigation is an essential element in emergency management. Disasters can have significant impacts on communities. They can destroy or damage life, property, infrastructure, local economies, and the environment.

This LHMP Update is intended to assist the City of Santa Cruz in reducing its risk from natural hazards by identifying resources, information, and strategies for risk reduction. The plan will help guide and coordinate mitigation activities throughout the city. Building on a tradition of progressive planning and past mitigation successes, the City of Santa Cruz planning team set out to develop a plan that would meet the objectives summarized below.

- The plan would meet or exceed program requirements specified under the DMA.
- The plan would not only meet state and federal requirements but also the needs of the City.
- The plan would coordinate existing and ongoing plans and programs so that high priority initiatives and projects to mitigate possible disaster impacts would be funded and implemented.
- The plan would create a linkage between the LHMP and established plans such as the City's General Plan, Climate Adaptation Plan and Emergency Operations Plan so that they can work together in achieving successful mitigation for the City.

It should be noted that DMA compliance is not the sole purpose of this LHMP. Santa Cruz has experienced a number of significant disasters but it also has a long-standing tradition of proactive planning and program implementation. This tradition is further enhanced by the development of this LHMP. Multiple objectives drive this planning effort, one of which is DMA compliance. Elements and strategies included in this plan were not selected only because they meet a program requirement; they were selected because they meet the needs of the community.

PLANNING PROCESS

This section describes the process used to develop the LHMP. This includes the federal requirement followed by the City's actions applied to this process.

DOCUMENTATION OF THE PLANNING PROCESS

2.1 Documentation of the Planning Process — Requirement §201.6(b):
In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process **shall** include:

(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and
(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

Requirement §201.6(c)(1):
The plan **shall** document the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

Project Teams: Then and Now

The City of Santa Cruz developed and adopted its first Local Hazard Mitigation Plan in 2007. The current plan is an update to our first Five Year LHMP (2012–2017). The following information outlines the team and process that was involved in the initial LHMP:

LHMP (2007–2012)

The Economic Development Department took on the initial responsibility for development of the 2007 LHMP. The first phase of the planning process established a project team made up of representatives from various City departments, especially those responsible for different aspects of hazard mitigation planning, including the Economic Development Department, Planning Department and its Building Division, Public Works, Emergency Operations Manager, Fire, and Information Technology's Geographic Information Systems (GIS) specialist.

The original project team was formed as a task group to develop the LHMP. Meeting dates were set intermittently based on progress and focus. The Project Team invited review of the plan at various stages of formation and completion from interested parties such as the University of California at Santa Cruz, Santa Cruz County, the Cities of Capitola, Watsonville and Scotts Valley, the County Office of Emergency Services, the local American Red Cross as well as scientific and technical specialists at the local, state, and national level.

The original plan was developed between June 2006 and March 2007. Project leaders met once per week and the team met approximately once per month from June 2006 through December 2006, and then as needed in 2007 until the draft plan was circulated for public review in April.

The project team list as well as the Technical Advisors list (Part 1: Acknowledgements), has been updated to reflect the team for the current LHMP (2017–2022).

LHMP Five Year Update (2017–2022)

The project team identified characteristics and potential consequences of natural hazards that are a potential threat to the City of Santa Cruz. With the understanding of the risks posed by the identified hazards, the team determined and reviewed previously listed priorities and assessed various methods to avoid or minimize any undesired effects. Recent historical incidents were noted and assessed. Responsible departments were consulted at several points in the development of the goals, objectives and actions. As a result, the mitigation strategy, including goals, objectives and actions, were determined, followed by an implementation and monitoring plan. This monitoring plan included tracking of hazard mitigation projects, changes in day-to-day City operations, and continued hazard mitigation development.

LOCAL CAPABILITIES ASSESSMENT AND INTEGRATION

This assessment of the mitigation goals, programs and capabilities included a review of the following items:

- Human and technical resources
- Financial resources and funding sources
- Local ordinances, zoning and building codes
- Ongoing plans or projects

The 2007 LHMP and the 2012 Five Year LHMP Update were informed by the General Plan Safety Element, Emergency Operations Plan, Urban Water Management Plan, Santa Cruz Water

Department Water Conservation Plan, City ordinances, zoning and building codes and the Capital Improvement Program (CIP). This information was also used for the current LHMP Update (2017–2022).

Consistency between these plans, programs and policies was reviewed by using these approved plans and policies as a foundation for the 2007–2012 LHMP and by consulting with the departments responsible for the various plans and programs. In reviewing the effectiveness of local programs, Appendix K lists successful programs and projects that have been implemented by the City. Appendix O is the City's Emergency Operations Plan (EOP). While these programs and the EOP have increased the City's hazard mitigation capabilities, funding availability is the limiting factor in the implementation of additional identified hazard mitigation programs.

The 2007–2012 LHMP Project Team met several times with the staff and members of the General Plan Advisory Committee to insure that the LHMP was consistent with the General Plan Safety Element. Project leaders met with representatives of the Water Department to incorporate hazard mitigation efforts identified by various Water Department plans. Project leaders met with Fire Department staff to insure that the LHMP was consistent with the current and planned programs and fire safety plans. The project leaders also met with the City's GIS coordinator to ensure that maps were current and consistent with those in the General Plan and were accurate as of the draft publication date.

The City of Santa Cruz Emergency Operations Center (EOC) Manager was a member of the Project Team and oversaw the review and incorporation of the Emergency Operations Plan and its appendices:

- County Standardized Emergency Management System (SEMS), Memorandum of Understanding (MOU) Resolution
- City of Santa Cruz Hazard Analysis Summary
- Wharf Hazard Plan
- Flood Hazard Plan
- Earthquake Hazard Plan
- Dam Inundation Hazard Plan
- Wildland Fire Hazard Plan
- Tsunami Hazard Plan

COMMUNITY PARTICIPATION

2017–2022

For this current LHMP Update the project manager promulgated a public survey in March 2017. The survey, entitled "*Are You Ready*? *Local Hazard Mitigation Public Survey* (detailed in Chapter 15: Public Outreach and Plan Development) was posted to the City of Santa Cruz website home page and on other public-facing social media pages. Additionally, the availability of the survey was called out in the city's daily newspaper of record. A local group, Santa Cruz

Neighbors, which has numerous chapters and affiliations throughout the city, agreed to review the survey questions and post its availability to it members, thereby furthering the public outreach across many city neighborhoods. Additionally, a Spanish language version of the survey was made available.

Furthering the goal of expansive public outreach, the following events were opportunities completed/scheduled (at the time of this writing) by the team working to update the LHMP and Climate Adaptation Plan (Appendix P).

Public Events Planned and Scheduled

- Panel discussant at St. Francis High School's Ecology Symposium................. 3/25/3017
- Radio interview on Planet Watch KSCO 4/2/2017
- Earth Day tabling at San Lorenzo Park.. 4/22/2017
- "City Hall to You" tabling at Peace Church... 5/4/2017
- Presentation to County of Santa Cruz Emergency Management Council 5/4/2017
- Information/presentation to Transportation and Public Works Commission......... 5/15/17
- Guest Lecture to UCSC global climate politics course 6/1/2017
- Information/presentation to Transportation and Public Works Commission..... 7/17/2017
- Information/presentation to Downtown Commission.. 7/27/2017
- City Council Presentation 8/8/17
- Information/presentation to City Planning Commission 9/7/17
- "Science on Tap" feature presentation at Crepe Place (planned)..................... 10/25/2017

Our local stakeholders and emergency managers will also have had the opportunity to review and comment on this plan. Their professional input has been an invaluable resource. The same process was followed for the original LHMP and its first Five Year Update.

2007–2012 and **2012–2017**

Public input during the development of the 2007–2012 mitigation plan assisted in helping shape the plan's goals and mitigation actions, and integrating the LHMP with the Safety Element of the General Plan Update. The Local Hazard Mitigation Plan was a topic of discussion at two public meetings of the General Plan Advisory Committee (GPAC).

When the draft LHMP was completed, a 30-day public comment period was initiated. A public notice was placed in the local paper to invite public review and comment on the draft plan. Copies of the plan were made available at the Central Branch of the Santa Cruz Public Library and at the Economic Development Department at City Hall. A draft of the plan was posted on the City's website with an interactive response option that provided an opportunity for interested members of the public to comment on the draft LHMP via the web. Those comments were incorporated into the final document. The LHMP was presented to the City Council on April 24, 2007. That meeting was open to the public for further comment.

The draft 2007 LHMP was sent to members of a technical committee which consisted of national, state and local scientists and experts for review prior to creation of the Public Draft. Comments received were incorporated into the final draft LHMP.

Table 3-1 LHMP Meetings

NOTE: During the development of the LHMP and Climate Adaptation Plan numerous informal meetings and other communications were underway among staff and other jurisdictional partners. These are not listed as formal meetings in the table below.

LHMP Meetings [2017]	Date	Type
Consultation re: Vulnerability Assessment	Jan 17, 2017	In house
City Kickoff Meeting	Feb 1, 2017	In house: Consultant selected; attorney review of contracts
Central Coast Wetlands Group	Feb 20, 2017	In house: Review scope
Confirm Climate Adaptation	Feb 28, 2017	In house: Assessing non-coastal impacts
Map layer and data consultation	Feb 28, 2017	In house
Consultant Kickoff	Mar 1, 2017	In house: With full LHMP group
Vulnerability Assessment	Mar 7, 2017	In house: Model assumptions
CCWG/Team meeting with Public Works	Mar 21, 2017	In house: Review (1) coastal armoring inventory; discuss water control structures; (2) progress of LHMP and Climate Adaptation Plans
LHMP and Climate Adaptation Team Leaders	Apr 5, 2017	In house: Timeline review; coordinate CAP with LHMP; next steps
LHMP Project Manager	Apr 18, 2017	Online conference — "Flood Plain Management, Hazard Mitigation, Emergency Management." California Ocean Protection Council; California Natural Resources Agency; Governor's Office of Planning and Research; California Energy Commission; and California Ocean Science Trust
LHMP Project Manager, OES/Analyst	Apr 27, 2017	Review multiple Chapters and Appendices; Schedule outreach to County Emergency Management Council
LHMP Project Manager	May 4, 2017	Presentation to Emergency Management Council
Climate Adaptation	May 31, 2017	In house: Discussion of progress and future peer review and presentations.
LHMP Project Manager, OES/Analyst	Sept 6, 2017	In house: Review and discuss LHMP progress at the near completion of the project

PART 3 — HAZARD IDENTIFICATION AND RISK ASSESSMENT

Significant Risks

- Earthquakes and Liquefaction
- Wildfires
- Floods and Associated Coastal Storms
- Drought
- Tsunami
- Coastal Erosion

Less Significant Risks

- Dam Failure
- Landslide

Multi-Hazard Summary

Identification and Profiling of Hazards

RISK ASSESSMENT OF HAZARDS IN SANTA CRUZ

3.0 Risk Assessment: §201.6(c)(2):

The plan **shall** include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards.

Local risk assessments **must** provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

It is important for a community's risk assessment, mitigation and preparedness efforts to be founded on accurate information about the types and scale of damage that hazards pose to the community. This section of the Plan contains a description of those hazards identified as potential significant threats to Santa Cruz — earthquakes, wildfires, floods, drought, tsunami, coastal erosion, landslide — and the exposure and vulnerability of the City to these hazards. These risks have been identified based on historical information of hazard events including researching past disaster declarations in the City, input from geologic, climatic, and wildfire specialists and organizations as well as public comments and newspaper articles. Probable damage and the consequences to the city's quality of life are described. One area to note in particular is the section on tsunami as it relates to the March 2011 earthquake near Honshu, Japan and its impact on our area.

The City of Santa Cruz has expanded its GIS database, mapping critical facilities, hazard risk areas, and sensitive habitat areas. Data from this mapping was used to determine hazards that present the greatest risk to the city.

Table A-1 Review of All Hazards

Hazard	Risk	Why/Why not
Avalanche	No	The City is not in an avalanche area
Coastal Erosion	Major	Past history indicates probability is high, potential for loss of life is low — potential for economic and infrastructure loss is high
Coastal Storm	—	Included with Flood
Dam Failure	Lesser	Past history indicates probability is low but consequence of failure is high
Drought	Major	Past history indicates probability is high
Earthquake	Major	Past history indicates probability is high
Expansive Soils	No	Does not affect City
Extreme Heat	No	Past history indicates probability is low
Flood	Major	Past history indicates probability is high
Hailstorm	No	Past history indicates probability is low
Hurricane	No	Past history indicates probability is low
Land Subsidence	No	Past history indicates probability is low
Landslide	Lesser	Past history indicates risk to water system is high
Liquefaction	—	Included with Earthquake
Winter Storm	No	Past history indicates probability is low
Tornado	No	Past history indicates probability is low
Tsunami	Major	Recorded history (200 years) indicates probability of a significant tsunami occurring is low but in the event that it should occur potential for life, property, economic and infrastructure loss is high
Volcano	No	Does not affect City
Wildfire	Major	The City is adjacent to many natural open space and urban /rural interface areas

3.1 Identifying Hazards - §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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

Table A-2 Hazard Screening for City of Santa Cruz

Risk	Affected Areas
VERY SIGNIFICANT RISK	
Earthquake (including liquefaction)	Entire city
Wildfire	Five identified wildland interface areas
Flood (including coastal storms)	San Lorenzo River floodplain including downtown and Tannery Arts Center; sections of Moore, Branciforte and Carbonera Creeks, and lower portion of Arana Gulch
Drought	Entire city
Tsunami	San Lorenzo River floodplain including beach area and downtown
Coastal Erosion	Coastal boundaries
LESSER RISK	
Dam Failure	Loch Lomond Reservoir and water delivery system and the inundation area of the reservoir
Landslide	Loch Lomond Reservoir and water delivery system. Other unstable slopes present risk to roadways.

The City of Santa Cruz is exposed to a number of natural hazards that vary in their potential intensity and impact on the City. This mitigation plan addresses six high-risk natural hazards, selected because of the likelihood of occurrence or the potential consequences, as well as two additional hazards that present either less risk of occurrence or extent of damage. The natural hazards: floods, earthquake, and tsunami are of great concern because they can occur independently, or in combinations that can trigger secondary hazards such as dam failure. Another high risk hazard, drought, can exacerbate the potential for wildfires.

The natural hazards included in this plan were identified through a community-based process including input from scientific experts in various fields and in conjunction with the update of the General Plan including the Safety Element. Prior versions of the Local Hazard Mitigation Plan were the result of a number of public meetings, project team meetings, scientific expert and community input as well as suggestions submitted by community members of Santa Cruz. Key contributors included members of the Project Team, the General Plan Advisory Committee, Dr. Gary Griggs of University of California at Santa Cruz, David Saroka of National Oceanic and Atmospheric Administration (NOAA), the Association of Monterey Bay Area Governments (AMBAG), as well as many others who worked with the City on programs and research that were incorporated into the Emergency Operations Plan and General Plan Safety Element. Other natural hazards that are extremely rare or nonexistent in Santa Cruz are not included in this plan but are listed in Appendix A.

The worst potential disaster that Santa Cruz might face involves multiple hazards occurring at the same time. A major earthquake could trigger tsunamis, wildfires or floods which would be exacerbated by damage to dams, stream culverts and storm drains. The City's emergency teams and those assigned to the Emergency Operations Center and Department Operations Center(s) have trained and practiced responding to similar, challenging, multi-hazard events. The City of Santa Cruz plans for and responds to emergency events in accordance with the Santa Cruz County Operational Area Memorandum of Understanding (MOU). The Emergency Operations Plan describes the role and operation of the City departments and personnel during a major emergency (Appendix O). In addition to researching each hazard individually, this Plan explores how the hazards interact, and how mitigation activities for each hazard impact the overall disaster risk in Santa Cruz.

CHAPTER 4: EARTHQUAKES AND LIQUEFACTION

4.3.0 RISK ASSESSMENT

4.3.1 IDENTIFYING EARTHQUAKE HAZARDS

3.1 Identifying 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

An earthquake is a sudden release of built-up tension in the earth's crust and upper mantle, i.e., lithosphere. Caused by movement along fault lines, earthquakes vary in size and severity. The *focus* of an earthquake is found at the first point of movement along the fault line, and the *epicenter* is the corresponding point above the focus at the earth's surface.

Earthquake intensity is measured in various ways, the most familiar being the Richter *magnitude* scale which determines the amount of ground displacement or shaking that occurs near the epicenter; the Rossi-Forel scale which measures ground shaking intensity in terms of perception and damage; and the Modified Mercalli Intensity Scale which takes into account the localized earthquake effects.

Table 4-1 Modified Mercalli Intensity Scale

Intensity	Severity	Level of Damage	Richter Scale
1–4	Instrumental to Moderate	No damage.	</= 4.3
5	Rather Strong	Damage negligible. Small, unstable objects displaced or upset; some dishes and glassware broken.	4.4–4.8
6	Strong	Damage slight. Windows, dishes, glassware broken. Furniture moved or overturned. Weak plaster and masonry cracked.	4.9–5.4
7	Very Strong	Damage slight-moderate in well-built structures; considerable in poorly-built structures. Furniture and weak chimneys broken. Masonry damaged. Loose bricks, tiles, plaster, and stones will fall.	5.5–6.1
8	Destructive	Structure damage considerable, particularly to poorly built structures. Chimneys, monuments, towers, elevated tanks may fail. Frame houses moved. Trees damaged. Cracks in wet ground and steep slopes.	6.2–6.5
9	Ruinous	Structural damage severe; some will collapse. General damage to foundations. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground; liquefaction.	6.6–6.9
10	Disastrous	Most masonry and frame structures/foundations destroyed. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Sand and mud shifting on beaches and flat land.	7.0–7.3
11	Very Disastrous	Few or no masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Rails bent. Widespread earth slumps and landslides.	7.4–8.1
12	Catastrophic	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted.	> 8.1

Masonry Types

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.
Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.
Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.
Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

The harmful effects of an earthquake vary with the geologic composition and manmade infrastructure of the region, as well as the amount of accumulated energy released when the earthquake occurs.

Ground motion

Ground motion is the primary cause of damage and injury during earthquakes and can result in surface rupture, liquefaction, landslides, lateral spreading, differential settlement, tsunamis, building failure, and broken gas and other utility lines, leading to fire and other collateral damage.

The intensity and severity of ground motion is dependent on the earthquake's magnitude, distance from the epicenter and underlying soil and rock properties. Areas underlain by thick, saturated, unconsolidated soils will experience greater shaking motion than areas underlain by firm bedrock.

Fires and structural failure are the most hazardous results of ground shaking. Most earthquake-induced fires start because of ruptured power lines and gas or electrically-powered stoves and equipment. Structural failure is generally the result of age and type of building construction.

Liquefaction

Liquefaction is the transformation of loose, water-saturated granular materials (such as sand or silt) from a solid to a liquid state. Liquefaction commonly, but not always, leads to ground failure. Liquefaction potential varies significantly and site-specific analysis is needed to accurately determine liquefaction potential in earthquake prone areas.

Much of the downtown in the City of Santa Cruz flood plain experienced liquefaction during the 1989 Loma Prieta earthquake. Liquefaction and severe earth shaking have been the two primary causes of damage during earthquakes in Santa Cruz.

4.3.2 HAZARD PROFILE – EARTHQUAKES AND LIQUEFACTION

3.2 Profiling 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

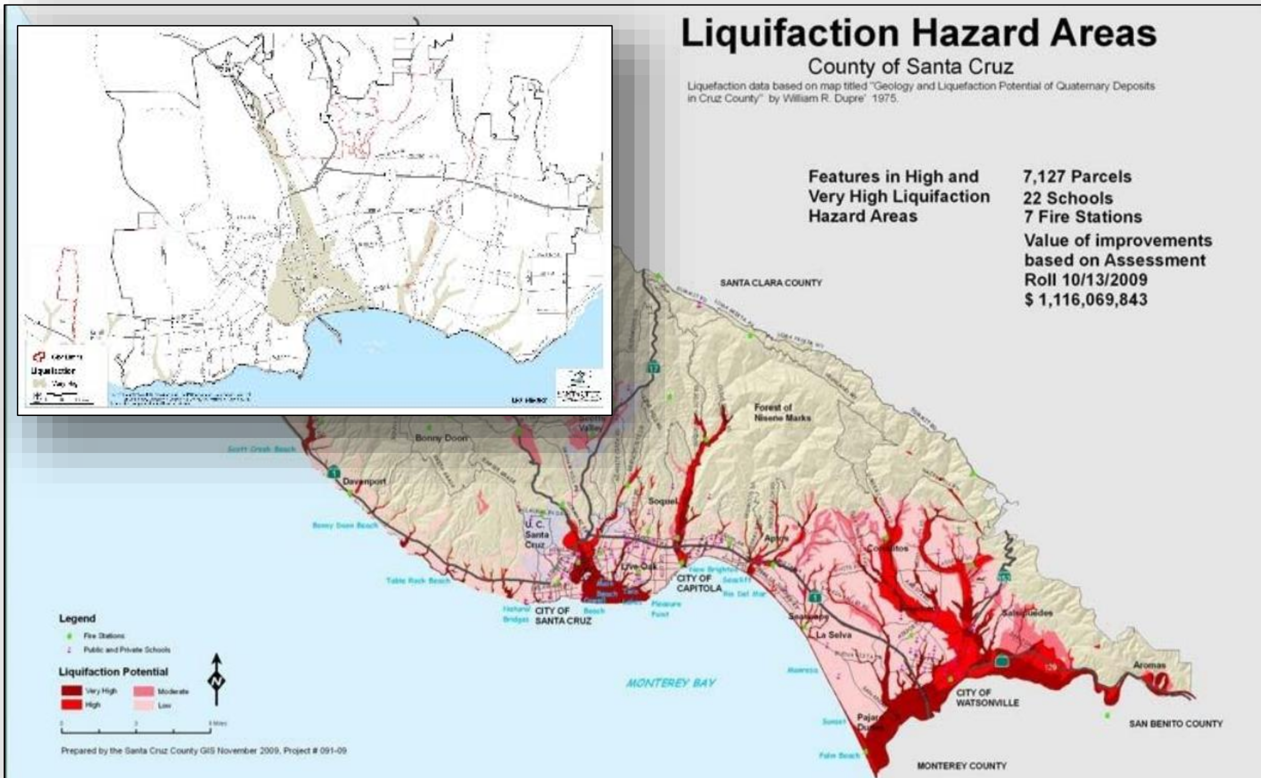


Figure 6 – Areas in Santa Cruz Potentially Vulnerable to Liquefaction

Past experience has shown that the entire community is vulnerable to earthquake. Within Santa Cruz County there are several active and potentially active faults. These include the San Andreas, San Gregorio, Zayante, Ben Lomond and Butano Faults, the Monterey Bay Fault Zone, as well as numerous fault complexes and branches of these major faults.

Santa Cruz lies within 15 miles of at least six major seismic faults and fault systems, placing it in an area of high seismic risk; however there is only one fault, the Ben Lomond Fault that actually passes through the city. The Ben Lomond Fault is not considered to have moved in historic time, however, and may be inactive.

B EXTENT: MAGNITUDE OR SEVERITY

Several of the faults located in the Santa Cruz area are considered to be either possibly active (showing signs of recent geologic movement, within the last 10,000 years) or probably inactive (movement within the last two million years). However, the Hayward, Calaveras, San Gregorio and San Andreas faults are all considered historically active (movement within the last 200 years). Even a moderate earthquake in the area could result in deaths, property and environmental damage as well as the disruption of normal economic, transportation, government and community services.

The most active region and threat to the city is the San Andreas Fault zone which passes through the Santa Cruz Mountains 12 miles northeast of the city. Based on records from the 1906 San Francisco earthquake, it is estimated that the maximum credible earthquake likely to occur along the San Andreas Fault would equal 8.3 M, which represents more than 30 times the energy released by the 1989 Loma Prieta Earthquake. The city was one of the hardest hit communities during that earthquake. This is the highest magnitude earthquake expected in the region but it is estimated that the Hayward, Calaveras and San Gregorio faults are all capable of generating earthquakes greater than 7.4 M.

C PREVIOUS OCCURRENCES

The following is a list of previous events, dates, severity, level of damage, duration, sources of information used, and maps (where available) to show areas affected. While Santa Cruz has sustained numerous earthquakes throughout its history, the two most destructive ones were the 1906 San Francisco earthquake and the 1989 Loma Prieta earthquake.

April 18, 1906: (Richter Magnitude: 8.3)
No recorded deaths in Santa Cruz but the courthouse was almost destroyed; about one third of the chimneys within the city were destroyed or damaged; there was major landsliding with gaping cracks in the earth, especially along the water; bridges were destroyed; and the water supply was shut off by broken mains and pipes.

October 1926: (Richter Magnitude: 6.1)
Two large earthquakes occurred during this year. Three of the aftershocks cracked plaster in Santa Cruz, almost bringing down the chimneys of numerous buildings. It broke plate glass windows along Pacific Avenue. The city water main broke at Laguna Creek and articles fell from shelves at stores.

October 17, 1989 (Richter Magnitude: 7.1)
Two people died in Santa Cruz as a direct result of this earthquake. In the greater San Francisco/Oakland Bay Area, there were sixty-two fatalities. The earthquake epicenter was located approximately 10 miles east of the city center. The earthquake destroyed much of the historic downtown and many areas of the city were very badly damaged. Roads in and out of the city were impassable and many residents lost power and water for up to a week.

Isoseismal Map — Santa Cruz Mountains (Loma Prieta), California
UTC (Local 10/17/1989) [6] Magnitude 6.9 Intensity IX

(NOTE: An isoseismal [line] is a contour or line on a map bounding points of equal intensity for a particular earthquake.)

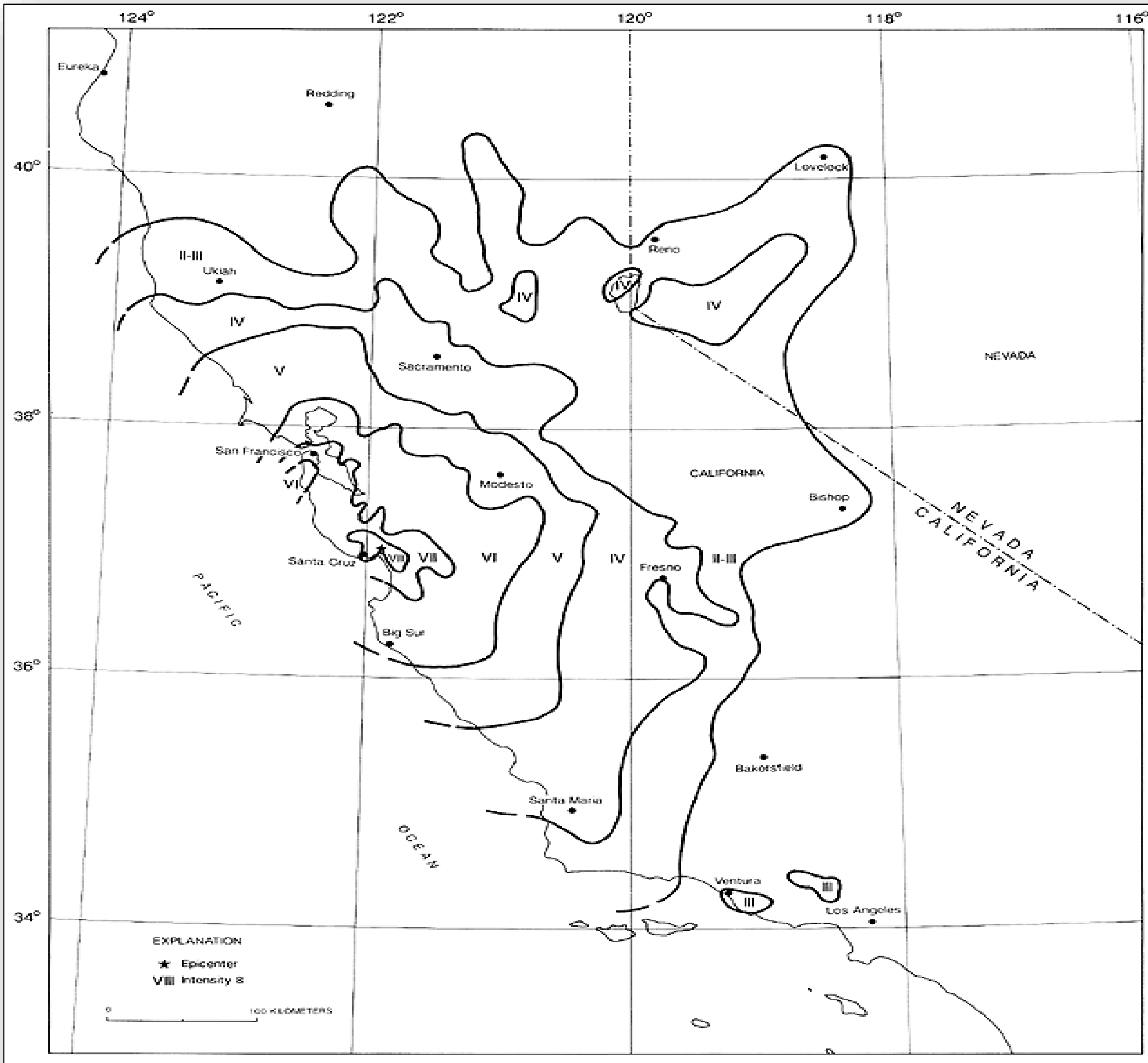


Figure 7 – Intensity and Magnitude of the 1989 Loma Prieta Earthquake in Santa Cruz

D PROBABILITY OF FUTURE EVENTS

The City lies within 15 miles of at least six (6) major seismic faults and fault systems, placing it in an area of high seismic risk. Because earthquakes can cause severe damage over a long distance, the Santa Cruz area remains at risk from continued seismic activity along the many faults in the region.

The reduction of seismic stresses that occurred in the Loma Prieta earthquake did nothing to relieve, and possibly increased, stresses within other faults, including other sections of the San Andreas Fault. As a result, it is expected that Santa Cruz will be subjected to violent, earthquake-induced ground shaking in the future.

On the basis of research conducted since the 1989 Loma Prieta earthquake, U.S. Geological Survey (USGS) and other scientists conclude that there is a 62% probability of at least one magnitude 6.7 or greater quake, capable of causing widespread damage, striking the San Francisco Bay region (including Santa Cruz) before 2032. Major quakes may occur in any part of this region. This emphasizes the urgency for all communities in the region to continue preparing for earthquakes.[7]

The USGS, the California Office of Emergency Services, the California Geological Survey and the Association of Bay Area Governments jointly conducted a loss estimation study focused on the ten most likely damaging earthquakes. These earthquakes occur on six of the seven major fault systems in the area and range in size from a magnitude 6.7 on a blind thrust underlying Mount Diablo to a magnitude 7.9 repeat of the 1906 rupture on the San Andreas Fault in northern California. Their 30-year probabilities range from a high of 15.2% for a M7.0 rupture of the Rodger’s Creek fault to 3.5% for a M7.4 combined rupture of the Peninsula and Santa Cruz Mountains segment of the San Andreas. The ten most likely earthquakes and their 30-year probabilities are:[8]

Table 4-2 Ten most likely damaging Earthquake scenarios in California

Ten most likely damaging Earthquake scenarios	30-year probability	Magnitude
Rodgers Creek	15.2%	7.0
Northern Calaveras	12.4%	6.8
Southern Hayward (*possible repeat of 1868 earthquake*)	11.3%	6.7
Northern + Southern Hayward	8.5%	6.9
Mt. Diablo	7.5%	6.7
Green Valley-Concord	6.0%	6.7
San Andreas: Entire Northern California segment (*possible repeat of 1906 earthquake*)	4.7%	7.9
San Andreas: Peninsula segment (*possible repeat of 1838 earthquake*)	4.4%	7.2
Northern San Gregorio segment	3.9%	7.2
San Andreas: Peninsula + Santa Cruz segment	3.5%	7.4

Because the ten most likely future earthquakes in the Bay Area occur on faults throughout the region, the impact and potential losses reported here reveal significant risk for the entire Bay Area region including the City of Santa Cruz.

4.3.3 ASSESSING VULNERABILITY: OVERVIEW

3.3 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.

A OVERALL SUMMARY OF VULNERABILITY TO EARTHQUAKE

The vulnerability of a community to earthquake hazard is based on a variety of factors including proximity to active and inactive faults, the age of structures, the density of the population and development, the value of property and infrastructure, the construction materials used in residential and non-residential buildings, and the location of critical facilities in a community.

Recent history indicates that Santa Cruz has a very high vulnerability to earthquakes due to proximity to faults, density of population and downtown development in the San Lorenzo River floodplain which is subject to liquefaction. A number of buildings in the downtown were rebuilt or seismically retrofitted after the 1989 Loma Prieta Earthquake which damaged or destroyed much of the old downtown.

The October 17, 1989 Loma Prieta earthquake was responsible for 62 deaths (including three in the City of Santa Cruz) and 3,757 injuries. In addition, over $6 billion in damage was reported including damage to 18,306 houses and 2,575 businesses. Approximately 12,053 people were displaced.

The most intense damage was confined to liquefaction areas where buildings and other structures were situated on top of loosely consolidated, water saturated soils. Loosely consolidated soils tend to amplify shaking and increase structural damage. Water saturated soils compound the problem due to their susceptibility to liquefaction and corresponding loss of bearing strength.

During the Loma Prieta earthquake, extensive liquefaction occurred along the shoreline of the Monterey Bay. Most of the City of Santa Cruz downtown along the San Lorenzo River is in a liquefaction area. Liquefaction is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Liquefaction has been responsible for tremendous amounts of damage in earthquakes around the world including the City of Santa Cruz.

Liquefaction occurs in saturated soils, that is, soils in which the space between individual particles is completely filled with water. This water exerts a pressure on the soil particles that influences how tightly the particles themselves are pressed together. Prior to an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other. When liquefaction occurs, the strength of the soil decreases and, the ability of a soil deposit to support foundations for buildings and bridges is reduced.[9] Some examples of these phenomena are shown below.

Failure and cracks induced by liquefaction have been observed in the past (*see below*: photographers unknown). These images, probably from the 1906 event, show cracks formed by liquefaction at the San Lorenzo River.[10, 11]

4.3.4 ASSESSING VULNERABILITY: IDENTIFYING STRUCTURES

A TYPES AND NUMBERS OF EXISTING BUILDINGS, FACILITIES AND INFRASTRUCTURE

Past experience has shown that the entire community is vulnerable to earthquake. The entire downtown commercial area is in a liquefaction hazard area. The remainder of the town is at risk for severe ground shaking as indicated by the maps below showing the probability of earthquake impacts to the Santa Cruz area within the next 50 years.

These estimates were formulated using HAZUS, a geographic information system-based, nationally standardized, loss estimation tool developed by FEMA. They are recent California Geological Survey maps and are limited to ground motion-induced losses to *buildings only*. In other words, the losses to other elements of the built environment, such as transportation, lifeline and communication facilities are not reported. Furthermore, the losses reported are only the *direct economic losses* due to building damage, which consist of *capital stock loss* and *income loss*.

This survey reviews 34 potential earthquake scenarios. Two of the ten most likely earthquake scenarios, most damaging to Santa Cruz are shown on the following maps.

Scenario N-9 shows a possible repeat of the 1906 San Francisco earthquake and the intensity and potential damage to the City of Santa Cruz. The map indicates that the intensity would be up to IX or X which represents violent or extreme perceived shaking and very heavy potential damage. The next map shows the peak ground acceleration for this earthquake and the following two maps show the estimated building damage and economic loss as a result of the Sceniario-9 earthquake.

Scenario N-7 shows the projected impacts of an earthquake along the Santa Cruz Mountains + Peninsula + North Coast and the potential damage to the City of Santa Cruz. The map indicates that the intensity would be VIII or IX which represents severe to violent perceived shaking and moderate to heavy damage.

The next map shows peak ground acceleration for this earthquake scenario and the following two maps show the estimated building damage and economic loss as a result of the Scenario N-7 earthquake.

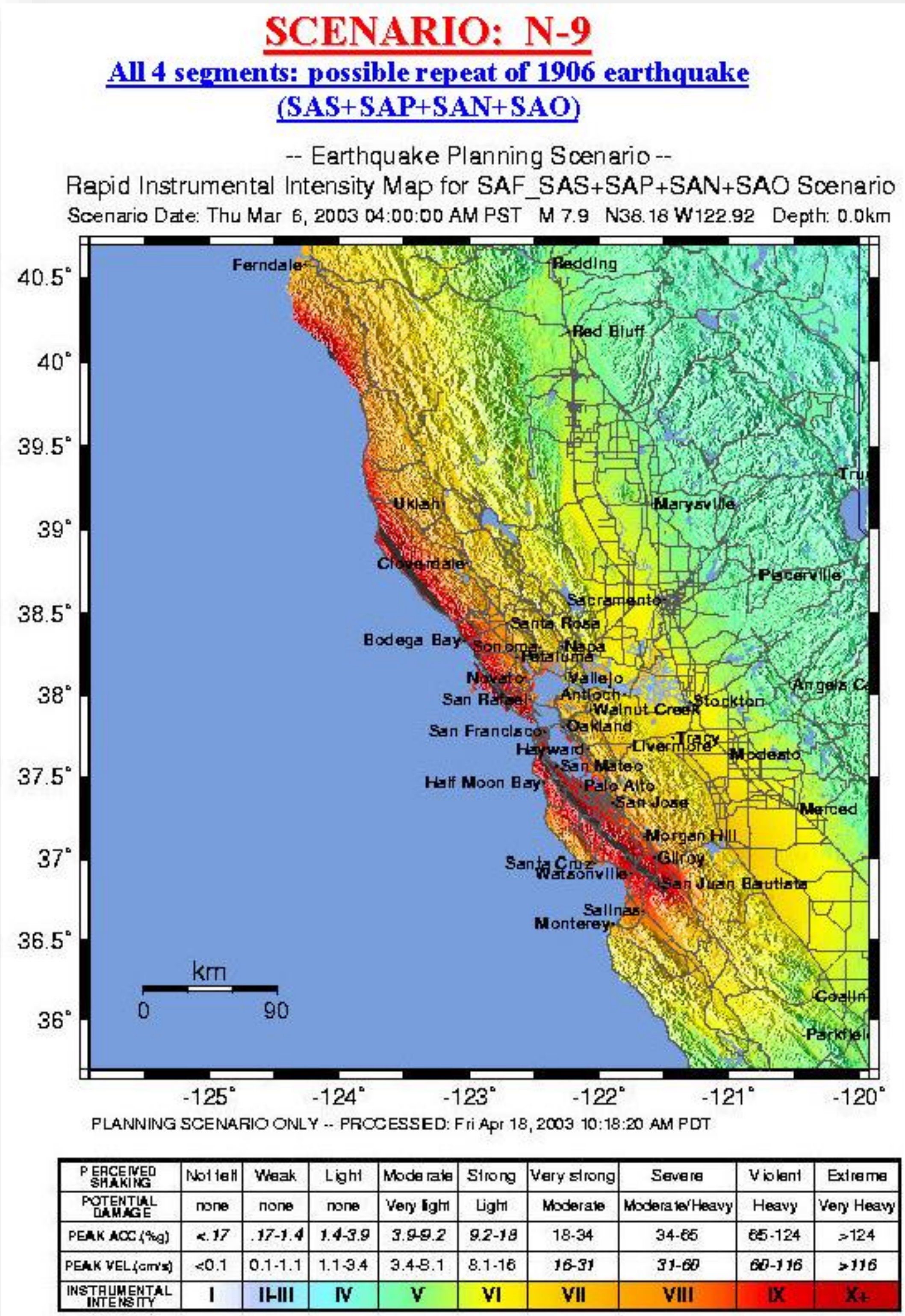


Figure 8 – Scenario N-9 Repeat of 1906 Earthquake

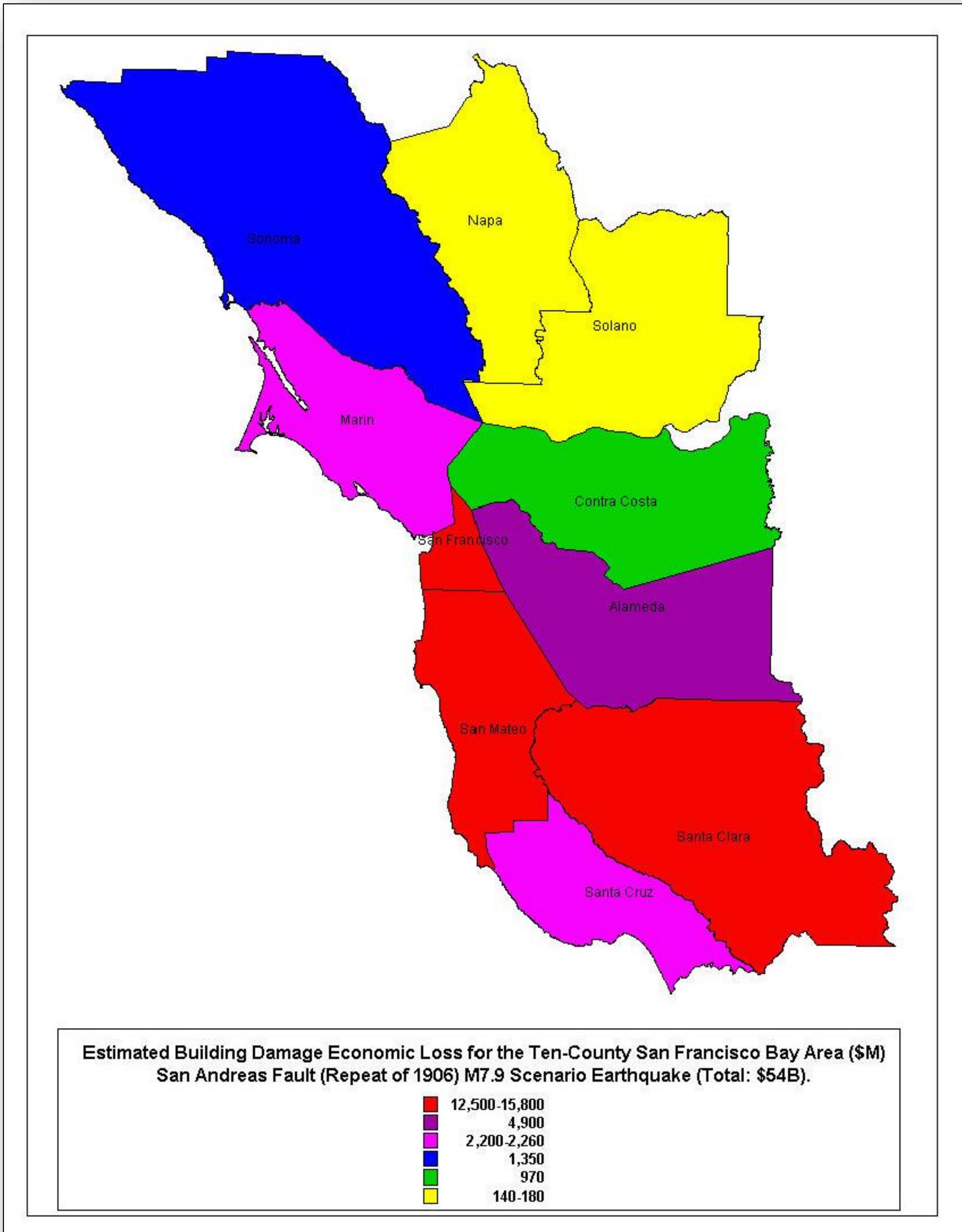


Figure 9 – Scenario N-9 Repeat of 1906 Earthquake — Building Economic Loss by County

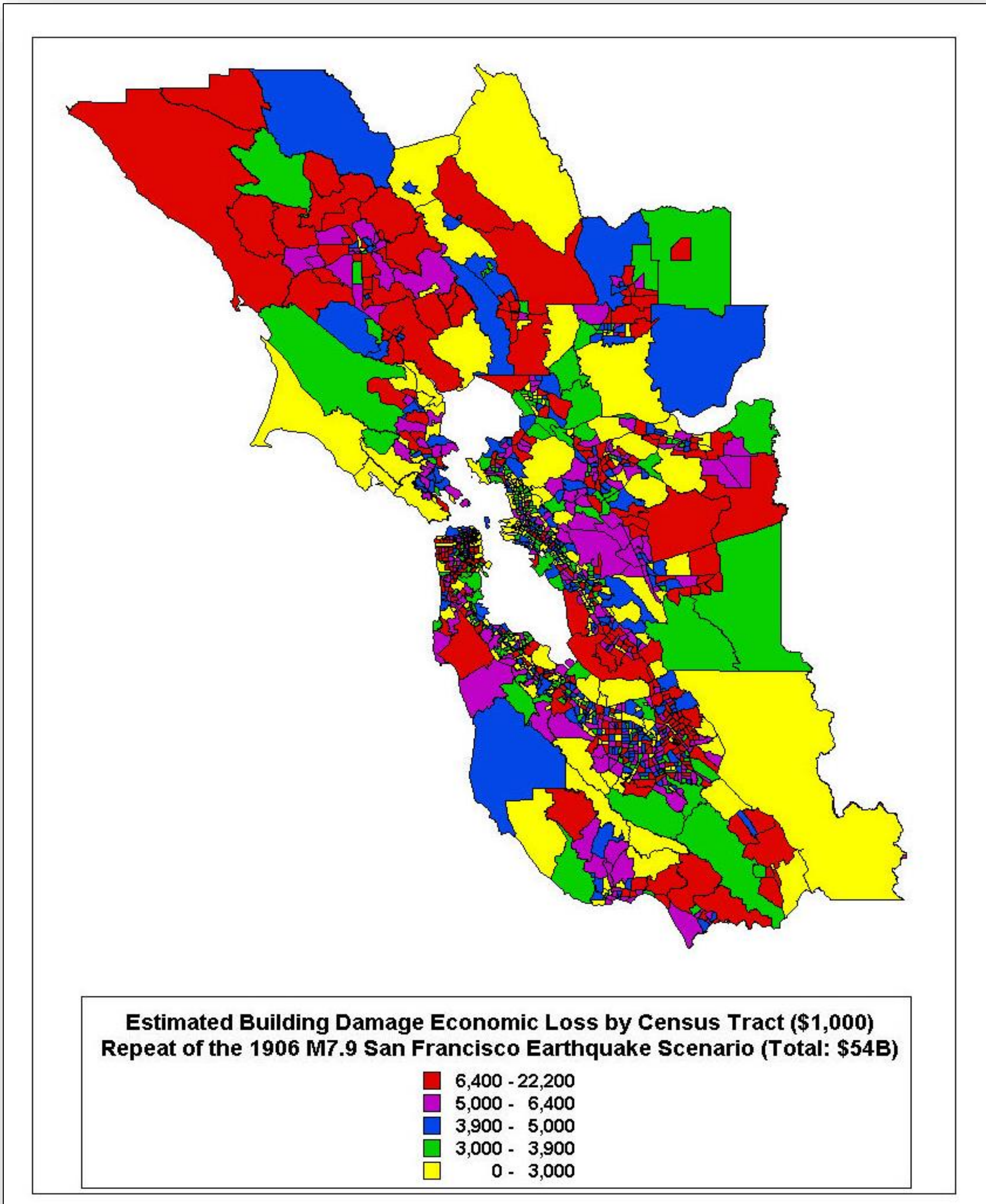
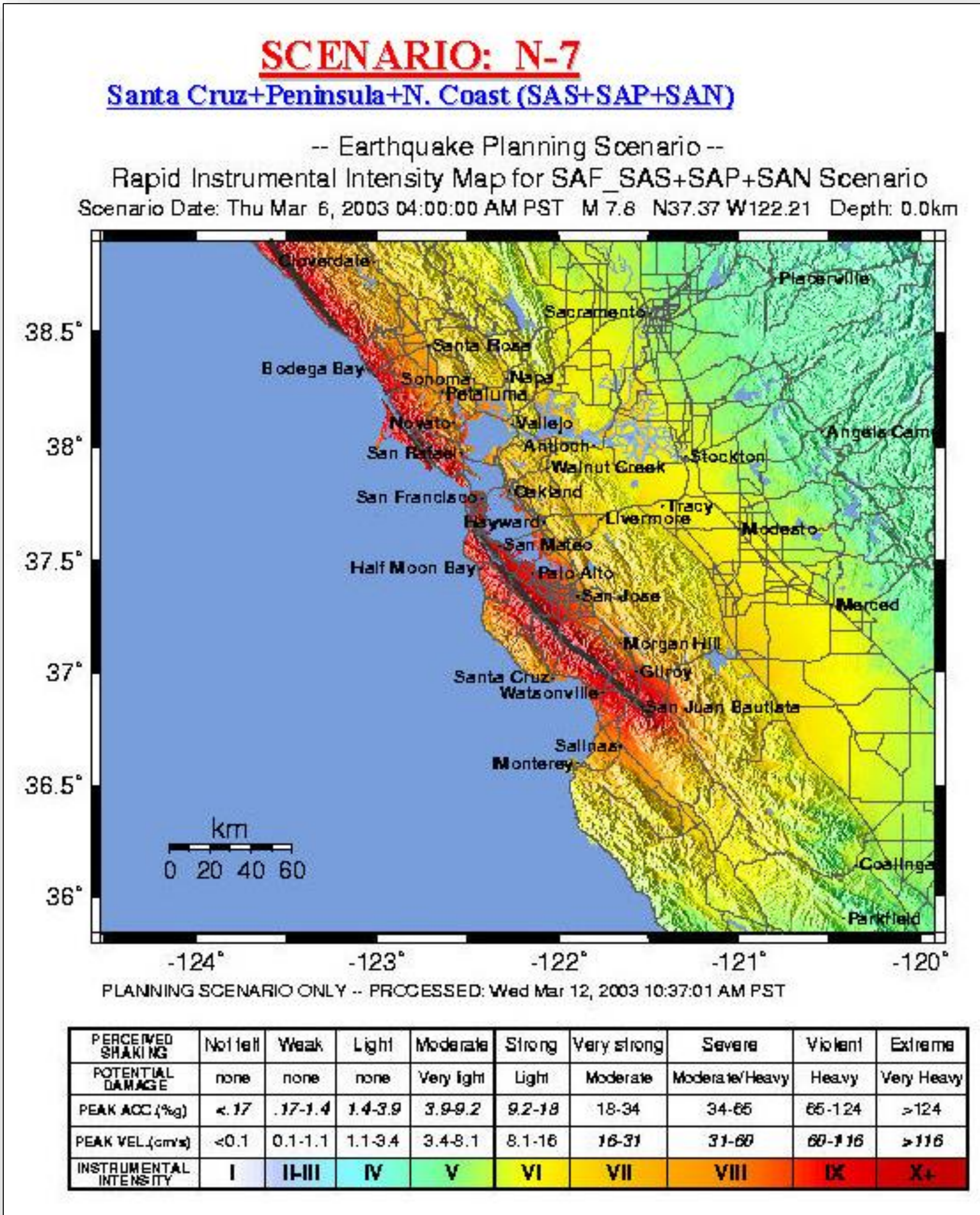


Figure 10 – Scenario N-9 Repeat of 1906 Earthquake Loss by Census Tract



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 11 – Scenario N-7 Santa Cruz Mountains

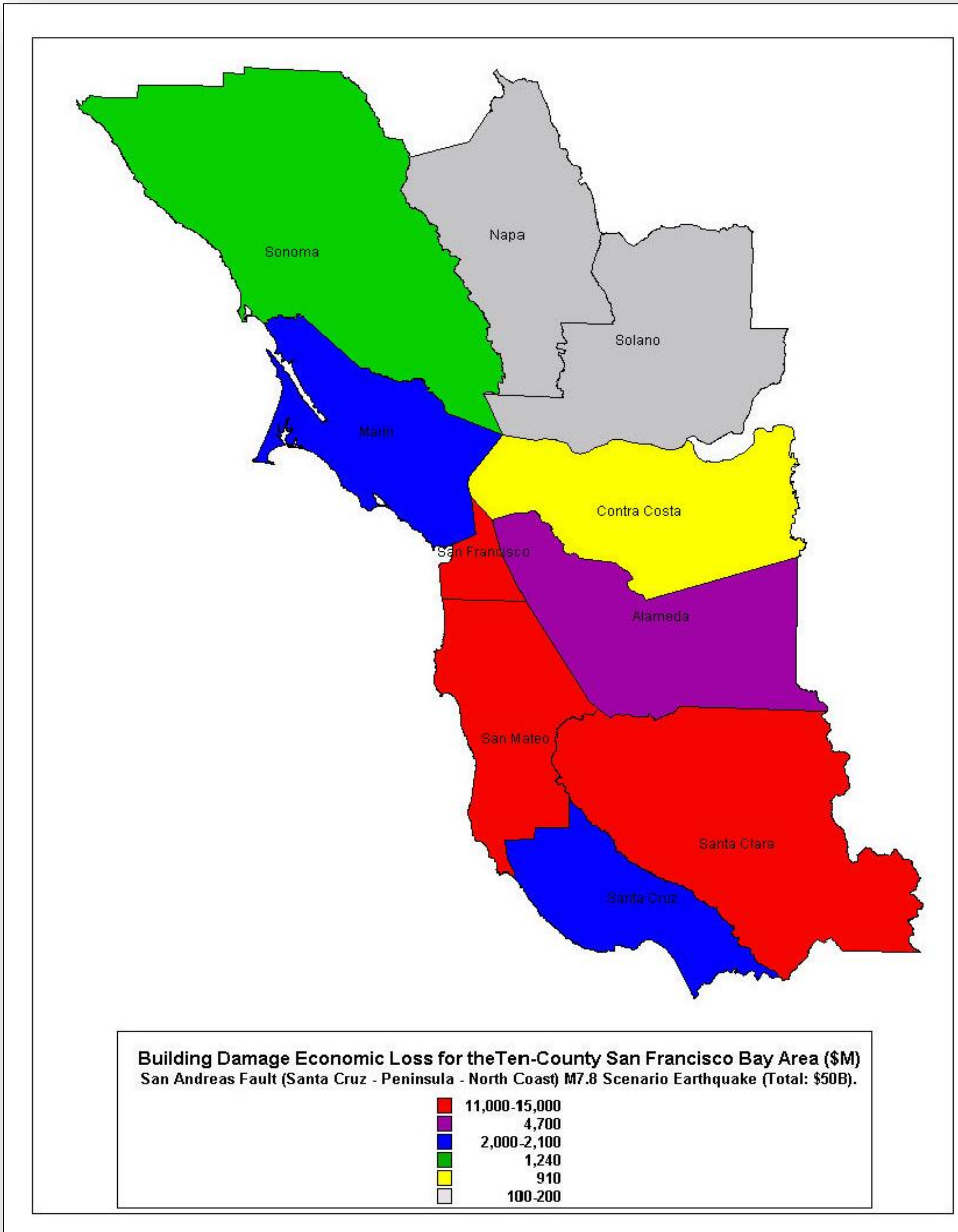


Figure 12 – Scenario N-7 Santa Cruz Mountains — Building Economic Loss by County

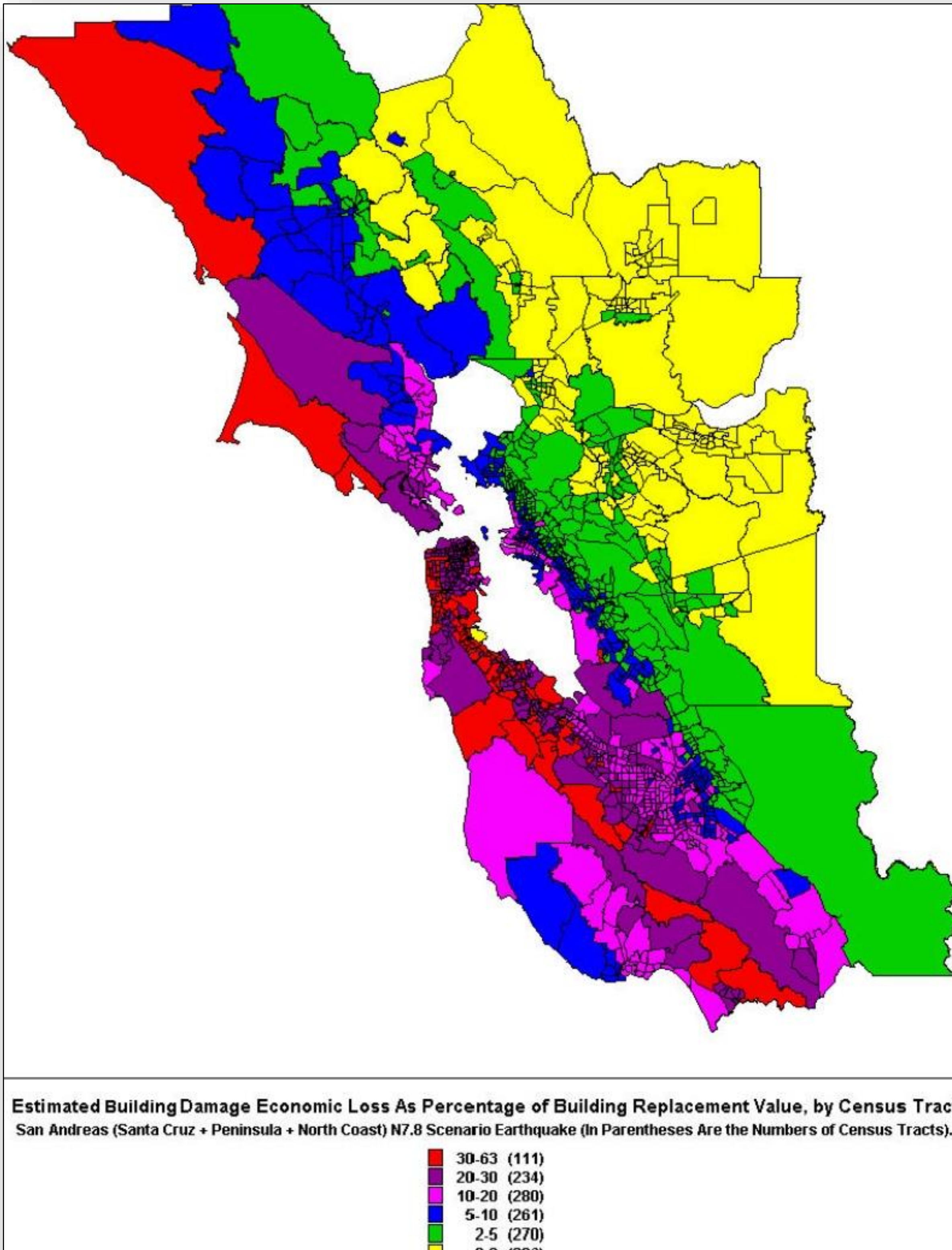


Figure 13 – Scenario N-7 Santa Cruz Mountains — Building Economic Loss by Census Tract

4.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

A POTENTIAL DOLLAR LOSSES TO VULNERABLE STRUCTURES

Table 4-3 Earthquake potential loss inventory

Inventory Assets				
EARTHQUAKE				
	# of Parcels	**# of Structures**	**Critical Structures**	**Loss in Value$***
Type	**Entire Community**	**Total**	**Total**	**Hazard**
Residential	14,916	17,363		$9,263,773,000
Commercial	1,54	1,310		$2,309,879,000
Industrial	307	299		$495,671,000
Agricultural	5	51		$29,942,000
Religion	56	99		$168,168,000
Government	217	30		$85,229,000
Education	228	65		$188,840,000
Total	**17,253**	**19,217**	**35**	**$12,541,502,000**
# of People	62,752			
Date: Census American Community Survey 2015				
Total = total number of structures, residents, values within the entire community				
Parcel Data is from January 2017. The entire community is within the earthquake hazard area.				
*Building Count/Total Replacement Value data is from 2014.				

B METHODOLOGY USED TO PREPARE ESTIMATE

Parcel Valuation:
Total Building Replacement Value (Building and Contents) and Building Count (Structure Count) from HAZUS-MH 3.2 Release 14.2.0. This data is from 2014.

Population:
Census population blocks were reduced to center points. If a hazard intersected a center point, that population was counted.

The losses to other elements of the built environment, such as transportation, lifeline and communication facilities are not reported. Furthermore, the losses reported are only the *direct economic losses* due to building damage, which consist of *capital stock loss* and *income loss*.

Indirect economic losses, representing the losses due to various forms of post-earthquake socioeconomic disruptions (such as employment and income, insurance and financial aids, construction, production and import-export of goods and services) are not included in the estimates reported. This is because of the higher level of uncertainty associated with the indirect losses, as compared to the direct losses. Therefore, it is expected that once the indirect building economic losses, the economic losses to non-building facilities, and the contributions of all earthquake hazards are taken into account, the estimated economic losses would be several times the numbers presented.[12]

Detailed results for all scenario earthquakes and for the State-wide annual losses are available on the CGS website.[13]

Among the 34 scenario earthquakes of the San Francisco Bay Area (SFBA), a repeat of the 1906 earthquake results in the largest economic loss for the ten SFBA counties. It would rupture four segments of the San Andreas fault and would cause approximately $54 billion of economic loss due to building damage. A number of other earthquakes on the San Andreas fault, rupturing different combinations of these four segments are also feasible. Should one occur, it would result in an estimated loss ranging from a few billion dollars to $50 billion. Other potentially damaging earthquakes in the SFBA are:

- A magnitude 6.9 event rupturing the entire Hayward fault causing $23 billion in losses;
- A magnitude 7.3 earthquake rupturing the entire Hayward fault and the Rodgers Creek fault causing $34 billion in losses.

Estimates were calculated using HAZUS version MH 3.2, Release 14.2.0, and uses 2010 census data. This information in HAZUS is, for the most part, derived from 2010 national census data. Using this process the most severe potential earthquake near Santa Cruz estimates a loss of over $9 billion dollars for the county. The City of Santa Cruz represents 20 percent of that population and has within its boundaries significantly more than 20 percent of the structures as it is the commercial center of the county.

4.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

3.6 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.

C DESCRIPTION OF LAND-USES AND DEVELOPMENT TRENDS

The City of Santa Cruz is a compact urban community that is surrounded by natural barriers to outward expansion including the Santa Cruz Mountains, the Pacific Ocean and a designated greenbelt. "Ongoing population growth… has been mirrored by an increase in urbanization for the Monterey Bay area. Development patterns in the coastal zone since the 1970s confirm these overall urbanizing trends."[14]

New development has occurred within or adjacent to the urban services line (i.e., the boundary point for such infrastructure as gas, water, and sewage hook-ups). In Santa Cruz, most development is now infill or reuse development.

Since the 1989 Loma Prieta earthquake all commercial and public buildings have been replaced or seismically retrofitted. Seismic safety standards are a requirement for all building permits. As infrastructure is repaired or replaced updated seismic safety standards are incorporated.

4.4.0 MITIGATION STRATEGY

4.0 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 primary mitigation strategy to avoid or reduce damage from earthquake is continuation of design review and code enforcement to meet current seismic standards, including adequate geotechnical monitoring protocols to insure structural integrity.

Mapping of liquefaction areas in Santa Cruz have been updated in this plan and represent a more accurate mapping of potential liquefaction areas. The inclusion of an updated liquefaction map was noted as an important goal of the 2007 LHMP.

4.4.1 MITIGATION GOALS

4.1 Local Hazard 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.

Earthquake Goals:

Earthquake 1 — Avoid or reduce the potential for life loss, injury, property or economic damage to Santa Cruz from earthquakes.
Earthquake 2 — Encourage mitigation activities that increase disaster resilience to earthquake. (A-6)

4.4.2 IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

4.2 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.

Earthquake Mitigation Actions:

Earthquake is one of the most significant threats to Santa Cruz. The following Actions (noted in parentheses), are listed in Part 4, Chapter 13: Mitigation Strategies. They are critical to the future safety of Santa Cruz:

- Coordinate preparedness efforts with other agencies. (A-2)
- Upgrade sewer, water and other infrastructure to withstand seismic shaking. (A-10)
- Continue retrofitting all non-complying unreinforced masonry buildings. (C-8)
- Upgrade seismic safety of all emergency use and critical structures. (C-9)

In regard to what has taken place since 2012 as it relates to earthquake mitigation for buildings and structures under the authority of the Building and Safety Division, the City of Santa Cruz adopted the most recent California Buildings Standards Code. These codes include structural design standards for seismic requirements. They also reference other applicable standards, such as ASCE7 (American Society of Civil Engineers). Current codes in use are the 2016 California Building Standards Code adopted through Santa Cruz Municipal Code, Title 18 (18.04.030 Adoption of Codes). Building permits are required by both the California Residential Code and the California Building code, resulting in structural/seismic design requirements for residential and nonresidential buildings and structures. Applications for permits include plans and supporting documentation showing seismic design compliance. Structural design is typically accomplished by a Registered Engineer. Plans are reviewed and approved by professional plan review staff. Inspections are accomplished by city inspection staff. Additionally, special inspection/material testing and structural observation may be accomplished by qualified third party inspection agencies and the project engineer as required.

CHAPTER 5: WILDFIRES

5.3.0 WILDFIRE RISK ASSESSMENT

5.3.1 IDENTIFYING WILDFIRE HAZARDS

3.1 Identifying 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

Wildland fire may be defined as any unwanted fire involving outdoor vegetation. While it is often thought of as occurring in forests, rangelands or crop fields, it may also occur in areas such as vacant lots, highway medians, parks and golf courses. With residential development spreading into pristine areas, a relatively new phenomenon has been created: the wildland/urban interface. This phenomenon has changed the nature of the wildland fire problem in some very significant ways. Both the life hazard and the potential economic losses in wildland areas have increased greatly, and the increase in human activity has multiplied the number and variety of potential sources of ignition.

Wildland fires are influenced by three factors: fuel, weather and topography. The spread of wildland fires depends on the type of fuel that exists within the area in the form of grasses, brush and trees. Wildland fire behavior is also influenced by local weather which can modify the burn rate (how fast the fire burns.) Examples of weather incidents that affect wildland fires are atmospheric stability, inversions, thunderstorms, relative humidity and wind. Finally, the severity of wildland fires is influenced by topography including slope, aspect, chimneys and drainages, and the accessibility of the location.

Priorities in the event of a wildfire are life safety, preservation of property and resource conservation. Life safety includes the potential for evacuation, sheltering in place (finding and directing citizens to a location safe from the threat of fire) and providing evacuation to safe refuge. Property conservation includes triage (evaluation and determination of priority of response) of threatened structures as well as evaluation of types of structures in surrounding areas. Natural resource conservation includes assessing the risk to timber, crops, wildlife, wetlands and pasture land.

CLIMATE ADAPTATION CONSIDERATIONS

As noted in the City of Santa Cruz Climate Adaption Plan (*see* Appendix P), the impacts of changing precipitation patterns will exacerbate wildland fire threats due to the potential of longer and dryer summers or wetter winters. Additionally, rising temperatures may contribute to increased wildland fires. It has been noted that the risk for large wildfires could increase by as much as 55 percent if temperatures rise to what is considered a medium warming range. Such a percent increase is twice as high as expected if temperatures only increased into the lower warming range. (*see* CalAdapt.org)

5.3.2 PROFILING WILDFIRE HAZARD EVENTS

A LOCATION

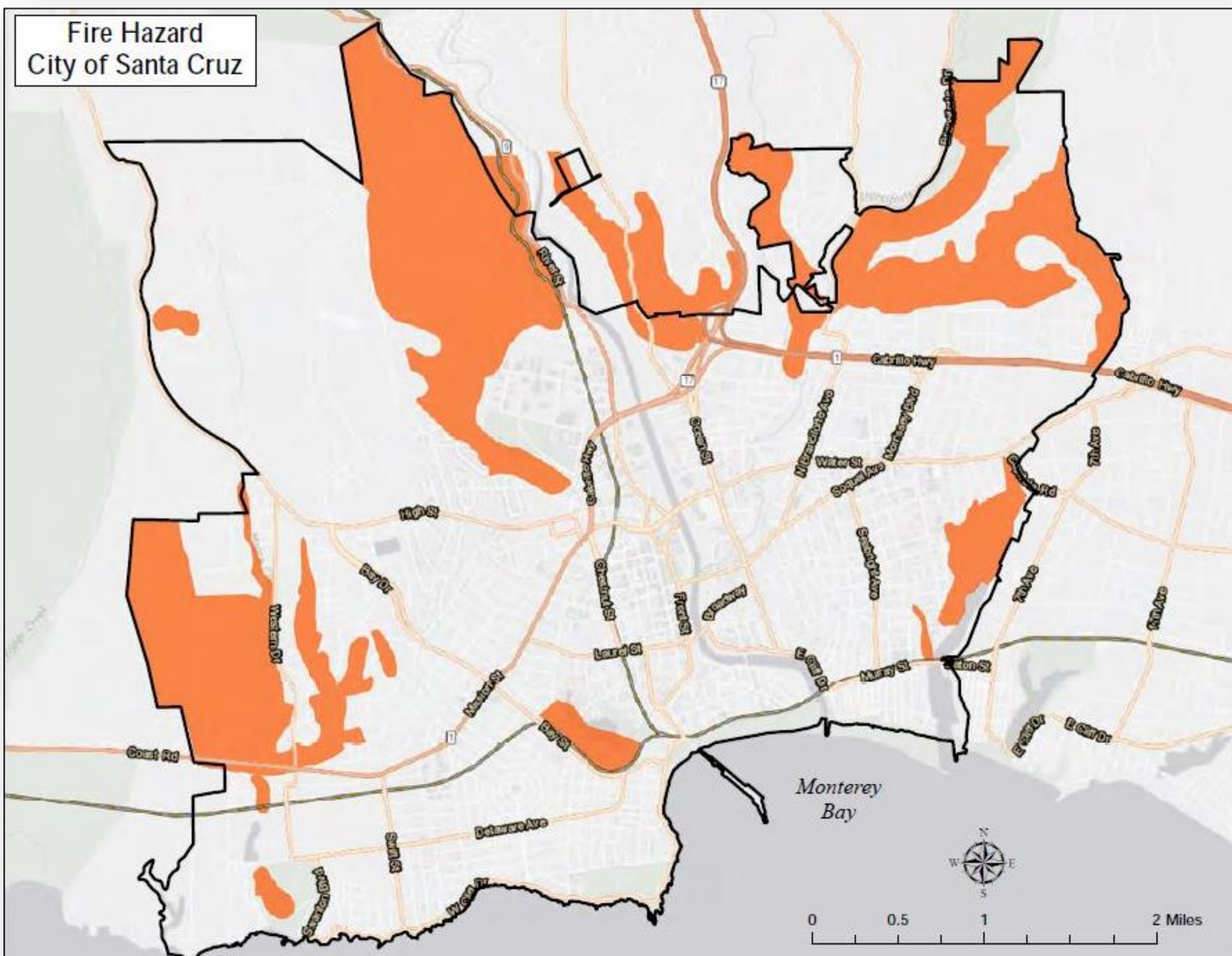


Figure 14 – Wildfire Hazard Areas within the City of Santa Cruz

Within the City of Santa Cruz there are five wildland/urban interface areas including three areas designated as *mutual threat zones* (also called *mutual response zone*). Mutual threat/response zones are defined as geographical areas where a wildfire would threaten property within the Santa Cruz fire protection district as well as property covered by another fire protection service.

For major emergencies that require more resources than can be provided by a single agency, the City of Santa Cruz, Santa Cruz County, the University of California at Santa Cruz and the State of California have an extensive mutual aid and emergency coordination system. Developed and managed in cooperation with the State Office of Emergency Services, this system allows departments and districts to share personnel and equipment as needed to address and control emergencies.

Shared Fire Department Command, Training, Resources

In September 2011, the City of Santa Cruz and UC Santa Cruz determined that it was in the best interest of both agencies to consolidate the local provision of fire prevention and suppression activities, emergency medical services and emergency/disaster management. Both agencies had these same responsibilities within their respective boundaries.

Due to the proximity of the two fire service departments to one another and, their similar organizational elements, both jurisdictions determined that it was in their best interests to cooperate in sharing fire management functions; as well as supervision of operations, training, fire prevention, administration, fiscal management and disaster preparedness.

On September 27, 2011, the Santa Cruz City Council passed and adopted a Resolution (NS-28,405) merging the two fire departments, in a two-year pilot process. This effectively eliminated redundancy and duplication of efforts and provided opportunities for cost savings and an increased level of service for each party, and their constituents. The newly shared fire command services enhance the City of Santa Cruz' ability to mitigate fire danger in the city and surrounding greenbelt areas.

On July 2, 2014 both agencies entered into a ten-year contract for fire and EMS response services (excluding prevention).

Mutual Threat Zones

Mutual threat zones (described above), are delineated in the Wildland Pre-Suppression Plan[15] for the mutual threat zone areas in and around DeLaveaga Park, the Pogonip property, and the Arroyo Seco/Meder Canyon area (*see* Figure 14). This plan is used to identify non-State Responsibility Areas* in which any fire is considered a threat to adjacent State Responsibility Areas. These geographic areas are designated mutual threat zones because of the urban development that has occurred along their canyons and the vegetation that is considered significant. The main populated areas of the University of California Santa Cruz is considered Local Responsibility, but the rest of the property is considered as State Responsibility area.

Source: CALFIRE — California Department of Forestry and Fire Protection

* The State Responsibility Area (SRA) is the area of the state where the State of California is financially responsible for the prevention and suppression of wildfires. SRA does not include lands within city boundaries or in federal ownership. (State Responsibility Area)

Wildland fires also present a risk to open space areas within the City of Santa Cruz and adjacent to residential homes. Additional areas of concern for these wildland/urban interface zones include the Arana Gulch property, Lighthouse Field, the Moore Creek Preserve as well as other smaller wildland/urban interface areas throughout the city. It should also be noted that there are City of Santa Cruz water service areas and water infrastructure areas that are located outside of the City limits that are potentially threatened by wildland fires.

B EXTENT: MAGNITUDE OR SEVERITY

The potential magnitude and severity of future fires could be predicted from experiences gained from recent fires in 2008/2009/2016 which occurred in the County of Santa Cruz. A few of these fires bordered jurisdictional boundary to the City of Santa Cruz. In a few of these fires, spotting exceeded 1 mile, with some flame lengths exceeding 100 feet. In 2008, over 75 structures were destroyed on three fires alone. During the 2008/2009 fire seasons over 13,000 acres have burned in five major fires in Santa Cruz County. In 2016 the second Loma Fire burned three homes, 2,250 acres and several vehicles.

Although the City of Santa Cruz Fire Department responds annually to about 50 vegetation type fires the opportunity for these events to become significant have been recognized over the past few fire seasons. Suppression costs to contain and extinguish each of these fires exceeded $60 million dollars. The state and local cost incurred to respond to these fires were covered by the Federal Fire Management Assistance Grant and California Disaster Assistance Act.

According to the *Meder Canyon Vegetation Management Plan*, prepared by Wildland Resource Management (2004), and the *Wildland Fire Safety Plan, DeLaveaga Park Area* prepared by the Hunt Research Corporation (1995), the potential for a significant wildland fire exists in and around various areas of Santa Cruz. Because some of these canyon areas have steep slopes with dense stands of eucalyptus trees, conifers, chaparral species and other vegetation, the potential for a fire with the intensity and effect of the 1991 Oakland Hills fire exists and many structures could be threatened. There are a large number of homes at the top of steep slopes.

Expected fire behavior in and around the canyons described above indicates that fire spread will be rapid and will run uphill toward structures. Without fuels modification and/or management, eucalyptus litter, shrubs and un-mowed grass would generate enough heat to cause shrubs, eucalyptus, or oak canopies to ignite, distributing embers widely and producing enough heat to potentially involve structures. Un-mowed grass and eucalyptus litter comprise the highest flash point type of fuels encountered in Santa Cruz.

Trees with low branches, and shrubs — particularly coyote brush and poison oak — are most likely to serve as “ladder fuel” to enable fires beneath to spread into the tree canopy or crown. Should fire become involved in the crown or tree canopy, embers may be expected to be cast throughout the neighborhood and potentially cause several additional fires. In such a case the burning debris may travel up to 1.5 miles away in a wind of 20 mph at ground level during a crown fire according to the Santa Cruz Fire Department.

In most of the wildland fire risk areas the fuels surrounding these areas have high moisture content due to the area’s marine influence. Winds tend to blow from the ocean upslope.

However, in the fall, *sundowner winds*, defined as strong, warming, downslope winds that develop over the southern slopes of mountains in late afternoons and evenings that pose a very serious threat during the height of fire season, can occur from the north/northeast towards the ocean. Wind speeds can be 20 mph or more. Temperatures can be 80º or more. In Santa Cruz, fuel moistures have been recorded as low as 34% by the Santa Cruz Fire Department.

C PREVIOUS OCCURRENCES

Recent Significant Wildland fires in the City of Santa Cruz

- 1990 — Meder Canyon Fire — Several acres consumed in 20 minutes

A number of other wildland fires in the Santa Cruz area including the Santa Cruz Mountains have been a concern to the City of Santa Cruz.

- 2016 .... Loma Fire............... 2,220 acres consumed
- 2009 .... Loma Fire.................. 485 acres consumed
- 2009 .... Lockheed Fire............... 7,819 acres consumed
- 2008 .... Trabing Fire.................. 630 acres consumed
- 2008 .... Martin Fire.................. 520 acres consumed
- 2008 .... Summit Fire............... 4,270 acres consumed

D PROBABILITY OF FUTURE EVENTS

Despite the fact that there has not been a recent significant wildland fire within the city limits, residential development continues to spread into wildland/urban interface areas increasing the danger to life and property should a fire occur. Areas targeted as “likely” to have a wildland fire include the Arroyo Seco/Meder Canyon, DeLaveaga, Pogonip, Moore Creek area and Arana Gulch. Increased use of these areas by residents, transient encampments with fires and young adults looking for a place to gather outside parental supervision, exacerbates the risks.

A fire threat will always exist in a wildland/urban interface area as long as vegetation, trees, down and dead fuels, structures and humans co-exist. There is a high probability that fires will occur in one or more of these areas. It is not a question of *if* they will occur but *when* will they occur.

The increasing trend of developing residences in the wildland urban interface in hazardous areas combined with recreational and transient uses of these locations have exacerbated the situation.

5.3.3 ASSESSING WILDFIRE VULNERABILITY: OVERVIEW

3.3 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.

A OVERALL SUMMARY OF VULNERABILITY TO WILDFIRES

Santa Cruz is a compact city surrounded by greenbelt. While the majority of the city is urban, wildfires remain a threat in several canyons and in the wildland/urban interface. The areas most vulnerable to wildfires within the city are:

- Pogonip
- DeLaveaga
- Moore Creek Preserve
- Arana Gulch
- Arroyo Seco Canyon
- UCSC

Vulnerability is increased in several of these areas due to limited access and transient use. This vulnerability can be further identified with hundreds of homes located in and around these areas, in addition to neighborhood schools, a major state university, commercial facilities, and water storage tanks. Furthermore, the Climate Adaptation Plan Update (Appendix P) identifies locations of *socially vulnerable populations* with respect to wildfire hazard zones. This important and unique social vulnerability analysis enhances response strategies and actions.

The impact of wildfire on the community could have the potential for devastating effects. These impacts could be the loss of life, environmental damage, and loss of property. During the rainy season, burned-over areas are subject to mudslides and debris torrents which can impact the infrastructure of the city. This downward flow can destroy fish habitats, compromise the water quality provided to customers, and affect the flow of water into the Monterey Bay/Pacific Ocean.

5.3.4 ASSESSING VULNERABILITY: IDENTIFYING STRUCTURES

3.4 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 area.

A TYPES AND NUMBERS OF EXISTING BUILDINGS, FACILITIES AND INFRASTRUCTURE

Most wildland fire areas are adjacent to residential or open space areas. Only a few public buildings are immediately threatened by wildland fires. Public buildings that are in threat areas are the historic Pogonip Clubhouse, DeLaveaga Golf Club and associated buildings, schools (including university housing and educational buildings within city limits) and day care centers and some park structures. There are commercial and/or industrial structures in the threat zone (*see* Table 5-1).

5.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

Potential Dollar Losses to Vulnerable Structures

Table 5-1 Wildfire potential loss inventory

Inventory Assets								
WILDFIRE								
	# of Parcels		**# of Structures**		**Critical Structures**		**Loss in Value$***	
Type	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**
Residential	14,916	1,169	17,363	1,011			$9,263,773,000	$525,269,466
Commercial	1,524	8	1,310	51			$2,309,879,000	$97,371,303
Industrial	307	14	299	13			$495,671,000	$39,210,240
Religion	56	2	99	4			$168,168,000	$8,251,306
Government	217	75	30	1			$85,229,000	$1,967,884
Education	228	1	65	2			$188,840,000	$2,648,227
Agricultural	5	1	51	2			$29,942,000	$1,321,091
Total	**17,253**	**1,270**	**19,217**	**1,084**	**35**	**3**	**$12,541,502,000**	**$676,039,516**
	Community	**Hazard**						
# of People	**62,752**	**6,026**						
Date: Census American Community Survey 2015								
Total = total number of structures, residents, values within the entire community								
Hazard= number of structures, residents, values that are located within the defined hazard area								
*Loss is based on Assessment Improvement values.								
Parcel Data is from January 2017. Building Count/Total Replacement Value data is from 2014.								

B METHODOLOGY USED TO PREPARE ESTIMATE

Parcel Valuation:

Total Building Replacement Value (Building and Contents) and Building Count (Structure Count) from HAZUS-MH 3.2 Release 14.2.0. This data is from 2014.

Population:
Census population blocks were reduced to center points. If a hazard intersected a center point, that population was counted.

Calculated replacement value for average size home in the area times the number of structures for residential and for each of the commercial structures. The average home is approximately 1,800 square feet. Replacement value is approximately $220 per square foot (2012 Building Department replacement valuation) for an average replacement value of approximately $400,000.

5.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

3.6 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.

C DESCRIPTION OF LAND-USES AND DEVELOPMENT TRENDS

As was discussed previously, the City of Santa Cruz is a compact urban community that is surrounded by natural barriers to outward expansion including the Santa Cruz Mountains, the Pacific Ocean and a designated greenbelt. As the demand for housing increases there is an increased risk created in the urban rural interface.

Although Santa Cruz has over 3,000 acres of greenbelt and parkland, the City does not have the resources to adequately police and protect this area. This inadequate policing increases the frequency of illegal camping (Santa Cruz has a substantial chronic homeless population), which can result in fires in limited access and canyon areas.

5.4.0 MITIGATION STRATEGY

4.0 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 City of Santa Cruz has initiated a number of wildfire mitigation programs in the past including the DeLaveaga Vegetation Management Program and the Arroyo Seco Canyon Vegetation Management project.

Providing vegetation management crosses several departments within the City of Santa Cruz. Identified areas for vegetation management include vacant lots, streets, islands, alleys, and greenbelt areas. Some of the practices of vegetation management include frequent mowing and abatement of vegetation in these areas and these activities continue on an annual basis.

The City also continues to maintain and develop cooperative agreements with the County, UCSC (with a contract for services, not mutual aid), the California Department of Forestry and other fire protection agencies to collaboratively avoid or minimize the threat from wildland/urban interface fires. An initial increase in the number of fire units dispatched to fire-related incidents has been initiated to contain and control these situations at the initial phase of fire development.

Routine and frequent training by local and state fire jurisdictions continues. Implementation of a "reverse 911" community notification and warning system has been developed.

Building partnerships with other City departments, particularly Parks and Recreation and Police, in patrolling wildland areas, is critical to mitigation efforts when staff resources are limited. Adoption of the state fire code has addressed the regulation of building materials, construction requirements, water system supply, and code enforcement in wildland urban interface areas.

Finally, through adoption of local amendments contained in the City of Santa Cruz Municipal Code, the City is more restrictive than the state fire code when it comes to turning radius requirements of fire apparatus in access/egress issues, and a "zero-based" fire sprinkler ordinance for fire extinguishing systems.

5.4.1 MITIGATION GOALS

4.1 Local Hazard 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.

Wildfire Goals:

Wildfire 1 — Avoid or reduce the potential for loss of life, injury, property and economic damage to Santa Cruz from wildfire. (C-6)

Wildfire 2 — Collaborate with other County fire districts, UCSC and the California Department of Forestry in mutual fire protection efforts. (A-7)

IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

4.2 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.

Wildfire Mitigation Actions:

Wildfire protection mitigation strategy includes the following actions:

- Cooperative fire protection agreements with other agencies (A-7)
- Reduction of fire risk in wildland/urban interface areas through improved vegetation management and appropriate code enforcement (A-8)
- Promotion of built-in fire extinguishing and warning fire alarm systems (B-9)
- Creation of a proactive (not reactive) hazard abatement program (B-10)
- Land use planning to reduce incidence of human caused wildfire (C-4)
- Adequate staffing to meet needs of City population and development (C-5)
- Fire prevention programs in schools, institutions and commercial buildings (C-6)

CHAPTER 6: FLOODS AND ASSOCIATED COASTAL STORMS

6.3.0 FLOOD RISK ASSESSMENT

6.3.1 IDENTIFYING FLOOD HAZARDS

3.1 Identifying 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

Flooding and coastal storms present essentially the same risks and are frequently related types of hazards in the City of Santa Cruz. Coastal storms can cause increases in tidal elevations (called *storm surge*) wind speed and erosion as well as flooding.

A flood is a natural event for rivers and streams. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto the banks and adjacent floodplains. Floodplains are lowlands adjacent to rivers, lakes and oceans that are subject to recurring floods. Several factors determine the severity of floods, including rainfall intensity (or other water source) and duration.

A flood occurs when a waterway receives a discharge greater than its capacity. Floods may result from intense rainfall, localized drainage problems, tsunamis or failure of flood control or water supply structures such as levees, dams or reservoirs. Floodwaters can carry large objects downstream with a force strong enough to destroy stationary structures such as bridges and break utility lines. Flood waters also saturate materials and earth resulting in the instability, collapse and destruction of structures as well as the loss of human life. The City of Santa Cruz has lost bridges and other infrastructure during previous storms.

Floods occur in relation to precipitation. Flood severity is determined by the quantity and rate at which water enters the waterway, increasing volume and velocity of water flow. The rate of surface runoff, the major component to flood severity, is influenced by the topography of the region as well as the extent to which ground soil allows for infiltration in addition to the percent of impervious surfaces. It is important to note that a stream can crest long after the precipitation has stopped.

CLIMATE ADAPTATION CONSIDERATIONS

The City of Santa Cruz Climate Adaptation Plan (CAP) considers flooding and severe coastal storms to be a considerable, potential risk to the city and its residents. Intense, increased rainfall may lead to larger flood flows. Noted in the CAP are the potential for greater storm surges, wind speeds and resultant coastal erosion. These events are predicted to occur more frequently due to climate change impacts, including those from sea level rise. In 2017, a Sea Level Rise Vulnerability Assessment was conducted, identifying the impacts from floods and coastal storms influenced by sea level rise. Flooding and coastal storm hazard zones were projected and mapped for years 2030, 2060 and 2100, quantified in terms of number of damaged or lost facilities and assets and their value, and potential effects on socially vulnerable populations.

6.3.2 PROFILING FLOOD HAZARD EVENTS

3.2 Profiling 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

A LOCATION

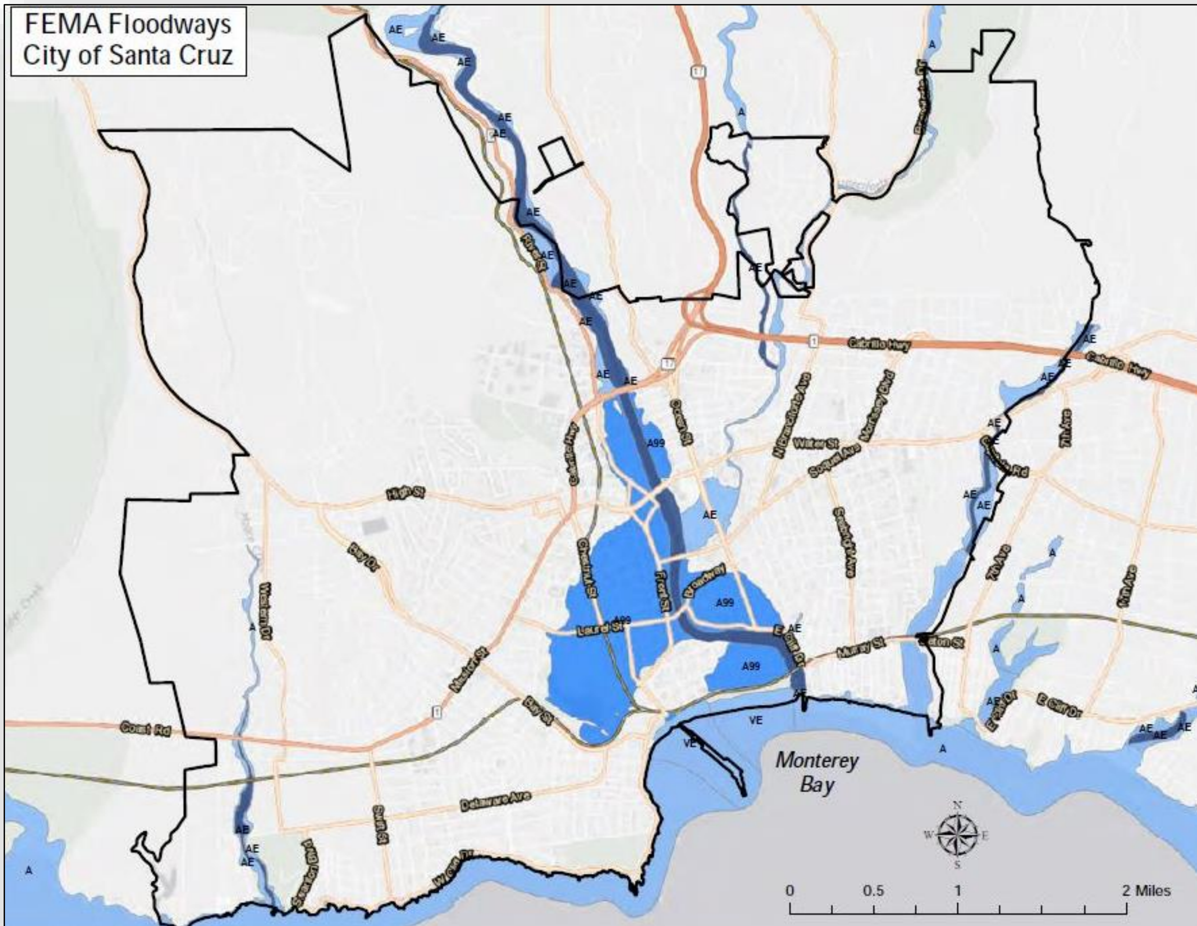


Figure 15 – FEMA Flood Map showing 100-year flood zone

Most of the known floodplains in the United States have been mapped by FEMA, which administers the National Flood Insurance Program (NFIP) The most recent FEMA flood maps for the City of Santa Cruz can be found using this link: [FEMA Flood Map Service Center](). When the user is at this web page enter a property address, city and state in the page's search box and the FEMA flood map for that property in the City of Santa Cruz will be located. The next page will give the user the choice of viewing the specific FEMA flood map which includes that property or, the user can download the FEMA flood map. The flood maps shown on this site are the most current for the City of Santa Cruz.

Within the City of Santa Cruz there are several areas subject to flooding. The San Lorenzo River runs through the downtown corridor and the majority of the downtown area is in the San Lorenzo floodplain. The San Lorenzo River also runs along the edge of the Harvey West Commercial/Industrial area including the Tannery Arts Center and its associated housing.

Flooding along the coast of Santa Cruz may occur with the simultaneous occurrence of large waves and storm swells during the winter. Storm centers from the southwest produce the type of storm pattern most commonly responsible for the majority of serious coastline flooding. The strong winds combined with high tides that create storm surges are also accompanied by heavy rains. When storms occur simultaneously with high tides, flood conditions including flooding at the mouth of the San Lorenzo River are exacerbated.[16]

There are several smaller creeks in the City that are subject to periodic flooding. Flooding is a hazard on the lower reaches of Moore Creek where only shallow stream channels are present, the lower portion of Arana Gulch, north of Santa Cruz Yacht Harbor, and along portions of Branciforte and Carbonera creeks. In these areas there is minimal impact on public structures and facilities and only a few residential structures are within these flood zones.

B EXTENT: MAGNITUDE OR SEVERITY

The San Lorenzo River drains 357 sq. km (138 square miles) of the central California coast range with the annual rainfall in the Redwood forest basin averaging 120 centimeters (47in.).[17] The flood season for the San Lorenzo River extends from November to April with most of the historic floods occurring in December or January. The floods that have caused the most damage were generally of short duration and were the result of the small size and steepness of the basin.

The FEMA Community Rating System (CRS) has awarded the City of Santa Cruz a Class 7 rating. The CRS rating is an important factor in determining the magnitude of the potential for flood along the San Lorenzo River. The Community Rating System is a voluntary incentive program that is part of the National Flood Insurance Program. The CRS recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

- Reduce flood losses
- Facilitate accurate insurance rating
- Promote awareness of flood insurance

For communities participating in the CRS, flood insurance premium rates are discounted in increments of 5 percent (Community Rating System). For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a five percent discount. A Class 10 community does not participate in the CRS and receives no discount. The CRS classes for local communities are based on 18 creditable activities organized under the following four categories:

- Public Information
- Mapping and Regulations
- Flood Damage Reduction
- Flood Preparedness

Currently, approximately 1,200 communities nationwide, including Santa Cruz, receive flood insurance premium discounts based on implementation of local mitigation, outreach, and educational activities that go well beyond minimum NFIP requirements.

The Flood Insurance Rate Map (FIRM) is an official map of a community for which the Federal Insurance and Mitigation Administration has delineated the Special Flood Hazard Area (SFHA) and the risk premium zones applicable to the community. All known areas of the city subject to natural flooding hazards have been designated and mapped by the Federal Emergency Management Agency, such as the 100 year floodplain boundaries which appear on FEMA's Flood Insurance Rate Maps and are a source for the floodplain map included in this chapter.

The City of Santa Cruz has worked to improve the flood capacity of the San Lorenzo River levees over the past twenty years. In 2002, FEMA re-designated much of the downtown and beach area from A-11 to the A-99 Flood Zone designation in recognition of the significant flood improvements resulting from the San Lorenzo River Flood Control and Environmental Restoration Project. (Flood Insurance Premium Reduction). Under the A-99 designation, new buildings and improvements are no longer mandated to meet FEMA flood construction requirements and flood insurance premiums are significantly reduced. The FEMA Community Rating System Class 7 rating for the City of Santa Cruz further reduces the National Flood Insurance Program A-99 flood insurance rates by five percent. At present the combination of the CRS Class 7 rating and the A-99 designation reduces flood insurance by 45%. The City of Santa Cruz is one of the 5.5% of communities in the FEMA National Flood Protection Program who participate in the CRS Program.

Despite recent flood control projects and improved flood rating in much of the downtown and beach area, the risk of flooding is still a concern to the city. While the levee project has resulted in a more flood-resistant downtown, floods may still occur. The levee project did not impact areas along the San Lorenzo River above the Highway 1 Bridge (including the Tannery Arts Center and the associated live-work studios) where flooding is still a significant risk and construction requirements must still address the risk of floods.

C PREVIOUS OCCURRENCES

The City of Santa Cruz is located around the floodplain of the San Lorenzo River and has been subject to floods throughout recorded history from the time the Mission was first built in 1793 to the "Christmas Flood" on December 22, 1955. Eighteen floods, eight of which have been considered severe, have occurred over the last ten decades in Santa Cruz. As discussed above, the San Lorenzo River Levee Project has significantly reduced the risk of flooding in the downtown area. However, the downtown and beach areas are still designated as floodplains.

During the last LHMP review period there were no repetitive loss properties in the City of Santa Cruz and at present there are no repetitive loss properties.

Historical Record of Severe Floods of Santa Cruz 1862-2006

- **January 11, 1862** — Land consumed and buildings along river banks destroyed. "Bulkhead" at Bulkhead Street was built after this flood to prevent water from reaching Main and Willow Streets (now Front Street and Pacific Avenue).
- **December 23, 1871** — Bridges built after 1862 flood across San Lorenzo damaged.

- **January 25, 1890 —** River level highest recorded to this date. A debris dam collected against pilings behind the rail bridge at the mouth of the river. With the failure of the rail bridge, flood levels dropped dramatically. The practice of using pilings to span the river was stopped after this flood.
- **January 4, 1895 —** Levels exceeded the Bulkhead and caused basement, yard and lot flooding in the downtown area.
- **March 27, 1907** — This flood had water levels higher than previous floods. Flood control discussion increased**.**
- **February 27, 1940** — Very severe flooding**.**
- **February 9, 1941** — This was the third flood to hit in four years. Flood control becomes a focus.
- **December 22, 1955 —** Highest historic flood in the area, filling 410 acres of lowlands outside the river channel including the downtown. Ninety percent of the damage in the county occurred within the City of Santa Cruz and cost the City millions of dollars.
- **January 4, 1982 —** Water rose to within two feet of the top of the levees along the San Lorenzo River and flooding occurred both north and south of the freeway along Carbonera and Branciforte Creeks in the Twin Creeks and Brookside Glen developments. This approximately 30-year event also reached the top of the concrete portion of Branciforte Creek at Market Street and overflowed. The older part of the Soquel Avenue bridge, built in 1923, collapsed.
- **February 1995 Storms —** Santa Cruz was one of 57 counties declared disaster areas due to flooding.
- **January 1997** — Santa Cruz was one of 48 counties declared disaster areas due to severe storms and flooding.
- **February 1998 El Niño —** Santa Cruz was one of a number of counties declared disaster areas due to El Niño.
- **April 2006 —** Severe storms and flooding. Santa Cruz was one of several counties to be declared a disaster area. FEMA Disaster 1646 (June 5, 2006)
- **March 2011 —** Severe storm damage. Santa Cruz County was among 19 counties proclaimed by the Governor as in a state of emergency due to storms between March 15 and March 27.
- **January/February 2017** — Emergency Declarations due to Winter Storms

Emergency Declarations — Winter Storms: 2017

City Council Resolution	Date	Action
NS-29,190	**Jan 7, 2017**	• Ratifying Proclamation declaring a local emergency due to January 7, 2017 storms • Requesting Governor's Proclamation of state of emergency
NS-29,197	**Feb 6, 2017**	• Ratifying Proclamation declaring the existence of a local emergency due to the severe weather and rainstorms beginning on February 6, 2017 • Requesting Governor's Proclamation of state of emergency
NS-29, 198	**Feb 28, 2017**	• Affirming existence of continued emergency due to January 7, 2017 storms (original Resolution NS-29,190)
NS-29-212	**Mar 28, 2017**	• Terminating Local Emergency due to January 7, 2017 Storms • Rescinding Resolutions NS-29,190 and NS-29,198

D PROBABILITY OF FUTURE EVENTS

Significant storms and associated damage from flooding strike the Monterey Bay communities with a frequency of one large storm every three to four years. A 100-year flood has a one percent probability of occurring in any given year and, while considered to be a severe flood, it still has a reasonable possibility of regular occurrence. For the purposes of the protection of property, life and safety, floods of other magnitudes and occurrence intervals should also be considered in mitigation efforts.

Floods and flooding are gauged by their size (width and depth of the affected area) and the probability of occurrence. The width and depth of the floodplain area is computed using mathematical models of precipitation, slope, runoff, soil type and cross-section. Flood depths are calculated at intervals along a stream or channel corridor and then mapped and interpolated between sections. This results in the floodplain map.

The probability of occurrence is expressed in a percentage of the chance of a flood of a specific extent occurring in any given year. The most widely adopted design and regulatory standard for floods in the United States is the 1% annual chance flood, and this is the standard formally adopted by FEMA. The "one percent" annual flood is also commonly referred to as the "100-year flood," leading to the misconception that it should occur only once every 100 years. In fact, a 100-year flood may occur in any year, regardless of the time that has passed since the last one. It is the probability that smaller floods occur more often than larger floods that compels the percentage.

Table 6-1 Flood Probability Terms

Flood Occurrence Intervals	Percent Chance of Occurrence Annually
10 years	10.0%
50 years	2.0%
100 years	1.0%
500 years	0.2%

6.3.3 ASSESSING FLOOD VULNERABILITY: OVERVIEW

3.3 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.

A OVERALL SUMMARY OF VULNERABILITY TO FLOODS

The City of Santa Cruz has worked for the past twenty years to improve the flood capacity of the San Lorenzo River levees. Work is now complete on the final phase of the Army Corps of Engineers San Lorenzo River Flood Control Project and FEMA has recognized the increased flood protection that the new higher levees provide by granting the A-99 flood zone designation. The downtown and the area along the river are still in a 100-year floodplain. Coastal storms contribute to the risk of flooding in this area.

The river bank north of the Highway 1 bridge (near the new Tannery Arts site) was not part of the Army Corps of Engineers Project and this area is subject to flooding as are some low lying areas near creeks and streams. While the most vulnerable areas along the river, particularly the downtown corridor, are now less vulnerable, they are still at risk during a 100-year storm, until the fifth phase of the Corps' project is completed.

6.3.4 ASSESSING FLOOD VULNERABILITY: IDENTIFYING STRUCTURES

3.4 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 area.

Types and Numbers of Existing Buildings, Facilities and Infrastructure

Much of the downtown and beach areas are in the 100-year floodplain. The backup Emergency Operations Center (Police Department) as well as most of the City and County government buildings are in the floodplain. The floodplain includes the following:

- 2,232 Structures (2,270 parcels)
- The Central Fire Station
- The Police Station
- City Hall campus
- Coast Pump Station
- Lifeguard and Marine Safety Headquarters
- The County Government Center
- 41 schools and day care centers
- Tait Wells

6.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

A POTENTIAL DOLLAR LOSSES TO VULNERABLE STRUCTURES

Table 6-2 Flood Potential Loss Inventory

Inventory Assets								
100 YEAR FLOOD								
	# of Parcels		**# of Structures**		**Critical Structures**		**Loss in Value$***	
Type	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**
Residential	14,916	1,592	17,363	2,046			$9,263,773,000	$1,357,848,262
Commercial	1,524	667	1,310	300			$2,309,879,000	$740,573,283
Industrial	307	9	299	33			$495,671,000	$42,732,525
Religion	56	9	99	18			$168,168,000	$33,487,566
Government	217	128	30	11			$85,229,000	$31,047,977
Agricultural	5	2	51	6			$29,942,000	$3,638,295
Education	228	4	65	8			$188,840,000	$37,000,587
Total	**17,253**	**2,411**	**19,217**	**2,422**	**35**	**18**	**$12,541,502,000**	**$2,246,328,493**
# of People	**62,752**	**14,464**						
Date: Census American Community Survey 2015								
Total = total number of structures, residents, values within the entire community								
*Building Count/Total Replacement Value data is from 2014.								
Parcel Data is from January 2017								

B METHODOLOGY USED TO PREPARE ESTIMATE

Parcel Valuation:
Total Building Replacement Value (Building and Contents) and Building Count (Structure Count) from HAZUS-MH 3.2 Release 14.2.0. This data is from 2014.

Population:
Census population blocks were reduced to center points. If a hazard intersected a center point, that population was counted.

Flood Analysis:
Since FEMA flood data is mapped on the federal level, the data is extremely coarse in horizontal accuracy. The data was not meant to be measured against parcel level information and therefore is a rough estimate of damage and loss.

Estimating flood losses is an established process. If a 100-year flood occurred in Santa Cruz, meaning the flood that had a 1% chance of occurring in any given year, it would impact approximately 2,200 structures to various degrees. This was determined by intersecting the city's database of structures with the FEMA developed maps of the 100-year floodplain.

Santa Cruz structures in the floodplain vary in construction, size and materials, ranging from single family homes to multi-family to commercial. The downtown of the City of Santa Cruz lies almost entirely within the 100-year floodplain. Many structures in this area are multi-story.

The primary purpose of the San Lorenzo Levee Project was to reduce flood damage and loss within the City of Santa Cruz 100-year floodplain. According to the Federal Emergency Management Agency, the December 1955 flood caused over $40 million in damage. The U.S. Army Corps of Engineers estimated that a 100-year flood in the downtown area in 2002 would have caused $86 million in damage.[18]

6.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

3.6 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.

A DESCRIPTION OF LAND USES AND DEVELOPMENT TRENDS

As was described previously, the City of Santa Cruz is a compact urban community that is surrounded by natural barriers to outward expansion including the Santa Cruz Mountains, the Pacific Ocean and a designated greenbelt. In Santa Cruz, most development is now infill or reuse development.[19]

The beach and downtown commercial areas are in the 100-year floodplain. Increasing residential density and mixed use development continue in the downtown core. The Tannery Arts project including a residential component is located in a floodplain next to the San Lorenzo River above the levee project area.

The City is required by Association of Monterey Bay Area Governments (AMBAG) to zone for its share of housing. Two of the three available properties with the highest density zoning are located in the floodplain.

6.4.0 MITIGATION STRATEGY

4.0 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 City of Santa Cruz addresses land use within the flood plain in the General Plan as well as actively enforcing building and zoning codes, and other land use regulations concerning development within the 100-year flood plain.

The City of Santa Cruz has worked to improve the flood capacity of the San Lorenzo River levees over the past twenty years. In 2002, FEMA re-designated much of the downtown and beach area from A-11 to the A-99 Flood Zone designation in recognition of the significant flood improvements resulting from the San Lorenzo River Flood Control and Environmental Restoration Project.

The City will continue to work with FEMA and the Army Corps of Engineers to minimize impacts of flooding in Santa Cruz. The City will also work to maintain or improve its CRS rating.

6.4.1 MITIGATION GOALS

4.1 Local Hazard 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.

The City of Santa Cruz has developed several flood hazard mitigation goals to create a more flood resistant community.

Flood Goals:

Flood 1 — Avoid or reduce the potential for life loss, property and economic damage from flooding.

Flood 2 — Facilitate accurate insurance ratings through participation in FEMA's Community Rating System.

Flood 3 — Promote public awareness of flood hazards, mitigation measures and flood insurance.

6.4.2 IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

4.2 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.

Flood Mitigation Actions:

The City participates in a number of ongoing mitigation actions to avoid or reduce the threats of flood. These measures are listed in this Plan in Part 4, Mitigation Strategy. Actions include:

- Participation with other agencies in an early warning system for evacuation of areas susceptible to flooding, tsunami or dam failure. (B-4)
- Regulations on development and alteration of flood plains, stream channels and protective barriers that accommodate overflow are in place. (B-5)
- Encouragement of property owners, potential buyers and residents living in flood plains and coastal inundation areas to participate in Federal Flood Insurance Program. (B-6)
- The City has adopted the Creeks and Wetlands Management Plan (February 28, 2006; certified by California Coastal Commission May 9, 2008) which provides guidelines including measures to reduce creek flooding. (B-7)
- The City is continually working to rehabilitate the city's culverts and storm drainage system to reduce flooding caused by inadequate storm drainage. (B-8)
- Annual flood control maintenance on the San Lorenzo River by the Public Works Department as required by the U.S. Army Corps of Engineers. Work consists primarily of managing in-stream riparian vegetation to encourage geomorphic form and function. The vegetation management is identified in the San Lorenzo Urban River Plan and requires vegetated buffer zones to be generally maintained at ten feet at the toe of the levees and five feet along the wetted edge of the river. Vegetation management is required in order for winter flows not to exceed the design capacity of the river and to promote scouring of the river. The maintenance generally takes about four to five weeks each year to complete. (B-12)

CHAPTER 7: DROUGHT

7.3.0 DROUGHT RISK ASSESSMENT

7.3.1 IDENTIFYING DROUGHT HAZARDS

3.1 Identifying 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.

From the City of Santa Cruz *Water Shortage Contingency Plan* (2009):

> Drought is a normal, naturally occurring but unpredictable climatic phenomenon of varying frequency, duration and severity. Droughts differ from other natural hazards in that they are not distinct weather events, like floods, hurricanes, or tornados. They may have a slow onset, persist and evolve over a period of years, affect a large spatial region, but cause little structural damage. The most difficult aspect of a drought is that no one can tell how long it will last.
>
> Five degrees of drought intensity are recognized nationally, including abnormally dry, moderate, severe, extreme, and exceptional.
>
> The California Department of Water Resources describes drought as:
>
> > *"A deficiency of precipitation over an extended period of time resulting in a water shortage for some activity, group, or environmental sector."*
>
> A water shortage, on the other hand, occurs when a particular utility's water supply is insufficient to meet its customers' ordinary drinking water needs. Besides weather conditions, there are a number of factors that affect water supply availability, including:
>
> - Source yield and reliability
> - Infrastructure capacity and operating constraints
> - Access to alternative sources
> - System demand characteristics

The City of Santa Cruz relies predominantly on local surface water sources, including coastal streams and the San Lorenzo River, for most of its annual water supply needs. The yield of these sources in any given year is directly related to the amount of rainfall received and runoff generated during the winter season. Water stored in Loch Lomond Reservoir is used mainly in the summer and fall seasons when the flows in the coast and river sources decline and additional supply is needed to meet dry season demands.

The problem of supply reliability stems primarily from two factors: the wide range in the yield of surface water sources from year to year and limited storage capacity. No water is purchased from state or federal sources or imported to the region from outside the Santa Cruz area.

Every year in late January the City prepares an initial "water supply outlook" that evaluates winter water conditions, including rainfall, stream flow, reservoir storage, and cumulative runoff, and issues a report discussing water conditions and the need, if any, for water shortage actions for the dry season ahead. A final water supply outlook is issued in late March or early April. If needed, a recommendation to declare a water shortage is brought to the City Council at a public hearing for its consideration and adoption.

CLIMATE ADAPTATION CONSIDERATIONS

Santa Cruz' water supply reliability issue is the result of having only a marginally adequate amount of storage to serve demand during dry and critically years when the system's reservoir does not fill completely. Both expected requirements for fish flow releases and anticipated impacts of climate change will turn a marginally inadequate problem into a seriously inadequate one in the coming years.

7.3.2 PROFILING DROUGHT HAZARD EVENTS

3.2 Profiling 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

A LOCATION

The City of Santa Cruz is located on the central coast of California along the northern shore of Monterey Bay. The Santa Cruz water system provides water service to an area approximately twenty square miles in size, including the entire City of Santa Cruz, adjoining unincorporated areas of Santa Cruz County, a small part of the City of Capitola, and coastal agricultural areas north of the city. A map of the water system coverage area, excluding the north coast, is included Figure 16 (*below*).

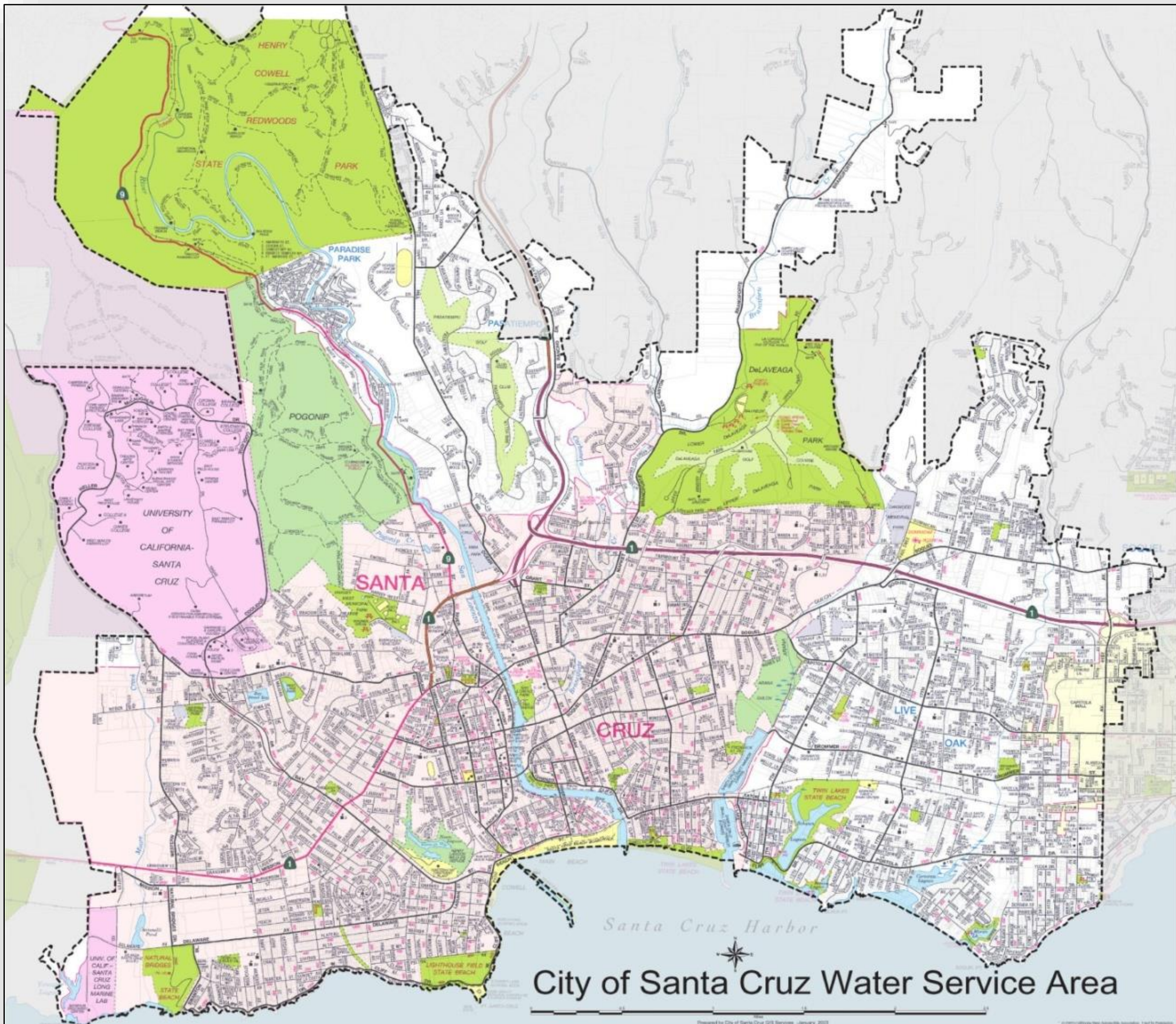


Figure 16 – Water Service Area

The geographic scale that is affected by major drought, however, is much larger that the City's water service area, covering parts of or all of the state of California and the western United States. At the height of the most recent drought, in late 2015, almost half the state was classified as being in a state of exceptional drought. The large geographic extent means many other water suppliers are facing the same problem at the same time, media coverage is extensive, and the state actively coordinates its response with local suppliers.

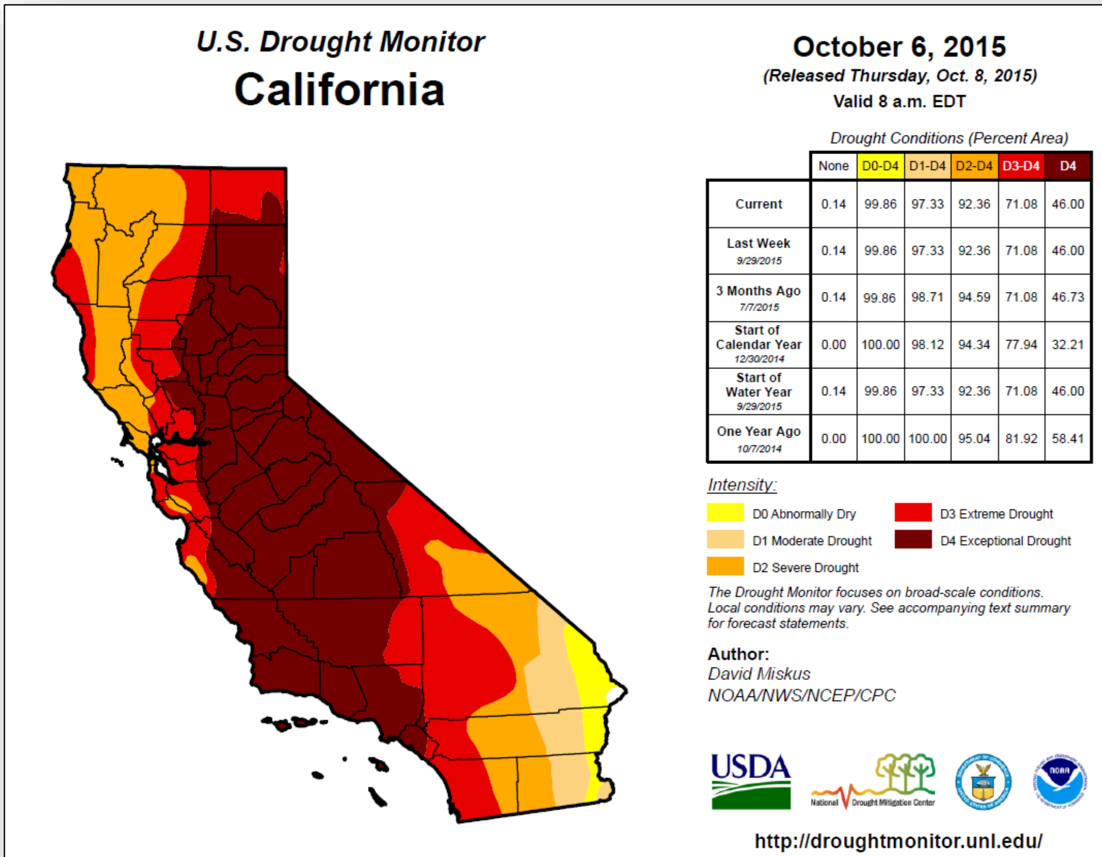


Figure 17 – US Drought Monitor, late 2015

B EXTENT: MAGNITUDE OR SEVERITY

As indicated in Figure 17 (*above*), 5 degrees of drought intensity area recognized nationally, including abnormally dry, moderate, severe, extreme, and exceptional.

The Water Department uses a local water year classification system to characterize the City's overall annual water supply condition. Under this classification system, the water year beginning October 1 is designated as one of four types — **Wet**, **Normal**, **Dry**, or **Critically Dry** — depending on the total annual discharge of the San Lorenzo River, measured at the stream gage in Felton, and expressed in acre-feet. As can be seen from the chart below, there have been at least six multi-year dry periods since 1921, including the most recent drought extending from 2012 to 2015 (Figure 18).

In normal and wet years when rainfall and runoff are abundant, base flows in the coast and river sources are restored by winter rains, and Loch Lomond Reservoir is typically replenished to full capacity with runoff from the Newell Creek watershed.

The water system, however, is highly vulnerable to shortage in drought years when the San Lorenzo River and coast stream sources run low. In single dry or below average years, the system relies more heavily on water stored in Loch Lomond to satisfy demand, which draws down the reservoir level lower than usual and depletes available storage.

In multi-year or critical drought conditions, the combination of very low surface flows in the coast and river sources and depleted storage in Loch Lomond reservoir reduces available supply to a level which cannot support average dry season demands. Compounding the situation is the need to maintain instream flow releases to fish habitat and reserve some amount of storage in Loch Lomond in the event drought conditions continue into the following year.

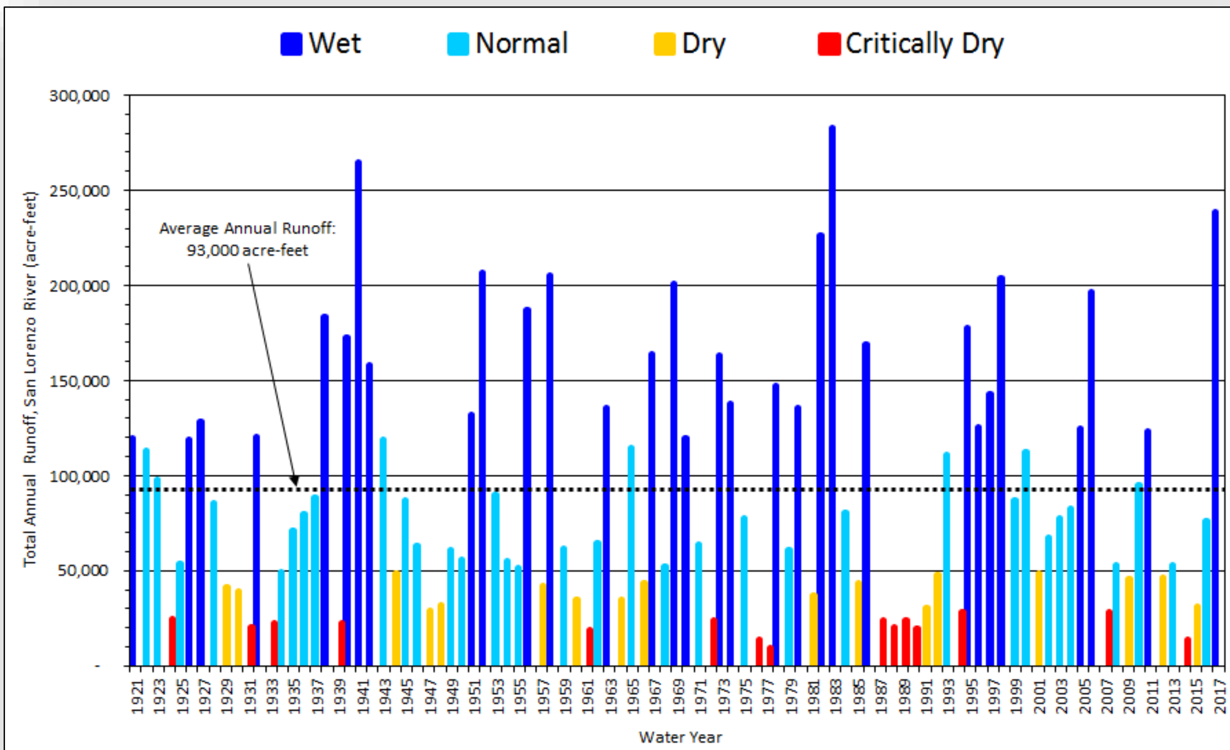


Figure 18 – Water Year Classification is based on Total Annual Runoff in the San Lorenzo River (acre feet)
Source: 2015 Urban Water Management Plan

Single Dry Year:

The total water supply estimated to be available to the City in single dry years like 2014 is 2,600 to 2,700 million gallons (mg) or about 15 to 20 percent less than is available in normal years. Table 7-1 (*below*) shows that there would be a fairly significant supply deficit in single dry years under projected demand conditions, which will actually decrease as demand declines over time.

Table 7-1 Single Dry Year Supply and Demand Assessment (million gallons/year)

	2020	2025	2030	2035
Supply Totals	2,619	2,658	2,692	2,692
Demand Totals	3,327	3,225	3,205	3,220
Difference	(708)	(567)	(513)	(528)

Source: 2015 Urban Water Management Plan

Multiple Dry Years:

In an extreme two-year drought similar to the 1976–77 event, the estimated water supply available to the City in the second year of that event is between 1,900 and 2,000 mg or about 40% less on an annual basis than is available in normal water years. Table 7-2 below shows that there would be a severe water supply shortage of about 1,200 to 1,400 mg under projected demand conditions in the second year of a multiple year drought, which will grow slightly less worse as demand declines over time.

The magnitude of the shortfall is greatest during the peak season between April and October, since these are the months of the year that would be most affected by a supply shortage. Under such conditions, the water system would be barely able to meet half of normal requirements of the water service area.

Table 7-2 Multiple Dry Year Supply and Demand Assessment (million gallons/year)

	2020	2025	2030	2035
Supply Totals	1,918	1,942	1,968	1,969
Demand Totals	3,327	3,225	3,205	3,220
Difference	(1,409)	(1,283)	(1,237)	(1,251)

Source: 2015 Urban Water Management Plan

C PREVIOUS OCCURRENCES

The City has responded to major, multi-year droughts on three separate occasions since the 1970s. These include the 1976–77, 1987–1992, and 2012–2015 droughts. In all three events, the City had to declare a water shortage emergency and institute mandatory water restrictions and rationing. In the most recent drought, the City declared a Stage 1 Water Shortage Alert in 2012 and 2013, and a Stage 3 Water Shortage Emergency in both 2014 and 2015.

D PROBABILITY OF FUTURE EVENTS

The City recently performed an analysis of its challenge to meet current and future demand during the Water Supply Advisory Committee (WSAC) process. The key conclusion of that analysis, assuming that future hydrology looks like the historic record and, assuming expected fish flow requirements, is that the City faces some likelihood of water shortage in approximately one out over every five years. In order to properly evaluate solutions, WSAC determined a 1.2-billion gallon projected worst-year gap between peak season available supply and demand during an extended drought.

To address the problem the City accepted the supply augmentation strategy and implementation plan developed by the WSAC and adopted by City Council under the 2015 Urban Water Management Plan. The implementation plan elements included in the current plan are:

- Expanded conservation programming
- Regional aquifer recharge by passive or active process
- Alternatives for recycled water use, and
- An updated option for desalination

Several milestones and decision points are built into the plan based on the target for supply sufficiency by 2025. Should the City be unable to overcome the supply-demand gap under the current plan, the community will be exposed to a much greater risk of shortages and be subject to higher rates of curtailment.

7.3.3 ASSESSING VULNERABILITY: OVERVIEW

> **3.3 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.

A OVERALL SUMMARY OF VULNERABILITY TO DROUGHT

The City water service area is a physically and geographically isolated, self-reliant system. The City does not now, nor does it plan to, purchase or import water either from outside the Central Coast Hydrologic Region or outside the county. The system relies entirely on rainfall, surface runoff, and groundwater infiltration occurring within the watersheds located within Santa Cruz County. Due to its isolation and reliance on surface water supplies, the City is highly vulnerable to shortage in drought years when the San Lorenzo River and coast sources run low.

As described further below, the City is actively working to reduce its water demand through water conservation and increase its supply to increase water supply reliability. The Water Shortage Contingency Plan would be invoked again if the City were to face another shortage before additional supplies are brought online.

7.3.4 ASSESSING VULNERABILITY: IDENTIFYING STRUCTURES

3.4 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 area.

A TYPES AND NUMBERS OF EXISTING BUILDINGS, FACILITIES AND INFRASTRUCTURE

Structures and facilities are not vulnerable to drought. Physical losses would probably be limited to public and private landscaping. However, the impacts to the landscaping which occur as the result of severe drought conditions also increase the risk of wildfire and subsequent damage to structures as a result.

7.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

A POTENTIAL DOLLAR LOSSES TO VULNERABLE STRUCTURES

While structures are not at risk, significant economic losses may occur as a result of severe rationing during a water shortage. One of the City's major industries is tourism. The vulnerability to drought (or more specifically water shortages as a result of drought) reaches its peak during the summer tourism season.

Restaurants, hotels, amusement parks and other tourist serving businesses would all be at risk of closing or severe restrictions during a critical drought. This is critical to funding ongoing City services because of the City's reliance on the Transient Occupancy Tax (TOT). Other industries such as agriculture, food processing, contractors, landscapers, nurseries, golf courses, public landscaping and school grounds would all experience economic costs and losses, and other water dependent businesses would suffer economic damages. These economic losses have not been calculated.

B METHODOLOGY USED TO PREPARE ESTIMATE

While potential economic losses have been considered they have not been calculated; therefore, there is no loss estimate.

7.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

3.6 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.

A DESCRIPTION OF LAND-USES AND DEVELOPMENT TRENDS

Santa Cruz is a compact urban City surrounded by mountains, greenbelt and the Pacific Ocean. The size of the water service area is fixed. It has remained constant over time due to a policy prohibiting water main extensions to unserved areas, and the acquisition of open space lands which creates a greenbelt around the City that serves to inhibit urban sprawl. Accordingly, any growth and redevelopment that does happen going forward is expected to be concentrated within the confines of the existing service area boundary.

Within the City of Santa Cruz, only a small amount of land remains undeveloped. The same is true in the parts of the County and City of Capitola served by the City. Because of the relative scarcity of raw land, the majority of future growth in the area is likely to be achieved through redevelopment, remodeling, increased density on underutilized land, and infill development in the urban core and along major transportation corridors, along with new construction on the little amount of vacant land remaining.

The City of Santa Cruz water system currently serves approximately 96,000 people and is anticipated to grow to 112,000 by 2035. This number includes estimated additional University growth. According to utility billing records, there are some 37,003 housing units within the City's water service area.

7.4.0 MITIGATION STRATEGY

4.0 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 2015 Urban Water Management Plan (UWMP) that includes the Water Supply Advisory Committee Final Report on Agreements and Recommendations and the Water Shortage Contingency Plan was adopted to overcome drought impacts.

Since the adoption of the UWMP, a Water Supply Augmentation Strategy was developed and is currently being implemented by following a Work Plan that includes the approved elements and adaptive management strategy from the WSAC process. The following elements are included in the Work Plan:

Water Conservation

In addition to the existing conservation programs the WSAC recommends looking at new programs, such as increased rebates and better management of peak season demand. The goal of these additional programs would be to further reduce demand by 200 to 250 million gallons per year by 2035, with a particular focus on producing savings during the peak water demand season.

Groundwater Recharge by "In Lieu" Water Transfers or Aquifer Storage and Recovery

Using in lieu water transfers, available winter flows would be delivered to Soquel Creek Water District and/or Scotts Valley Water District customers, thus allowing reduced pumping from these regional aquifers and enabling the aquifer to passively rest and recharge. Using Aquifer Storage and Recover (ASR), available winter flows would be injected into aquifers thereby actively recharging aquifers. A portion of the water delivered using In Lieu or ASR would be effectively banked in the aquifers to be extracted and available to the City when needed in future dry years.

Advanced-treated recycled water, with desalination as a back-up

In the event the groundwater storage strategies prove insufficient to meet the plan's goals, these two options would be developed as supplemental or replacement supply.

The overall goal of the Work Plan is to overcome the known worst-year supply gap of 1.2 billion gallons per year through a combination of enhanced conservation programs and increased water storage options. If needed, the Work Plan includes alternatives for supply augmentation either with recycled water or seawater desalination. The Work Plan was developed consistent with an objective for significant improvement to the sufficiency and reliability of the water supply in

2025 and several milestones and decision points are built into the change management framework to react as conditions, information, and technology changes occur.

Until such time that the City has increased the reliability through conservation and storage options, the mitigation measures outlined in the Water Shortage Contingency Plan would be implemented in the event of a future drought. The City's Water Shortage Contingency Plan describes the conditions which constitute a water shortage and provides guidelines, actions, and procedures for managing water supply and demands during a declared water shortage. The overarching goals of this plan are as follows:

1. To conserve the water supply of the City for the greatest public benefit;
2. To mitigate the effects of a water supply shortage on public health and safety, economic activity, and customer lifestyle, and
3. To budget water use so that a reliable and sustainable minimum supply will be available for the most essential purposes for the entire duration of the water shortage.

This plan uses a staged approach that classifies a shortage event into one of five levels spanning a range from less than 5 percent up to 50 percent. The overall concept is that water shortages of different magnitudes require different measures to overcome the deficiency.

As the City has few short term options for increasing the supply of water, the focus of this contingency plan is primarily on measures that reduce water demand. Each stage includes a set of demand reduction measures that become progressively more stringent as the shortage condition escalates (Table 7-3, *below*).

Table 7-3 Water Shortage Contingency Plan

Summary of Demand Reduction Actions and Measures		
Water Shortage Condition	**Key Water Department Communication and Operating Actions**	**Customer Demand Reduction Measures**
Stage 1: **Water Shortage Alert** **(0–5%)**	• Initiate public information and advertising campaign • Publicize suggestions and requirements to reduce water use • Adopt water shortage ordinance prohibiting nonessential uses • Step up enforcement of water waste • Coordinate conservation actions with other City Departments, green industry	• Voluntary water conservation requested of all customers • Adhere to water waste ordinance • Landscape irrigation restricted to early morning and evening • Non-essential water uses banned • Shutoff nozzles on all hoses used for any purpose • Encourage conversion to drip, low volume irrigation
Stage 2: **Water Shortage Warning** **(5–15%)**	• Intensify public information campaign • Send direct notices to all customers • Establish conservation hotline • Conduct workshops on large landscape requirements • Optimize existing water sources; intensify system leak detection and repair; suspend flushing • Increase water waste patrol • Convene and staff appeals board	• Continue all Stage 1 measures • Landscape irrigation restricted to designated watering days and times • Require large landscapes to adhere to water budgets • Prohibit exterior washing of structures • Require large users to audit premises and repair leaks • Encourage regular household meter reading and leak detection

Summary of Demand Reduction Actions and Measures		
Water Shortage Condition	**Key Water Department Communication and Operating Actions**	**Customer Demand Reduction Measures**
Stage 3: **Emergency Water Shortage** **(15–25%)**	• Expand, intensify public information campaign • Provide regular media briefings; publish weekly consumption reports • Modify utility billing system and bill format to accommodate residential rationing, add penalty rates • Convert outside-City customers to monthly billing • Hire additional temporary staff in customer service, conservation, and water distribution • Give advance notice of possible moratorium on new connections if shortage continues	• Institute water rationing for residential customers • Reduce water budgets for large landscapes • Require all commercial customers to prominently display "save water" signage and develop conservation plans • Maintain restrictions on exterior washing • Continue to promote regular household meter reading and leak detection
Stage 4: **Severe Water Shortage Emergency** **(25–35%)**	• Contract with advertising agency to carry out major publicity campaign • Continue to provide regular media briefings • Open centralized drought information center • Promote gray water use to save landscaping • Scale up appeals staff and frequency of hearings • Expand water waste enforcement to 24/7 • Develop strategy to mitigate revenue losses and plan for continuing/escalating shortage	• Reduce residential water allocations • Institute water rationing for commercial customers • Minimal water budgets for large landscape customers • Prohibit turf irrigation, installation in new development • Prohibition on on-site vehicle washing • Rescind hydrant and bulk water permits
Stage 5: **Critical Water Shortage Emergency** **(35–50%)**	• Continue all previous actions • Implement crisis communications plan and campaign • Activate emergency notification lists • Coordinate with CA Department of Public Health regarding water quality, public health issues and with law enforcement and other emergency response agencies to address enforcement challenges • Continue water waster enforcement 24/7	• Further reduce residential water allocations • Reduce commercial water allocations • Prohibit outdoor irrigation • No water for recreational purposes, close pools • Continue all measures initiated in prior stages as appropriate

7.4.1 MITIGATION GOALS

> **4.1 Local Hazard 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.

Drought Goals:

Drought 1 — Implement the City's Water Conservation Master Plan to reduce average daily water demand and maximize the community's efficient use of water resources.

Drought 2 — Periodically update the City's Water Shortage Contingency Plan to prepare for responding to future water shortages.

Drought 3 — Implement the Water Supply Augmentation Strategy Work Plan to overcome the known worst-year supply gap of 1.2 billion gallons per year by 2025 (+/- 2 years).

7.4.2 IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

> **4.2 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.

Drought Mitigation Actions:

- Additional water conservation to maximize the efficient use of existing water resources. (A-11)
- Strengthen local drought resilience through improved planning and updating of the City's Water Shortage Contingency Plan, and conducting annual drought risk assessments. (A-12)
- Diligently pursue projects for regional aquifer storage to include both passive and active recharge elements. (A-12)
- Evaluate advanced treated recycled water alternatives and update seawater desalination project evaluation. (A-12)

Water Conservation

Both the state water law and the City's General Plan call for a strong emphasis on water conservation and elimination of water waste to stretch existing sources, minimize the need for new water sources, and protect the environment.

The City is implementing a Water Conservation Master Plan to maximize the community's efficient use of water. The plan includes 35 measures to be implemented over a 20 year period between 2015 through 2035. The focus of the plan is on reducing peak season water use and reducing per capita water use to the maximum extent feasible.

The primary regulatory requirement for California water utilities regarding water conservation involves preparing and submitting a complete Urban Water Management Plan (CA Water Code Sections 10601–10656). Chapter 9 of the UWMP — Demand Management Measures — outlines the City's water conservation program and addresses all mandatory elements that include: water waste prevention, metering, conservation pricing, public education and outreach, and programs to assess and manage distribution system losses. In addition, water utilities are required to calculate baseline water use and meet urban per capita water use targets in 2015 and 2020 (CA Water Code Sections 10608–10608.64). Eligibility for state grants and loans is conditioned upon an agency meeting its 2015 interim target. Chapter 5 of the plan documents that the City of Santa Cruz far surpassed its 2015 target of 111 gallons per capita day (gcpd), (actual water use was 70 gcpd) and is therefore in compliance with the requirements.

Drought Resilience

Refer to the above summary of the City's Water Shortage Contingency Plan in Section 7.4.0.

Aquifer Storage and Supply Alternatives

At the conclusion of the Water Supply Advisory Committee process a Final Report on Agreements and Recommendations was accepted by the City Council. The recommendations include strategies to overcome the 1.2 billion gallon peak supply gap during the expected worst year drought conditions. These strategies include elements of aquifer storage and development of a new water supply source.

Aquifer storage options include projects for passive recharge — in lieu through water transfers with partners who would rest production wells and active recharge — aquifer storage and recovery that injects surface water into a groundwater basin that can be drawn when needed.

Alternative supply options include projects for advanced treated recycled water and seawater desalination. These projects will consider regional collaboration and partnership in addition to increasing City supply reliability.

B ACTIONS AND PROJECTS TO REDUCE THE EFFECTS OF HAZARDS ON NEW BUILDINGS

Drought does not present a direct hazard to buildings.

C ACTIONS AND PROJECTS TO REDUCE EFFECTS OF HAZARDS ON EXISTING BUILDINGS

Drought does not present a direct hazard to buildings.

Proper maintenance and weed abatement including removal of dead landscape vegetation adjacent to buildings will reduce the threat of structure fire during dry years.

7.4.3 IMPLEMENTATION OF MITIGATION ACTIONS

4.3 Implementation of Mitigation Actions — Requirement §201.6(c)(3)(iii):

The mitigation strategy section **shall** include an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction.

Prioritization **shall** include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their assorted costs.

A DISCUSSION OF PROCESS AND CRITERIA USED TO PRIORITIZE MITIGATION ACTIONS

The Water Conservation Master Plan involved analyzing water use, identifying and screening new conservation measures, and formulating programs to meet these objectives. The various measures were evaluated against the following criteria:

- Water savings potential
- Sustainable water savings
- Quantifiable water savings
- Widespread community and social acceptance
- Feasibility of implementation

The costs and benefits of different packages of programs were evaluated to aid in selecting the recommended plan.

The evaluation criteria used by the Water Supply Advisory Committee in developing its recommendations for pursuing supplemental water supply included the following:

- Technical feasibility
- Time required to demonstrate technical feasibility
- Time required to full scale production
- Adaptive flexibility
- Supply reliability
- Supply diversity
- Energy profile
- Regulatory feasibility
- Legal feasibility
- Administrative feasibility
- Potential for grants and loans
- Political feasibility
- Cost metrics

B IMPLEMENTATION AND ADMINISTRATION OF MITIGATION ACTIONS

Even though the City is already one of the top water-saving cities in the state, it is actively carrying out new programs as guided by the Water Conservation Master Plan. In 2016, the City implemented the following water conservation actions:

- Completed an exhaustive Water Loss Control Study to reduce leakage in the distribution system
- Doubled rebates for turf removal and high efficiency clothes washers
- Expanded the large landscape water budget program
- Updated the city water efficient landscape ordinance
- Implemented budget-based water rates for irrigation accounts

The City also participated in a statewide process to eliminate water waste, use water more wisely, and strengthen local drought resilience to advance progress under the California Water Action Plan and help "Make Conservation a Way of Life."

The Water Supply Augmentation Strategy is being actively implemented and steady progress continues on each element of the Work Plan. The Work Plan is designed to achieve the goal to eliminate future water shortages by the year 2025, give or take a few years. Embedded in the Work Plan are agreements that include:

- A specific goal for Yield: 1.2 BGY during modeled worst year conditions
- A timeframe for improving the reliability of supply: year 2025 (±2 years)
- Water Supply Augmentation Elements: conservation, aquifer recharge, new water supply
- An adaptive pathway to provide structure to the Work Plan progress and decision-making
- A change management strategy to guide adjustments and adaptation based on three key types of thresholds: Cost, Yield, and Timeliness

The elements of the Work Plan were selected based on two strategy options in order of preference:

Strategy 1:
Development of groundwater storage using a combination of both passive and active recharge approaches and available surface water flows during the rainy season; and

Strategy 2:
Development of advanced treated recycled water or desalinated water if and as needed to address any remaining supply-demand gap.

While the details of the elements and the proposed change management strategy can be referenced in the 2015 Urban Water Management Plan, an overview of the elements and implementation plan is described below.

Element 0:
Additional water conservation with a goal to generate an additional 200 to 250 million gallons of demand reduction by 2035 from expanded water conservation programs;

Element 1:

Passive recharge of regional aquifers by working to develop agreements for delivering surface water as an in lieu supply to the Soquel Creek Water District and/or the Scotts Valley Water Districts so they can rest their wells, help the aquifers recover, and effectively store water for use by SCWD in drought years;

Element 2:

Active recharge of regional aquifers by using existing infrastructure (wells, pipelines, and treatment capacity) and potential new infrastructure in the regionally shared Purisima aquifer in the Santa Cruz Mid-County Basin and/or in the Santa Margarita/Lompico/Butano aquifers in the Scotts Valley area to store water that can be available for use by Santa Cruz in drought years;

Element 3:

A potable water supply using advanced treated recycled water as its source, as a supplemental or replacement supply in the event the groundwater storage strategies described above prove insufficient to meet the Plan's goals of cost effectiveness, timeliness, or yield.

In the event advanced treated water does not meet the needs, desalination would then become Element 3.

The recommended Water Supply Augmentation Strategy and Work Plan include a preference for pursing a groundwater storage and retrieval strategy provided the yield goal can be achieved in a cost-effective and timely manner. Before making a choice to move away from groundwater storage, the City will diligently pursue all reasonable measures to make the groundwater strategies work.

C EMPHASIS ON THE USE OF COST–BENEFIT REVIEW

The City did not use a formal cost-benefit analysis. Costs were carefully considered when determining goals and objectives but there was not an emphasis on cost-benefit review to maximize benefits.

CLIMATE ADAPTATION CONSIDERATIONS

Santa Cruz does not import external water supplies. The amount of water available from local sources changes from year to year as a function of rainfall and runoff. The San Lorenzo River provides the largest portion of the City's water. Loch Lomond Reservoir serves as the City's primary storage reservoir.

Changing precipitation patterns that may occur as a result of climate change could significantly alter both the quantity and quality of water available to the City. More intense winter precipitation may result in lower summer base flows reducing the time window during which water can be diverted from streams. Elevated winter flows may also limit diversions due to high sediment loads. Climate change potentially impacts both pumping and precipitation patterns and the resulting ability to store water so it is available during high demand time periods.

CHAPTER 8: TSUNAMI

8.3.0 TSUNAMI RISK ASSESSMENT

8.3.1 IDENTIFYING TSUNAMI HAZARDS

3.1 Identifying 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

A *tsunami* is a series of waves generated by an impulsive disturbance in the ocean or in a small, connected body of water. Tsunamis are produced when movement occurs on faults in the ocean floor, usually during very large earthquakes. Sudden vertical movement of the ocean floor by fault movement displaces the overlying water column, creating a wave that travels outward from the earthquake source.

An earthquake anywhere in the Pacific can cause tsunamis around the entire Pacific basin. Since the Pacific Rim is highly seismically active, tsunamis are not uncommon. There has been minimal damage and loss of life due to tsunamis in Santa Cruz during recorded history.

Even though the potential for a significant tsunami may be low or possibly uncertain, the potential outcome of such a tsunami could be significant damage and loss of life.

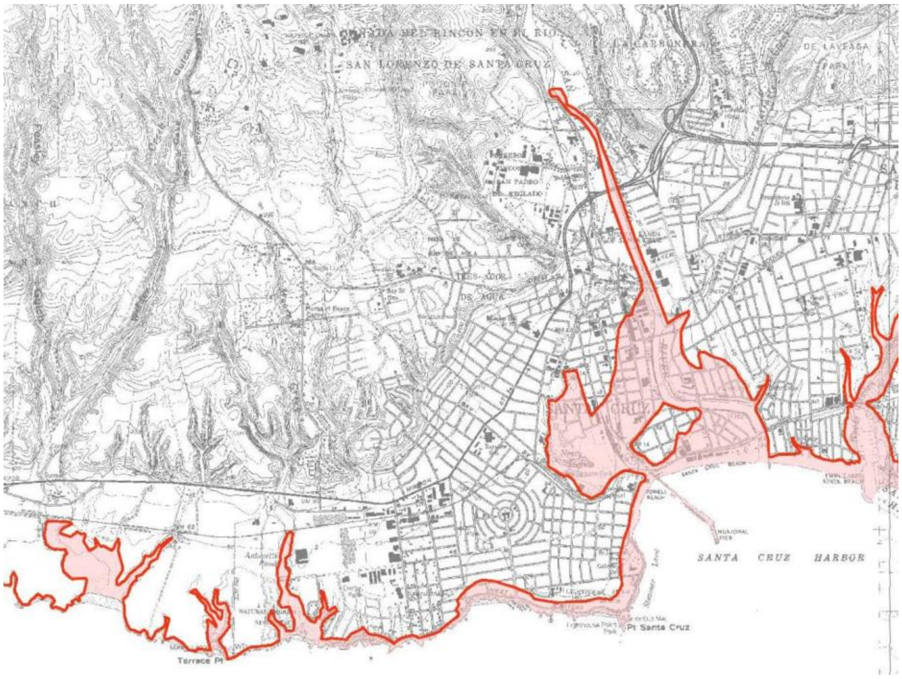
8.3.2 PROFILING TSUNAMI HAZARD EVENTS

3.2 Profiling 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

A LOCATION



- CA Office of Emergency Services
- California Geological Survey
- Univ. of Southern California

This tsunami inundation map was prepared to assist cities and counties in identifying their tsunami hazard. It is intended for local jurisdictional, coastal evacuation planning uses only. This map, and the information presented herein, is not a legal document and does not meet disclosure requirements for real estate transactions nor for any other regulatory purpose.

Tsunami Inundation Map for Emergency Planning
Detailed information available at: Tsunami Inundation Map (July 2009)

DISCLAIMER: The California Office of Emergency Services (CalOES), the University of Southern California (USC), and the California Geological Survey (CGS) make no representation or warranties regarding the accuracy of this inundation map nor the data from which the map was derived. Neither the State of California nor USC shall be liable under any circumstances for any direct, indirect, special, incidental or consequential damages with respect to any claim by any user or any third party on account of or arising from the use of this map.

Figure 19 – Tsunami Inundation Area — Worst Case Scenario (for planning purposes only)

The City of Santa Cruz is located on the Monterey Bay. Several active and potentially active earthquake faults are located within or near Santa Cruz. Even a moderate earthquake occurring in or near any of the nearby faults could result in local source tsunamis from submarine landsliding in Monterey Bay. Additionally, distinct source tsunamis from the Cascadia Subduction Zone to the north, or *teletsunamis* (distant-source) from elsewhere in the Pacific Ocean are also capable of causing significant destruction in Santa Cruz.

B EXTENT: MAGNITUDE OR SEVERITY

A local source tsunami generated by an earthquake on any of the faults affecting Santa Cruz could arrive just minutes after the initial shock. The lack of warning time from such a nearby event would result in higher causalities than if it were a distant tsunami where the Tsunami Warning System for the Pacific Ocean could warn threatened coastal areas in time for evacuation. Past experience has not resulted in extensive damage from tsunami, but proximity to faults does create the possibility as a result of future quakes.

C PREVIOUS OCCURRENCES

On April 1, 1946 a magnitude 7.8 earthquake in the Aleutians produced a 115-foot wave which destroyed the Scotch Cap lighthouse killing five Coast Guardsmen. It was 56 feet high in Hawaii killing 173 people. The wave was observed all along the west coast. In Santa Cruz, a man drowned and minor damage was done by 10-foot waves.[20]

It should be noted that scientific observations place the 1946 tsunami run up at 1.5 meters. It should also be noted that there are significant differences during a tsunami between maximum wave height and the maximum elevation reached by tsunami run-up, which is a function of the offshore *bathymetry* (depth measurements) and coastal topography.

In the aftermath of the 1989 Loma Prieta earthquake several docks in the Harbor became stuck to the piers and had to be lifted manually, or were broken, implying that the water level fell below the usual low tide level. Several boats were lying on the harbor floor implying a permanent change in the water level. A small tidal wave was observed rushing out of the harbor following the earthquake that continued for 15–20 minutes. The sudden water level adjustment was probably due to a vertical uplift of 4–8 inches over a ten second interval.

California is at risk from both local and distant source tsunamis. Eighty-two possible or confirmed tsunamis have been observed or recorded in California during historic times. Most of these events were small and only detected by tide gages. Eleven of these events were large enough to cause damage and four resulted in deaths. Two tsunami events caused major damage.[21]

March 2011 Tsunami

Based on the events of the March 11, 2011 Honshu, Japan earthquake and tsunami, the City, while minimally affected, had the opportunity to collaborate with the County Operational Area, and, in the aftermath, with the Santa Cruz Port District.

The City sent agency liaisons to the County Emergency Operations Center, including public safety officers and members of the city's EOC Policy group. There, they monitored State Operational Center conference calls and relayed information back to those activated in the city.

Within the City of Santa Cruz, key EOC positions were notified and activated including the EOC Manager, Director of Emergency Services, and the EOC Director. Other positions activated included Departmental Operations Center (DOC) staff from Public Works and the Parks and Recreation Departments, Police and Fire personnel. First responders closed roads, beaches and access to them, and closed off the City's Municipal Wharf.

During early recovery efforts, and due to the significant impact on the local harbor, the City of Santa Cruz and the Port District forged a mutual assistance Memorandum of Understanding.

The Santa Cruz Port District website (Santa Cruz Harbor) details the impacts and recovery from the March 11, 2011 tsunami. The Harbor is a separately governed district located within City limits. The City dispatched Public Works Associate Civil Engineers to help assess damage and plan for future rebuilding of the damaged harbor docks.

Tsunami Education and Outreach

The County, in the midst of preparing their "Tsunami Ready: Designation activities, had set up a series of community meetings on tsunami dangers and how to prepare for them. All county residents were invited to hear Steven Ward, Research Geophysicist (UCSC Institute of Geophysics and Planetary Physics) discuss "*The Local Threat of Tsunamis*" and to view the latest inundation area maps for their neighborhoods. The City's community room (located in the former EOC) was packed with a standing room only crowd of about 250 residents. The public meeting, while having long been scheduled, followed just a mere 10 days after the actual event.

The City of Santa Cruz EOC Manager participated in the initial community meeting and then another one a week later that was arranged for mono-lingual Spanish speaking residents in the Lower Ocean Street and Beach Flats neighborhoods.

CalOES and the California Geological Survey have partnered to develop the *Tsunami Response Playbook* (2014) for local agencies.

> To provide more detailed information for secondary evacuation zones, tsunami evacuation "playbooks" have been developed to plan for tsunami scenarios of various sizes and source locations. NOAA-issued Tsunami Alert Bulletins received in advance of a distant event will contain a forecasted tsunami amplitude, or wave height, and arrival time for a number of locations along the coastline. Elevation "playbook" evacuation lines can be useful for partial tsunami evacuations when information about forecasted tsunami amplitudes and arrival times is available to coastal communities and there is sufficient time to implement a partial evacuation. Provision for multiple elevation evacuation lines and response plans for those lines enables planning for different evacuation scenarios based on the forecast tsunami amplitude, potentially alleviating the need for an "all or nothing" decision with regard to evacuation.
>
> Scenario tsunami playbooks and guidance have been developed for maximum local and regional tsunamis, and for tsunamis generated by the Cascadia Subduction Zone that impact central and southern California. Scenario playbook information about the expected tsunami amplitude and travel time is available from the numerical modeling results for these sources. These are important scenarios for emergency managers to prepare for as there could only be ten to fifteen minutes to evacuate before a local tsunami arrives, or just a few hours to conduct response or evacuation activities before a regional tsunami arrives. To assist in the decision making process of what level of evacuation should occur, an analytical tool called the "FASTER" approach has been developed that takes the forecast amplitude of the tsunamis and integrates other factors influencing tsunami inundation, including storm, tides, modeling errors, and location specific tsunami run-up potential. Both the evacuation playbooks and FASTER approach will help communities better evaluate the amount of expected flooding, and implement evacuations and response activities for minor to moderate (less than maximum) tsunami events (i.e. events where the worst-case scenario evacuation may be excessive).

Source: California Geological Survey

Table 8-1 Locally Generated Tsunami Source

Source Zone	Major Offshore Faults	Major Submarine Canyons	Earthquake Magnitude (Year)	Historical Tsunami Run-up (Year)
San Francisco to Monterey	San Gregorio Fault(s)	Pioneer, Ascension, Monterey	M = 7.1 (1989)	0.3 meters (1989)

D PROBABILITY OF FUTURE EVENTS

Tsunami Hazard

Prior to the impacts from the March 11, 2011 Tohoku, Honshu Island tsunami, historically, this portion of the California coast has not been subject to significant tsunami hazards although more than twenty tsunamis of different heights have been observed or recorded in the past two centuries. Given the intense coastal land use and recreational activities along the coast, even a small hazard may pose high risk.[22] Appendix J lists tsunami heights recorded around Monterey Bay as a result of the three major earthquakes around the Pacific Ocean in the last 50 years. Maximum tsunami wave heights reached nine feet (2.7 meters) at Monterey harbor due to the 1964 Alaskan earthquake.

The US Army Corps of Engineers has looked at potential earthquake sources around the Pacific and modeled expected tsunami impacts on the coast of the Monterey Bay (US Army Corps of Engineers, 1975). Their study estimated that a tsunami wave with a probability of occurrence of one every 100 years would be about 5.9 feet high. A tsunami with a probability of occurrence of one every 500 years is expected to be 11.5 feet high.

More recently, studies have been undertaken by Richard K. Eisner, Jose C. Borrero and Costas E. Synolakis through the Governor's Office of Emergency Services and the Department of Civil Engineering at the University of Southern California, Los Angeles. In *Inundation Maps for the State of California* the authors clarify that the results are based on worst case scenario events and the maps they have produced are meant to be used for emergency preparedness and evacuation pre-planning.

Pre-1994 inundation computations underestimated inundation heights. Newer inundation models have now proven capable of modeling extreme events accurately. These new inundation models (known as MOST, for "Method of Splitting Tsunami"), permit quantitative evaluation of the inundation from *near-field* tsunamis (thirty minutes or less travel time), provided accurate regional tectonic models exist and accurate high resolution bathymetry. Even using state of the art inundation prediction tools, California presents unique challenges in assessing tsunami hazards.

Unique challenges in assessing tsunami hazards:

- There is an extremely short historic record of tsunamis in the state. In California there are no known records before the 19th century.
- Most of the geologic work in the state has concentrated on identifying the risks associated with onshore faults and there is scant information available on offshore faults or landslide and slump scars that are suggestive of past submarine mass failures.
- Earlier estimates of tsunami hazards relied almost entirely on far field sources and used pre-1980's technology, creating the impression among planners and the public that the tsunami hazard was small.
- Near-shore seismic events may trigger tsunamis arriving within less than 20 minutes, allowing little time for evacuation.[23]

The perception in California is that tsunamis are extreme events, and that there is very little we can do to mitigate the hazards. Costas Synolakis, director of the Tsunami Research Center at the University of Southern California states, "In reality, until recently we have not been able to model tsunamis adequately. It was a hazard that was ignored."

Synolakis and Borrero first proposed mapping California's tsunami zones in 1995. It's a complex undertaking that goes far beyond drawing a line on a map. In any given place, the height of the wave depends on the contours of the ocean bottom.

Ultimately, Synolakis said, California needs hazard maps that reflect the probability of flooding from tsunamis set off by specific earthquakes, not just general worst case scenarios.[24]

8.3.3 ASSESSING TSUNAMI VULNERABILITY: OVERVIEW

3.3 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.

A OVERALL SUMMARY OF VULNERABILITY TO TSUNAMI

There are two primary types of tsunami vulnerability in Santa Cruz. The first is a distant source tsunami from elsewhere in the Pacific Ocean. This type of tsunami is capable of causing significant destruction in Santa Cruz. However, this type of tsunami would usually allow time for the Tsunami Warning System for the Pacific Ocean to warn at risk and threatened coastal areas in time for evacuation.

The more vulnerable risk to the City of Santa Cruz is a tsunami generated as the result of an earthquake along one of the many earthquake faults in the region. Even a moderate earthquake occurring in or near the areas mentioned above could result in local source tsunamis from submarine landsliding in Monterey Bay.

A local source tsunami generated by an earthquake on any of the faults affecting Santa Cruz would arrive just minutes after the initial shock. The lack of warning time from such a nearby event would result in higher causalities than if it were a distant tsunami.

8.3.4 ASSESSING VULNERABILITY: IDENTIFYING STRUCTURES

3.4 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 area.

A TYPES AND NUMBERS OF EXISTING BUILDINGS, FACILITIES AND INFRASTRUCTURE

Much of the downtown and the beach areas including the core commercial centers are in the mapped tsunami inundation zone. Most of the city and county government buildings and the Lifeguard and Marine Safety Headquarters on the Municipal Wharf are located in the inundation threat zone. The tsunami inundation threat zone includes the following:

- 3,191 structures
- Central Fire Station
- Police Station
- City Hall campus
- Lifeguard and Marine Safety Headquarters
- County Government Center
- 29 schools and day care centers

8.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

A POTENTIAL DOLLAR LOSSES TO VULNERABLE STRUCTURES

Table 8-2 Tsunami potential loss inventory

Inventory Assets								
TSUNAMI								
	# of Parcels		**# of Structures**		**Critical Structures**		**Loss in Value$***	
Type	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**
Residential	14,916	1,189	17,363	1,589			$9,263,773,000	$986,835,911
Commercial	1,524	405	1,310	220			$2,309,879,000	$536,777,720
Industrial	307	2	299	25			$495,671,000	$25,859,985
Agricultural	5	2	51	6			$29,942,000	$3,718,454
Religion	56	8	99	11			$168,168,0000	$22,784,103
Government	217	116	30	0			$85,229,000	$160,640
Education	228	1	57	12			$128,938,000	$28,736,000
Total	**17,253**	**1,723**	**19,217**	**1,856**	**35**	**4**	**$12,541,502,000**	**$1,608,785,273**
	Community	**Hazard**						
# of People	**62,752**	**14,165**						
Date: Census American Community Survey 2015								
Total = total number of structures, residents, values within the entire community								
Hazard= number of structures, residents, values that are located within the defined hazard area								
*Government Parcels, Public Schools and most Utilities are not assessed.								
Parcel Data is from January 2017. Building Count/Total Replacement Value data is from 2014.								

B METHODOLOGY USED TO PREPARE ESTIMATE

Parcel Valuation:
Total Building Replacement Value (Building and Contents) and Building Count (Structure Count) from HAZUS-MH 3.2 Release 14.2.0. This data is from 2014.

Population:
Census population blocks were reduced to center points. If a hazard intersected a center point, that population was counted.

Flood Analysis:
Tsunamis create many risks similar to flood and the tsunami and flood risk areas are almost identical. Since FEMA flood data is mapped on the federal level, the data is extremely coarse in horizontal accuracy. The data was not meant to be measured against parcel level information and therefore is a rough estimate of damage and loss in a worst case scenario.

8.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

> **3.6 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.

A DESCRIPTION OF LAND-USES AND DEVELOPMENT TRENDS

As was described previously, the City of Santa Cruz is a compact urban community that is surrounded by natural barriers to outward expansion including the Santa Cruz Mountains, the Pacific Ocean and a designated greenbelt. In Santa Cruz, most development is now infill or reuse development.[25] The beach and downtown commercial areas are in the 100-year floodplain which is similar to the tsunami inundation area. Increasing residential density and mixed use development continue in the downtown core.

The City is required by Associated Monterey Bay Area Governments (AMBAG) to zone to allow for its share of housing. Some of the potential housing properties identified with the highest density zoning are located in the tsunami inundation area.

8.4.0 MITIGATION STRATEGY

> **4.0 Mitigation Strategy — Requirements §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.

Mitigation strategy includes continuation of an up to date Emergency Operations Plan, an effective public information program and continuing collaborative efforts with the County, other cities, agencies and community organizations to facilitate joint efforts in providing up-to-date tsunami mapping, preparation, information, warning dissemination and education.

Mapping of tsunami inundation areas in Santa Cruz including the map used in this plan have been improved. The map (Figure 19, *above*) should be viewed as an estimate of a worst case scenario for planning purposes only. More accurate mapping of potential tsunami outcomes based on simulations of specific geologic events has been identified as an important component in preparing updates to this Local Hazard Mitigation Plan.

8.4.1 MITIGATION GOALS

4.1 Local Hazard Mitigation Goals – Requirements §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.

Tsunami Goals:

Tsunami 1 — Avoid or reduce the potential for life loss, injury, property and economic damage to Santa Cruz from tsunami events.

Tsunami 2 — Continue to enhance emergency management systems including a defined public information process that includes an early warning system for evacuation prior to a tsunami event.

8.4.2 IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

4.2 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.

"Tsunami Ready" Designation
The City of Santa Cruz has embarked on a plan to obtain Tsunami Ready status. GIS staff, engineers and operations personnel have mapped locations for tsunami signage. This effort has been held back somewhat due to staffing and budget constraints. However, the County has completed their effort, and the city is "surrounded" by tsunami-related signage. In the next LHMP update cycle the city hopes to complete Tsunami Ready efforts — by December 2018.

Tsunami Mitigation Actions:

- Coordination with other agencies including Santa Cruz County (A-2)
- Management of the early warning system. (B-4)
- Tsunami and Floodplain development regulations (B-5)
- Encouraging participation in Federal Flood Insurance Program (B-6)

CHAPTER 9: COASTAL EROSION

9.3.0 COASTAL EROSION RISK ASSESSMENT

9.3.1 IDENTIFYING COASTAL EROSION HAZARDS

3.1 Identifying 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

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 is considered a function of larger processes of shoreline change, which include *erosion* and *accretion*. Erosion results when more sediment is lost along a particular shoreline than is re-deposited by the water body. Accretion results when more sediment is deposited along a particular shoreline than is lost. When these two processes are balanced, the shoreline is said to be stable.

Erosion is 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.)[26]

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 man-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 a slowly rising sea level. 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 so many factors involved in coastal erosion, including human activity, sea-level rise, seasonal fluctuations and climate change, that sand movement will not be consistent year after year in the same location.

Wind, waves, and the long-shore currents are 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 land-side dunes, deep ocean trenches, other beaches and deep ocean bottoms.

CLIMATE ADAPTATION CONSIDERATIONS

As noted in the City of Santa Cruz Climate Adaption Plan (*see* Appendix P), the impacts of coastal erosion have, in the past, been significant. Any increase in coastal storm frequency or severity will increase coastal cliff retreat rates. This will in turn endanger coastal properties and infrastructure. The 2011 Climate Adaptation Vulnerability Study, in the previous LHMP Update, outlined the history of coastal erosion and noted the potential impacts that climate change may have on our local beach frontage and cliffs. These impacts range from issues at the Santa Cruz Harbor, beach and cliff frontage at the mouth of the San Lorenzo River, coastal bicycle paths and areas around the historic Lighthouse.

In 2017, a revised Vulnerability Assessment was conducted, identifying the impacts from erosion influenced by sea level rise. Erosion hazard zones were projected and mapped for years 2030, 2060 and 2100, quantified in terms of number of damaged or lost facilities and assets and their value, and potential effects on socially vulnerable populations.

9.3.2 PROFILING COASTAL EROSION HAZARD EVENTS

3.2 Profiling 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.

The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

A LOCATION

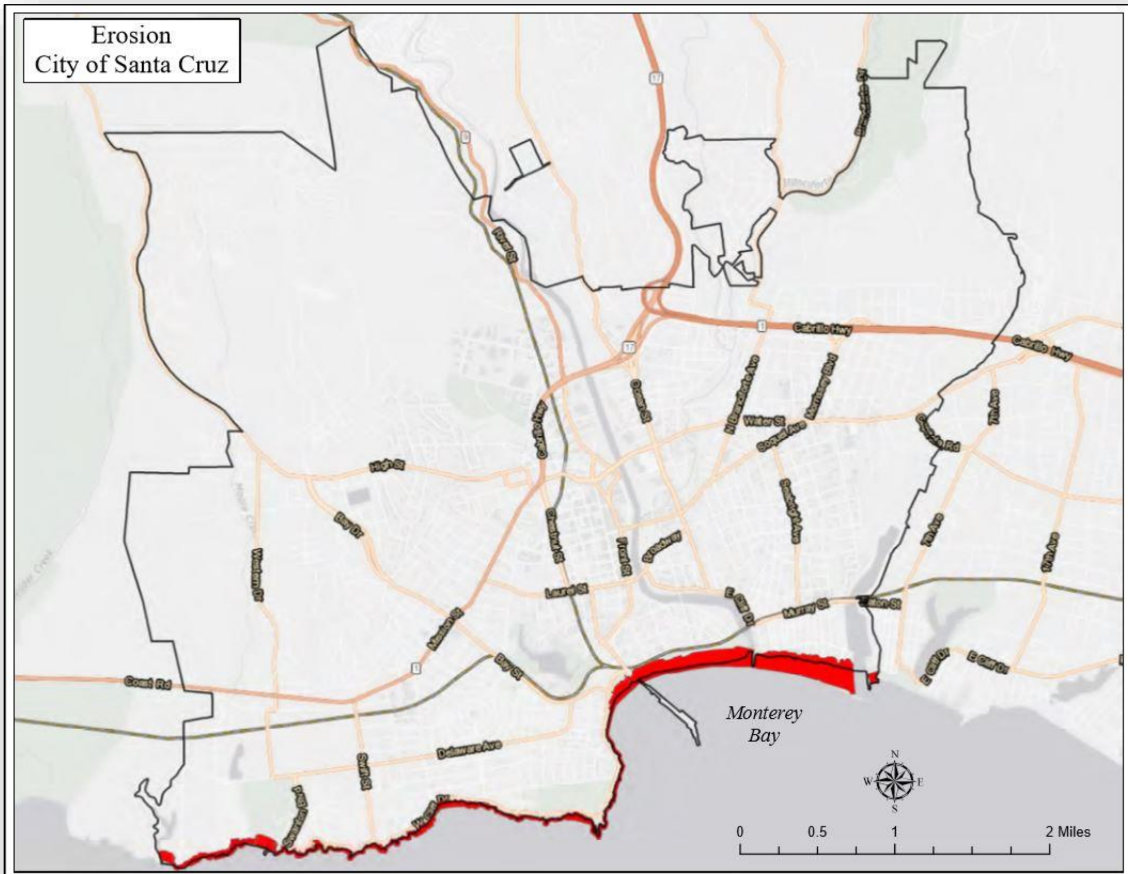


Figure 20 – Areas Susceptible to Coastal Erosion

The City of Santa Cruz is bounded on one side by the Pacific Ocean. The entire coastal edge of the City is affected by coastal erosion. West Cliff Drive from Cowell Beach to Natural Bridges State Park is at the highest risk of, and continues to be shaped and impacted by, coastal erosion.

B EXTENT: MAGNITUDE OR SEVERITY

Most of the significant cliff, bluff or dune erosion occurs during the winter months at times of very high tides and large storm waves. All of the cliffs along the ocean in the City of Santa Cruz and some along the San Lorenzo River experience some degree of coastal erosion. Some portions of the roadway and bicycle path along West Cliff Drive are at risk of being lost. The Lighthouse Museum and its supporting structures on West Cliff Drive are also at risk due to coastal erosion.

C PREVIOUS OCCURRENCES

Approximately 85 percent of the California coast is actively eroding due to complex oceanographic and geologic conditions and human activities that affect the delivery and movement of sand along the coast.[27] Within the City of Santa Cruz, the most threatened area is West Cliff Drive where beaches are narrow or non-existent so that waves attack the bluffs and cliff directly during winter high tides.[28]

During the severe El Niño winters of 1983 and 1997–98, sea levels were further elevated and storm damage along the West Cliff Drive 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.

Rising sea levels and winter wave attack have led to the retreat of the Santa Cruz coastline; this process will continue into the future. Over the past several decades it has been discovered that 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.

D PROBABILITY OF FUTURE EVENTS

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 3 feet higher by 2100*. Given these estimates, the probability of future coastal erosion is very high.

**see,* City of Santa Cruz Climate Adaptation Plan, Chapter 3 (LHMP Appendix P)
Source, California Ocean Protection Council

9.3.3 ASSESSING COASTAL EROSION VULNERABILITY: OVERVIEW

> **3.3 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.

A OVERALL SUMMARY OF VULNERABILITY TO COASTAL EROSION

Much of the West Cliff Drive coastline has been progressively armored with rip rap over the past 40 years. In 1990 the California Department of Boating and Waterways granted the City approximately four million dollars for coastal armoring. During the 1980s and 1990s the Highway Administration gave the City approximately five million dollars to repair coastal erosion as a part of declared disasters within the City.

The impact of wave attack has been slowed in some areas, although large winter waves can still overtop cliffs and threaten pathways and parking areas. The Woodrow Drive area (along West Cliff) is a good example of wave overtopping because it is at a lower elevation. Lighthouse Point is another site where some protection exists but continued wave attack has created several large caves that extend under the pathway and are getting closer to the lighthouse. Ongoing coastal erosion is a significant problem along West Cliff Drive and this will continue as sea levels continue to rise.

9.3.4 ASSESSING VULNERABILITY: IDENTIFYING STRUCTURES

> **3.4 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 area.

A TYPES AND NUMBERS OF EXISTING BUILDINGS, FACILITIES AND INFRASTRUCTURE

Although there are only a few houses, two hotels and one City museum along the ocean cliff frontage, the City is attempting to preserve a significant amount of infrastructure including roadways, bike paths, parks and storm drains which are continually threatened by coastal erosion. Additionally, the Santa Cruz Harbor, beach frontage, and cliff frontage near the mouth of the San Lorenzo River are also threatened by varying degrees of erosion.

9.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

> **3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

A POTENTIAL DOLLAR LOSSES TO VULNERABLE STRUCTURES

Table 9-1 Coastal Erosion Potential Loss Inventory

COASTAL EROSION								
	# of Parcels		# of Structures		Critical Structures		Loss in Value$*	
Type	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**	**Total**	**Hazard**
Residential	14,916		17,363	50			$9,263,773,000	$32,928,480
Commercial	1,524		1,310	7			$2,309,879,000	$11,735,655
Industrial	307		299	1			$495,671,000	$1,112,865
Agricultural	5		51	1			$29,942,000	$227,780
Religion	56		99	0			$168,168,000	$0
Government	217		30	0			$85,229,000	$0
Education	228		65	0			$188,840,000	$0
Total	**17,253**	**72**	**19,217**	**59**	**35**	**0**	**$12,541,502,000**	**$46,004,779**
# of People	**59,946**	**2,563**						
Date: Census American Community Survey 2015								
Total = total number of structures, residents, values within the entire community								
Hazard= number of structures, residents, values that are located within the defined hazard area								
*Critical Structures include the Municipal Wharf and Harbor								
Parcel Data is from January 2017. Building Count/Total Replacement Value data is from 2014.								

B METHODOLOGY USED TO PREPARE ESTIMATE

Parcel Valuation:
Total Building Replacement Value (Building and Contents) and Building Count (Structure Count) from HAZUS-MH 3.2 Release 14.2.0. This data is from 2014.

Not included in the valuation:
Potential dollar losses including replacement of roads, paths and lighthouse including property acquisition.

9.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

> **3.6 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.

A DESCRIPTION OF LAND-USES AND DEVELOPMENT TRENDS

Every coastal community in California is dealing with the issues of sea level rise and shoreline retreat. The armoring of the shoreline is becoming an increasingly controversial and contentious issue. 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 promulgate the process of coastal erosion through poor land use methods. Thus, issues of beach restoration and erosion control are at the forefront in coastal communities.

Santa Cruz' shoreline is now part of the Monterey Bay Marine Sanctuary which will also influence development trends along the Santa Cruz coast. Protecting the natural resources of the area as well as preserving the infrastructure that is already in place, such as the lighthouse and bike path, are the primary land use objectives.

9.4.0 MITIGATION STRATEGY

4.0 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.

9.4.1 MITIGATION GOALS

4.1 Local Hazard 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 from coastal erosion.

Coastal Erosion 2 — Protect and preserve natural resources.

Coastal Erosion 3 — Protect and preserve current infrastructure.

9.4.2 IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

4.2 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 Actions

- Protect and preserve coastline through permit review. (B-2)
- Protect and preserve coastline and infrastructure through restoration efforts. (B-3)

Minimizing Hazards from Coastal Erosion

Much of the West Cliff coastline has boulder riprap and some concrete retaining structures to protect the cliff. Other options include seawalls and jetties to minimize the energetic wave impacts that drive cliff erosion. Because these structures have finite life spans and may have adverse effects on other parts of the coast, engineering solutions can be very expensive in both the short- and long-term. In other cases, the solution is to leave the coastline relatively undeveloped and to allow erosion to occur naturally. This option allows for greater public access to the coastline. It also preserves the normal input of sand into the 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 reduction, 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 Reduction — A Commonsense Approach

The most logical method for preventing potential damage to new development in the coastal zone is to not build where coastal erosion will impact such development. This concept, known as *hazard reduction*, could circumvent many subsequent permitting and legal challenges. Hazard reduction 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. Santa Cruz already has a developed coastline including significant City owned infrastructure along the cliffs including roadways, bike paths, parks and park facilities.

Relocation — Moving Development Out of Harm's Way

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.

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 the erosion-prone area 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 feasible.

Coastal Protection

In situations where hazard reduction and relocation are not viable options, coastal protection strategies can be used to reduce the potential for beach loss and coastal erosion. 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 seawalls, revetments or bulkheads. "Soft" protection primarily involves dune or beach restoration or enhancement to reduce the chances of storm waves reaching the backshore. A hard protection device differs from most soft erosion response alternatives in that it does not add sand to the system of sediment.

CLIMATE ADAPTATION CONSIDERATIONS

As noted earlier in this chapter, Santa Cruz has experienced significant erosion in the past. An increase in coastal storm frequency and/or magnitude would increase cliff retreat rates and resulting damage to oceanfront property and City infrastructure.

The City has a developed coastline including significant City owned infrastructure along the cliffs, specifically, roadways, bicycle paths, parks and park facilities. In addition to City infrastructure there are a few houses, two hotels and one City museum along the ocean cliff frontage. The Santa Cruz Harbor, beach frontage, and cliff frontage near the mouth of the San Lorenzo River are also threatened by varying degrees of erosion which may occur more rapidly in the future as a result of climate change impacts.

Protecting the natural resources of the area as well as preserving the infrastructure that is already in place, such as the lighthouse and bicycle path, are primary land use objectives. There has been discussion of relocating the lighthouse if the coastal caves show evidence of collapsing. Additionally, the bicycle path may be relocated in the future for the same reason.

CHAPTER 10: DAM FAILURE	LESSER RISK

10.3.0 DAM FAILURE RISK ASSESSMENT

10.3.1 IDENTIFYING DAM FAILURE HAZARDS

> **3.1 Identifying 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.
>
> The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

Dam failure can occur as a result of earthquakes, *seiches* (surface water movement), structural instability, or intense rain in excess of design capacity. Timber, rock, concrete, earth, steel or a combination of these materials may be used to build the dam. Dams must have spillway systems to safely convey normal stream and flood flows over, around, or through the dam. Spillways are commonly constructed of non-erosive materials such as concrete. Dams also have a drain or other water withdrawal facility to control the reservoir level and to lower or drain the reservoir for normal maintenance and emergency purposes.

10.3.2 PROFILING DAM FAILURE HAZARD EVENTS

> **3.2 Profiling 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.
>
> The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

A LOCATION

The City of Santa Cruz owns and operates one dam. Newell Creek Dam is located near the town of Ben Lomond in the Santa Cruz Mountains and impounds Newell Creek to form Loch Lomond Reservoir. The reservoir was constructed in the early 1960s and has a maximum capacity of approximately 2.9 billion gallons.

Loch Lomond Reservoir is the City's primary raw water storage facility. Dams are under the jurisdiction of the California Department of Water Resources, Division of Safety of Dams (DSOD). The Water Department maintains maps and information on water system facilities including Loch Lomond. For security reasons, information regarding these documents is intentionally general in nature, omitting confidential details and effected assets.

B EXTENT: MAGNITUDE OR SEVERITY

A major dam failure at Newell Creek Dam could result in extensive property damage and loss of life.

C PREVIOUS OCCURRENCES

There have been no reported potential emergencies or dam failures at Newell Creek Dam.

D PROBABILITY OF FUTURE EVENTS

Accumulated data, ongoing analyses, and monitoring of critical dam infrastructure (e.g., spillway) give no indication that the dam would fail or otherwise sustain damage under normal circumstances including historic flood events, potential earthquakes, and other hazards. This does not include man-made disasters or a catastrophic event.

10.3.3 ASSESSING DAM FAILURE VULNERABILITY: OVERVIEW

3.3 Assessing Vulnerability: Overview — Requirements §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.

A OVERALL SUMMARY OF VULNERABILITY TO DAM FAILURE

The losses to life and property associated with complete dam failure would be high. Given the monitoring protocol, level of security, and infrastructure design capacities; the probability of dam failure is very low.

10.3.4 ASSESSING VULNERABILITY: IDENTIFYING STRUCTURES

In 2007, the California Department of Water Resources, Division of Safety of Dams conducted a seismic stability analysis of Newell Creek Dam. Analysis parameters included an M7.0 event on the Zayante Fault and an M8.0 event on the San Andreas Fault. In 2009, the City received confirmation that the analysis concluded that "the dam is safe for continued use" under these parameters. In 2016, DSOD confirmed this analysis was still valid.

> **3.4 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 area.

A TYPES AND NUMBERS OF EXISTING BUILDINGS, FACILITIES AND INFRASTRUCTURE

A dam failure would result in significant downstream flooding to buildings, infrastructure and critical facilities located along Newell Creek and the San Lorenzo River. The downstream hazard area includes Ben Lomond, Glen Arbor, Felton, Beulah Park, Paradise Park, and downtown Santa Cruz. Critical facilities located in the flood path include the City Corporation Yard, Coast Pump station, City Hall, Fire Station #1, Fire Administration Building, Civic Auditorium, Post Office, Police Department and Louden Nelson Community Center.

The Water Department is currently in the process of updating its dam failure inundation maps using modern methodologies and data to:

1. Reflect new development in the downstream flood zone
2. Assist with determination of evacuation zones, and
3. Identify all buildings, facilities and infrastructure located within the inundation limits

10.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

> **3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

A DOLLAR LOSSES TO VULNERABLE STRUCTURES

This information is not available at this time.

B METHODOLOGY USED TO PREPARE ESTIMATE

This information is not available at this time.

10.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

> **3.6 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.

A DESCRIPTION OF LAND-USES AND DEVELOPMENT TRENDS

As was stated earlier, the City of Santa Cruz is a compact urban community that is surrounded by natural barriers to outward expansion including the Santa Cruz Mountains, the Pacific Ocean and a designated greenbelt.

Ongoing population growth in the area has been mirrored by an increase in urbanization for the Monterey Bay area. Development patterns in the coastal zone since the 1970s confirm these overall urbanizing trends. New development has occurred within or adjacent to the urban services line (i.e., the boundary point for such infrastructure as gas, water, and sewage hook-ups). In Santa Cruz, most development is now infill or reuse development.[29]

Increasing population densities expands the potential population and property at risk from a dam failure.

10.4.0 MITIGATION STRATEGY

> **4.0 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 primary mitigation strategy is the continuation of monitoring protocols for structural integrity. These include the monitoring of the Newell Creek Dam as follows:

- Water pressures within the dam and seepage are monitored monthly and after established rainfall and earthquake triggers.
- Critical dam infrastructure (embankment, spillway, outlet pipeline, etc.), is normally monitored monthly with daily monitoring while the spillway is flowing.
- Horizontal and vertical movement is monitored annually at Newell Creek Dam.
- Periodic seismic reviews are conducted to ensure stability with respect to current seismic standards.

Additional mitigation strategies include updating of the Newell Creek Dam Emergency Action Plan (EAP), periodic updates to inundation mapping as new technology and downstream development occurs, and additions to the City's raw water sources.

10.4.1 MITIGATION GOALS

4.1 Local Hazard 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.

Dam Failure Goals:

Dam Failure 1 — Avoid or reduce the potential for life loss, injury, property or economic damage to Santa Cruz from dam failure.

Dam Failure 2 — Encourage mitigation activities that increase disaster resilience of the water system essential to a functioning City of Santa Cruz.

10.4.2 IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

4.2 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.

Dam Failure Mitigation Actions:

- The primary actions to mitigate the risk of dam failure are a careful monitoring program and the creation of redundancy in the water service infrastructure. (B-11).

CHAPTER 11: LANDSLIDE

11.3.0 LANDSLIDE RISK ASSESSMENT

11.3.1 IDENTIFYING LANDSLIDE HAZARDS

3.1 Identifying 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. The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

Landslides are defined as the rapid downward movement of rock, earth or artificial fill on a slope. Factors causing landslides include the rock strength and orientation of elements on the slope, erosion, weathering, high rainfall, steepness of slopes, and human activities such as the removal of vegetation and inappropriate grading.

Landslide deposits and soil creep occur primarily on slopes in the western side of the city near Moore Creek Canyon. Deposits are also found in the upper portions of Arana Gulch and DeLaveaga Park and other isolated locations in the city.

Landslides are prevalent upstream of the city's drinking water intakes and affect production of potable water in many ways. Generally speaking, the impacts on drinking water production are the following:

- Elevated, persistent turbidity which requires increased treatment or source changes due the potential presence of pathogens in highly turbid water and total suspended solids (i.e., sand).
- Collateral damage on infrastructure and increased maintenance costs as pumps suffer sanding problems, basins fill with sand, pipelines burst from sediment deposition and flow changes, etc.

The raw water delivery system is also vulnerable to the risk of landslide. Loch Lomond Reservoir and a significant amount of the raw water system infrastructure are located in the Santa Cruz Mountains, some in areas that have experienced landslides. Because of this placement, the greatest threat to the City of Santa Cruz from landslides is in the Santa Cruz Mountains.[30]

Landslides occur in all U.S. states and territories. In a landslide, masses of rock, earth or debris move down a slope. Landslides may be small or large, slow or rapid. They are activated by:

- Storms
- Earthquakes

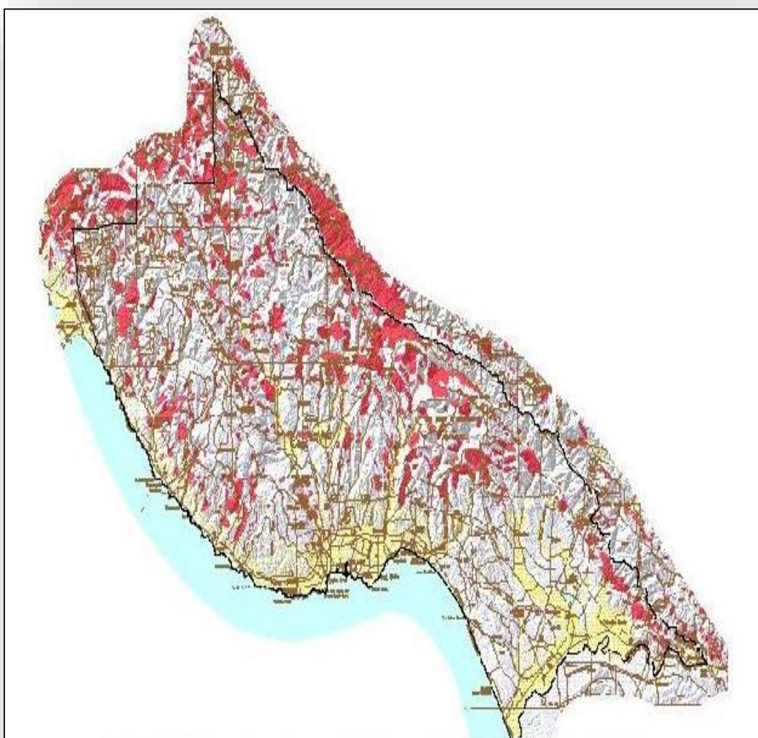
- Volcanic eruptions
- Fires
- Alternate freezing and thawing
- Alternate wetting and drying
- Increase in slope steepness by erosion or human modification

Debris and mud flows are rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or "slurry." They can flow rapidly, striking with little or no warning at very high speeds. They also can travel several miles from their source, growing in size as they pick up trees, boulders, cars and other materials.

Landslide problems can also be caused by land mismanagement, particularly in mountain, canyons, and coastal regions. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Land-use zoning, professional inspections and proper design can minimize many landslide, mudflow, and debris flow problems.[31]

11.3.2 PROFILING LANDSLIDE HAZARD EVENTS

A LOCATION



Map Units

Mostly Landslide — Consists of mapped landslides, intervening areas typically narrower than 1,500 feet, and narrow borders around landslides; defined by drawing envelopes around groups of mapped landslides.

Many Landslides — Consists of mapped landslides and more extensive intervening areas than in 'Mostly Landslide'; defined by excluding areas free of mapped landslides; outer boundaries are quadrangle and County limits to the areas in which this unit was defined.

Few Landslides — Contains few, if any, large mapped landslides, but locally contains scattered small landslides and questionably identified larger landslides; defined in most of the region by excluding groups of mapped landslides but defined directly in areas containing the 'Many Landslides' unit by drawing envelopes around areas free of mapped landslides.

Flat Land — Areas of gentle slope at low elevation that have little or no potential for the formation of slumps, translational slides, or earth flows except along stream banks and terrace margins; defined by the distribution of surficial deposits

(*Wentworth, 1997*)

Figure 21 — Slides and earth flows in Santa Cruz County

Summary Distribution of Slides and Earth Flows in Santa Cruz County
by Carl M. Wentworth, Scott E. Graham, Richard J. Pike, Gregg S. Beukelman, David W. Ramsey, and Andrew D. Barron

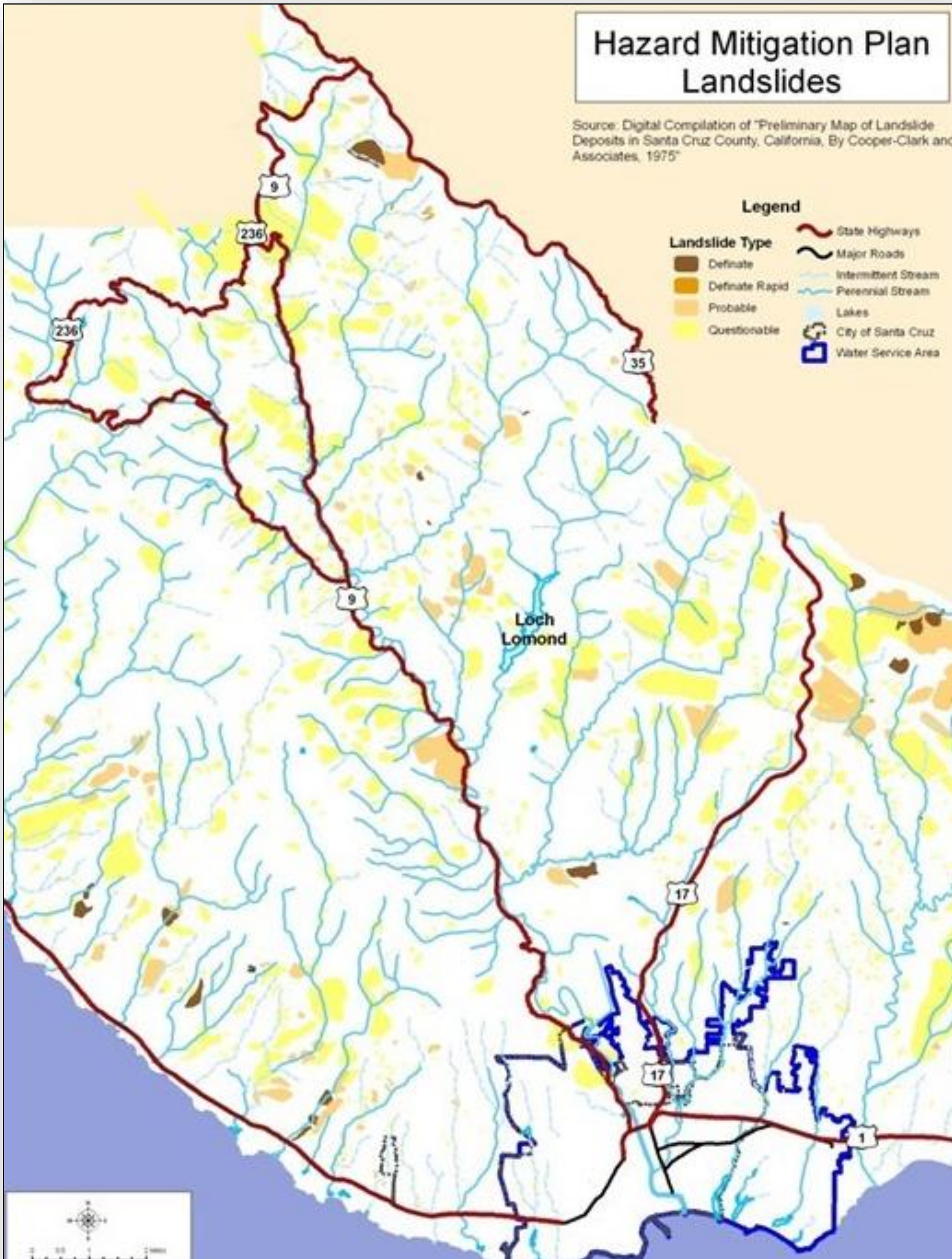


Figure 22 — Potential slide threats to Santa Cruz

B EXTENT: MAGNITUDE OR SEVERITY

Landslides are a common occurrence in the Santa Cruz Mountains. Our intense winter storms, high rainfall amounts and steep terrain are all conducive to land sliding. Earthquake activity can add to the problem. The earthquake of 1906 set off dozens of large landslides in the Santa Cruz Mountains, some of which claimed human lives. The potential for loss of life and property is greater today due to the increase in population residing in areas of possible instability. However, new building and site design standards also reduce the risk for loss of life and property.

Although nature-caused landslides are beyond control, most recent landslides in the Santa Cruz Mountains have been caused by a combination of human activity and natural factors. Human activities which act to further destabilize slopes are logging, woodland conversion, road building, housing construction and any activity which alters normal drainage patterns. Whether or not any of these activities will trigger land sliding depends on the existing natural conditions. Some soil and rock types are more prone to land sliding than others. Landowners should determine the inherent geologic stability of their property before beginning construction activities.[32]

C PREVIOUS OCCURRENCES

The City of Santa Cruz Water Department has property, access rights of way, and infrastructure located in areas susceptible to land sliding.

The rainfall in winter 2017 was the cause of the most recent series of landslides and slope failures that resulted in leaks on several raw water transmission mains, culvert failures, and road failures.

Historical Record of Severe Landslides of Santa Cruz

January 1982
Severe storms caused multiple landslides affecting water pipelines and access roads. One landslide along Love Creek, west of Loch Lomond Reservoir, killed ten people. While this landslide was not on City-owned property and did not affect City-owned facilities, it was and continues to be an indicator of the potential severity of landslide activity and the need for observation and/or mitigation.

The City did experience less significant landsliding along the alignment of the Newell Creek pipeline north and south of Brackney Road, in Ben Lomond. To the south, a slide created a 5-foot high scarp which encroached to within a few feet of the pipeline. Two other landslides along this alignment occurred north of Brackney Road creating 2–5-foot scarps that extended from the outside edge of the access road towards the river.

Also associated with these storms were:

- Two landslides along the Laguna Creek pipeline alignment downstream of the trestle bridge crossing Laguna Creek; an 8-foot high scarp exposed and undercut the pipeline and,

- Smaller landslides also affected portions of the entrance and access roads to Loch Lomond Reservoir and nine separate slides occurred around the reservoir rim.

Loch Lomond East Bank Landslide

There are two landslides located along the east bank of the City's only raw water storage reservoir, Loch Lomond Reservoir. These landslides are referred to as the "ancient and recently active" landslides. The recently active landslide is contiguous with, and lies directly above the ancient landslide.

While it is postulated that movement in the recently active landslide was initiated in 1971 or earlier, movement of the recently active landslide was actually observed in 1980 and again in 1982. Formal study of the landslides began in 1980 with the installation of piezometers to quantify the recently active landslide, installation of tiltmeters in 1990 to observe movement in the recently active landslide, and the installation of inclinometers in 1992 to further the study of movement in both landslides.

Monitoring data collected in the spring of 2006 indicated that the recently active landslide appeared to have reactivated movement in the ancient landslide; however, movement in the ancient landslide has not been noted since that one single event in the spring of 2006.

The City continues to monitor the slide in accordance with various triggers including quarterly, after heavy rainfall events and following significant earthquakes.

The El Niño Winter Storms of 1998

The El Niño storms of 1998 caused multiple landslides affecting water pipelines and access roads. The area with the most damage occurred on the Laguna Creek Pipeline access road. The repair of the road required three retaining walls, grading and drainage at a cost of $525,000.

East Zayante Road

The City owns two parcels along East Zayante Road. Both parcels are subject to landsliding and/or debris flow due to various County and logging road cuts. In 2000, there was a debris flow from one of the locations onto the County Road. The City conducted a geotechnical paper study to provide initial recommendations on maintaining stable slopes. Due to the location, estimated probability of failure, and presumed damage in the event of a failure, the City has adopted an alternative that calls for periodic observations as opposed to a major structural repair. The latter alternative would be adopted should a significant change in conditions be noted.

Brackney Slide

This is an historic slide area through which the City's raw water pipeline from Loch Lomond is aligned. In 2002, the City installed multiple wye fittings on each end of two slide areas to facilitate temporary pipeline bypass connections should the area(s) slide away. The City's long-term Capital Improvement Program specifies replacement of the entire pipeline beginning in 2011/2012 and continuing to 2020 at a total projected cost of $13 million (2018–2020).

There is an additional $6.5 million allocated (in FY 2024 $1.5 million and FY 2025 $5 million) for additional replacement. Consideration will be given to realigning the pipeline to avoid historic slide areas.

Graham Hill Water Treatment Plant
One landslide occurred on the Graham Hill Water Treatment Plant property in April 2006. The slide was located entirely within an old fill wedge that was placed on the existing native slope. Repairs to this slide were completed in the fall of 2008.

Multiple slides due to severe winter storms (2017)

- **Parkway Headwalk at Allerton Street**
  The headwall was overtopped during storm causing damage to road and erosion into the downstream channel.
- **Pasatiempo Creek Open Concrete Channel at Ocean Street and Plymouth Street**
  The Channel overflowed causing erosion under the channel and lifted the channel's bottom concrete slab causing major damage to structural integrity of channel.
- **East Cliff at Alhambra**
  Storm induced slope failure adjacent to existing concrete sack wall.
- **East Cliff at Third Street Stairs Slope**
  Storm caused erosion of slope adjacent to, and under, stairs. Erosion east of stairs is impacting existing guard rail and sidewalk.
- **Esmeralda Court**
  Impacted by enormous amount of spring water this winter. During storm events springs surface through sidewalk and street paving section. Street has been spot repaired several times to eliminate hazards associated with street heaving.
- **Upper Park Road**
  Washout due to heavy rains. This road provides access to the City Emergency Operations Center.
- **West Cliff Drive Path**
  Washout due to heavy rains.

D PROBABILITY OF FUTURE EVENTS

Many water system facilities are located in remote areas of Santa Cruz County. Facilities such as water diversions are at the water sources which are often located in remote hilly or mountainous areas. Pipelines carrying the water from the sources to the treatment facilities traverse hillsides, slopes and steep rugged terrain, much of which is prone to landslides.

11.3.3 ASSESSING LANDSLIDE VULNERABILITY: OVERVIEW

3.3 Assessing Vulnerability: part 2Overview — 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.

Past experience has shown that the water system is very vulnerable to landslides. While there could be significant expense involved in replacing landslide damaged infrastructure, there is also the risk of water outages caused by landslide events.

A OVERALL SUMMARY OF VULNERABILITY TO LANDSLIDE

The urban center of Santa Cruz is at relatively low risk for landslides although they do occur on steeper slopes within the City and can cause significant damage. However, the greatest vulnerability from landslide to the City of Santa Cruz is to the city water system.

The majority of the water storage and infrastructure for delivering water to the community is outside the city limits in mountainous terrain. The storage facilities, pipelines and treatment plants are vulnerable to landslide and have experienced landslides in the past.

11.3.4 ASSESSING VULNERABILITY: IDENTIFYING STRUCTURES

3.4 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 area.

Landslides threaten relatively few buildings and residences. The potential losses are to water storage, treatment and transport facilities and the impacts of these losses on the City of Santa Cruz water system consumers.

A TYPES AND NUMBERS OF EXISTING BUILDINGS, FACILITIES AND INFRASTRUCTURE

- Laguna Dam
- Laguna Pipeline (from dam to Highway 1)
- Liddell Spring
- Liddell Pipeline (from spring box to Highway 1)

- Majors Dam
- Majors Pipeline (from dam to Highway 1)
- Coast Pipeline (Highway 1 to the Coast Pump Station)
- Loch Lomond Reservoir (impounded by Newell Creek Dam)
- Newell Creek Pipeline
  (from Newell Creek Dam to the Graham Hill Water Treatment Plant)

11.3.5 ASSESSING VULNERABILITY: ESTIMATING POTENTIAL LOSSES

3.5 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)(i)(A) of this section and a description of the methodology used to prepare the estimate.

Table 11-1 Landslide Potential Loss By Structure

Facilities	Location	Costs
Laguna Dam		unknown
Laguna Pipeline	Dam to Highway 1	$350 per linear foot
Liddell Pipeline	Spring box to Highway 1	$350 per linear foot
Majors Dam		unknown
Majors Pipeline	Dam to Highway 1	$350 per linear foot
Coast Pipeline	Highway 1 to Coast Pump Station	$520 per linear foot
Loch Lomond Reservoir	Santa Cruz Mountains	unknown
Newell Creek pipeline	Dam to Graham Hill Water Treatment Plant	$520 per linear foot

B METHODOLOGY USED TO PREPARE ESTIMATE

Valuation:
Engineer's Estimate

Population:
The entire community of Santa Cruz as well as surrounding water service areas is at risk if there is damage to the water supply.

11.3.6 ASSESSING VULNERABILITY: ANALYZING DEVELOPMENT TRENDS

3.6 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.

A DESCRIPTION OF LAND-USES AND DEVELOPMENT TRENDS

Santa Cruz is a compact urban City surrounded by mountains, greenbelt and the Pacific Ocean. The size of the water service area has remained constant over time due to a policy prohibiting water main extensions to unserved areas and the acquisition of open space lands which creates a greenbelt around the City that serves to inhibit urban sprawl. Accordingly, any growth and redevelopment that will occur in the future is expected to be concentrated within the confines of the existing service area boundary.

Within the City of Santa Cruz, only a small amount of land remains undeveloped. Because of the relative scarcity of raw land, the majority of future growth in the area is likely to be achieved through redevelopment, remodeling, infill and increased density on underutilized land, along with new construction on the little amount of vacant land remaining. In other words, the service area has been fixed (not growing outward).[33]

The City of Santa Cruz water system currently serves approximately 90,000 people and is anticipated to grow to 100,000 by 2030. This number does not include additional University growth.[34]

The University of California at Santa Cruz has included significant growth numbers in its Long Range Development Plan (LRDP).

11.4.0 MITIGATION STRATEGY

4.0 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.

11.4.1 MITIGATION GOALS

> **4.1 Local Hazard 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.

Landslide Goals:

Landslide 1 — Avoid or reduce the potential for life loss, injury, property and economic damage from landslide hazards.

Landslide 2 — Protect the Santa Cruz water system and infrastructure from landslides including improvement in water system redundancy planning for continuous service.

11.4.2 IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

> **4.2 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.

Landslide Mitigation Actions:

- Protect Water System infrastructure through landslide monitoring (A-13)

The Landslides Hazard Program[35]
The enormous damages from landslides can be reduced. The primary objective of the National Landslide Hazards Program (LHP) is to reduce long-term losses from these hazards by improving our understanding of the causes of ground failure and suggesting mitigation strategies.

The LHP has operated since the mid-1970s in gathering information, conducting research, responding to emergencies and disasters and producing scientific reports and other products for a broadly based user community. The LHP publishes results of its investigations in various outlets for use by geologists and engineers in government, by those in academia and in private practice, by planners and decision makers from governmental entities at all levels, and the general public.

The results of these efforts have led to significant improvements in understanding the nature and scope of ground-failure problems nationally and worldwide. Such improvements are central to the role of the program because opportunities remain for fundamental advances in understanding that promise to save lives and dollars.

Hazard Mitigation Monitoring

The Water Department monitors the Loch Lomond East Bank Landslide quarterly as well as after significant rain or earthquake events through a set of 5 inclinometers and 10 piezometers.

After monitoring Loch Lomond East Bank Landslide for twenty years, and noting that the likelihood is low that the “recently active landslide” will suddenly slide into the reservoir with enough energy to generate a wave of sufficient amplitude to overtop Loch Lomond Dam, the Water Department evaluated the current monitoring program in fall of 2012. The evaluation determined that the department will continue monitoring the ancient landslide only, which is located above the more recently active landslide. Monitoring data collected in the spring of 2006 indicated possible movement in the ancient landslide; however, movement in the ancient landslide has not been noted since that one single event in the spring of 2006.

Due to the significant monetary and environmental expense to relocate water system facilities and the uncertainty of specific locations affected by slide events, the Water Department’s strategy for minimizing loss of water service due to a slide event is to improve water system redundancy. By developing multiple water sources, treatment facilities, and storage facilities, the risk of total outages is reduced due to loss of a facility.

The Water Department has installed wye valves on each side of the Brackney Slide to facilitate installation of temporary pipe in the event of a slide. The Water Department’s Long Term Capital Improvement Program calls for improvements in storage tank redundancy, replacement of pipelines and additional water supply augmentation over the next 10 years.

CLIMATE ADAPTATION CONSIDERATIONS

Landslides were not called out specifically as a climate change related vulnerability in the 2011 Climate Adaptation Plan. However, in the 2017 Climate Action Plan Update, landslides are — including as a vulnerability — since protecting the city water system infrastructure from erosion and landslides is noted in many of the 2011 Plan’s high priority action items. Furthermore, increases in storm intensity and duration, a potential impact from climate change, may exacerbate the potential for landslides.

CHAPTER 12: MULTI-HAZARD SUMMARY

Any of the hazards that threaten Santa Cruz could happen in combination with another hazard. In fact, there is a high likelihood that a major earthquake on the San Andreas or other faults would unleash secondary hazards that could be as disastrous to Santa Cruz as the earthquake itself. An unforgettable reference point for the Bay Area is the devastating fire in 1906 that burned down San Francisco, causing significantly more destruction than the earthquake that sparked it.

Earthquakes have started fires or caused other, secondary disasters throughout history. Within the recent past, one example is the 1995 Kobe, Japan earthquake. Another is the March 2011 Japanese earthquake resulting in a devastating tsunami and nuclear facility crisis. Earthquake shaking can start fires in numerous ways, such as tipping over appliances with pilot lights or damaging electrical equipment leading to sparks. Ruptured gas lines, both underground and where they connect to houses, or spilled flammable chemicals can cause post-earthquake fires to spread quickly. Efforts to fight fires after an earthquake are often severely hampered by non-functional water systems, damaged electrical systems that are needed to provide energy to pump water, or roads blocked by debris or landslides. These problems coincide with fire personnel being required for search and rescue activities and other disaster response activities.

Santa Cruz has experienced landslides during earthquakes and recent (2017) severe storms. These may be repeated occurrences, particularly if the earthquake occurs during rainy winter months. Small aftershocks could continue to cause slides for weeks after a quake, blocking roads and damaging homes. In addition, the next earthquake may cause significant damage to the city's water supply, located in a mountainous slide prone areas, and storm drain systems.

Although the risk is very low, an earthquake has the potential to cause dam failure. Breaks in the dams, levees and stream culverts could lead to catastrophic flooding in areas that have not seen floodwaters previously.

Drought increases the risk of wildfires, and wildfires increase the risk of landslide and flood. When all supporting vegetation is burned away, hills become destabilized and prone to erosion. The charred surface of the earth becomes hard and absorbs less water during rainfall, leading to increased runoff resulting in more rapid coastal erosion.

Many mitigation activities reduce risk from more than one hazard. However, there are some mitigation activities that reduce risk from one possible threat while increasing it from another. One example is placing utility lines underground. While underground utilities are less damaged by a major fire than those above ground, in an earthquake, underground utilities in areas prone to landslides or liquefaction are susceptible to damage and are more costly and time-consuming to repair than above ground utilities. Another example of mitigation with positive and negative impacts is vegetation removal for wildfire risk reduction. Trees and other established plants play a key role in securing hillsides and reducing landslide risk. They reduce erosion and slow rain runoff time, thus reducing flood peaks.

It is important to remember all of the implications of any risk reduction steps when planning mitigation activities.

PART 4 – MITIGATION STRATEGY

Mitigation Strategy

- Goals
- Objectives
- Actions

CHAPTER 13: MITIGATION STRATEGY

4.4.0 MITIGATION STRATEGY

4.0 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 City of Santa Cruz endeavors to be a disaster-resistant community that can survive and recover from a disaster while preserving the diversity and quality of its natural and built environments. The community strives to offer excellent cultural and community services as well as maintain and improve infrastructure, community safety and emergency preparedness. This Local Hazard Mitigation Plan is a part of this effort.

The City of Santa Cruz has developed a range of policies and programs to act as a "blueprint" for the hazard mitigation strategy. Strategies include "everyday operations" that also contribute to reducing the impact of future hazards as well as specific hazard mitigation projects. While City efforts are focused on evaluation and improvement of City-owned structures, particularly those identified as critical facilities, the plan also encourages the establishment of standards to encourage private property owners to upgrade the hazard resistance of their own properties. And, the City is actively engaged with other local and regional organizations to collaboratively work towards mitigation actions that meet the City of Santa Cruz' objective of being a disaster resistant community while striving to preserve the quality of its natural and built environments.

This plan focuses on mitigation goals and actions, meaning activities that occur prior to a hazard event that reduce or avoid damage when disasters strike. Damage prevention includes structural improvements to existing buildings, land use decisions that will minimize damage and ongoing programs such as vegetation reduction in wildland/urban interface areas.

This plan does not include emergency response activities. The City of Santa Cruz has an Emergency Operations Plan (EOP) that details the City's concept of operations in response to disasters. The EOP outlines how information and resources are coordinated for disasters or threat of disasters. The City's Emergency Operations staff (OES/Analyst) endeavors to conduct annual trainings, tabletop exercises and other drills and trainings that support the preparedness and response capabilities of City staff as well as the readiness of the Emergency Operations Center. Information updates and tabletop discussions are conducted to clarify staff roles and responsibilities in the EOC, in the Department Operations Centers (DOCs) and in the field to help protect people and property. This EOP is attached as Appendix O.

GOALS

Goals are general guidelines that explain what is to be achieved. They are usually broad-based, policy-type statements, long-term and represent global visions. Goals help define the benefits that the plan is trying to achieve. The success of the LHMP, once implemented, should be measured by the degree to which its goals have been met and the actual, resulting benefits in terms of hazard mitigation that occurs.

The original and subsequent LHMP Project Teams (2007, 2012) held several meetings to review the identified risks and developed goals, objectives and actions based on the most recent risk assessments. Goals which provided the greatest benefit in hazard reduction were identified as primary goals. This plan update continues the collaborative effort of city staff and key stakeholders that have reviewed the plan.

Goals specifically related to each identified potential hazard are presented under each hazard heading.

The Local Hazard Mitigation Plan has four primary mitigation goals:

1. Avoid or reduce the potential for life loss, injury and economic damage to Santa Cruz residents from hazard events;
2. Increase the ability of city government to serve the community during and after hazard events;
3. Protect the unique character, scenic beauty and values in the natural and built environment from being compromised by hazard events;
4. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and systems essential to a functioning City of Santa Cruz.

OBJECTIVES

The LHMP team selected the objectives listed below to meet multiple goals. They remain as the goals of this 2017 Plan Update. The objectives serve as a stand-alone measurement of a mitigation action rather than as a subset of a goal. Achievement of the objectives is a measure of the effectiveness of a mitigation strategy. The objectives are also used to help establish priorities.

Objectives are defined as short-term aims which, when combined, form a course of action to meet a goal. Unlike goals, objectives are specific and measurable.

The Local Hazard Mitigation Team identified this list of objectives:

1. Consider the impacts of hazards on future land use decisions in the city by coordinating with other planning mechanisms including the General Plan and land use code development.
2. Protect and sustain reliable local emergency operations and communication facilities during and after disaster.

3. Develop new, or enhance existing, early warning response systems
4. Seek to enhance emergency response capabilities through improvements to infrastructure and City programs
5. Seek mitigation projects that provide the highest degree of hazard protection at the least cost
6. Seek to update information on hazards, vulnerabilities, and mitigation measures by coordinating planning efforts and creating partnerships with appropriate local, county, state, and federal agencies
7. Seek to implement codes, standards, and policies that will protect life, property and quality of life including environmental, historic and cultural resources from the impacts of hazards within the City of Santa Cruz
8. Educate the community on preparedness for, and mitigation of, potential impacts of hazards to the City of Santa Cruz
9. Encourage retrofit, purchase, or relocation of structures in high hazard areas, including those known to be repetitively damaged

Identification and Analysis of Mitigation Actions

IDENTIFICATION OF ACTIONS

The local hazard mitigation goals are enumerated above. In support of those goals, the City of Santa Cruz has identified a number of hazard mitigation actions. During the development of the original LHMP, this set of actions was developed through an inclusive community process. The LHMP team, with input from the General Plan Update, Emergency Operations Plan, Capital Improvement Program, Urban Water Management Plan as well as other agencies, UCSC representatives and community members, has selected the following actions as the most beneficial for the City of Santa Cruz. These actions represent the highest priority mitigation actions identified for each hazard or for a multi-hazard event.

These mitigation actions have proven effective in reducing or eliminating hazard risk. Each of these actions directly meets an objective or goal listed in the City of Santa Cruz Local Hazard Mitigation Strategy. These actions are not meant to be exhaustive but rather to inspire thought and provide each department of the City of Santa Cruz with a role in hazard mitigation and a baseline of actions backed by a planning process, consistent with the goals and objectives and within the capabilities of the City. City departments were not bound to the list of alternatives presented. They were given the opportunity to edit the list. Actions not included in the action plan were eliminated based on the following:

- Action is currently outside the scope of the defined priority rankings
- City’s jurisdiction is not vulnerable to the hazard
- Action has already been implemented
- Estimated cost exceeded estimated benefit

Prioritization of Actions

The list below summarizes all of the identified actions, identifies the hazard(s) each one addresses, and indicates the assigned priority level of the action. The actions were prioritized in the same way that they were identified. The team leaders proposed an initial prioritization system, dividing the actions into categories of *Very High Priority*, *High Priority*, and *Important*.

City staff, Council members, commission(s) and community members were given an opportunity to review these categorizations.

Many factors were considered when assigning priorities. First, only those actions with strong community support were given *Very High* or *High* priority ratings. Second, addressing those hazards presenting the highest risk to Santa Cruz was given priority. The loss estimates in this Plan show that earthquakes, floods and tsunamis have the most potential to cause great economic and human losses. Water is essential to the survival of the City so drought and threats to the water system were also ranked as *High* or *Very High* priority. Finally, availability of funding (identified in the Capital Improvement Program or other source) was a determining factor in priority determination.

Section 201.c.3.iii of Title 44 of the Code of Federal Regulations requires that an action plan describe how actions identified were prioritized. The planning team has developed a prioritization methodology for the action plan that meets the needs of the City while at the same time meeting the requirements of Section 201.6 of Title 44 of the Code of Federal Regulations. The mitigation strategies identified were prioritized according to the criteria defined below.

Very High Priority

- A project that meets multiple plan objectives
- Benefits exceed cost
- Has strong community support
- Addresses those hazards presenting the highest risk exposure to life and property and the environment
- Funds are identified or potentially available
- Project can be completed in one to five years once project is funded

High Priority

- Project meets at least one plan objective
- Benefits exceed costs
- Funding has not been secured
- Project can be completed in one to five years once project is funded

Important

- Project mitigates the risk of a hazard
- Benefits exceed costs
- Funding has not been identified and/or timeline for completion is considered long-term (five to ten years)

A formal cost benefit analysis has not been done. However, in reviewing the mitigation actions proposed, the costs and benefits of each action were considered under the following rating:

Funding Considerations — Cost ratings

High	Existing funding levels are not adequate to cover the costs of the proposed project and would require an increase in revenue through an alternative source (for example, bonds, grants, and fee increases) to implement.
Medium	The project could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years.
Low	The project could be funded under the existing budget. The project is part of, or can be part of, an existing, ongoing program.

Benefit ratings

High	Project will have an immediate impact on the reduction of risk exposure to life and property
Medium	Project will have a long-term impact on the reduction of risk exposure to life and property or project will provide an immediate reduction in the risk exposure to property
Low	Long-term benefits of the project are difficult to quantify in the short term

In recent years, and in response to the 1989 Loma Prieta Earthquake, the City of Santa Cruz has made significant progress through efforts to reduce risk in public buildings, fire stations, major municipal facilities and public schools. This updated plan will continue these efforts and expand upon them throughout the community. These efforts will protect future generations from the devastation of natural hazards experienced by the residents of Santa Cruz in the past.

The City will pursue the implementation of these actions to meet the goals set out above. The *Very High* and *High* priority actions will be conducted actively as funding becomes available. The following Action lists have been updated (2017).

A = Very High Priority Action

	Action	**Hazard**	**Department**	**Timeline**
A-1	Establish pre-event planning for post-disaster recovery as an integral element of the Emergency Operations Plan of the City Council and each of the City departments including ongoing staff training	Multi-hazard	Emergency Operations; All City Departments	ongoing
A-2	Coordinate preparedness efforts with Santa Cruz County Office of Emergency Services, UCSC and other cities and agencies in the region	Multi-hazard	Emergency Operations	ongoing

	Action	Hazard	Department	Timeline
A-3	Educate and inform the community about emergency preparedness options in the event of a hazard event; including meeting the guidelines and becoming recognized as a Tsunami Ready community	Multi-hazard	Emergency Operations; Public Information Officer(s)	ongoing
A-4	Ensure completeness and availability of identified emergency supplies such as water main repair parts, road clearing equipment, sandbags, medical and communications equipment	Multi-hazard	Emergency Operations; Water; Public Works; Fire; Building	ongoing
A-5	Add repeaters as needed to enhance cellular services to critical facilities	Multi-hazard	Emergency Operations	ongoing
A-6	Encourage mitigation activities to increase the disaster resilience of institutions, private companies and systems essential to a functioning Santa Cruz	Multi-hazard	Planning and Building; Emergency Operations	ongoing
A-7	Continue cooperative/merged fire protection agreements with UCSC, the County fire districts and the California Department of Forestry	Wildfire	Fire; City Manager; [UCSC]	ongoing
A-8	Increase efforts to reduce fire risk in existing development and in wildland/ urban interface areas particularly steep canyons and arroyos through improved vegetation management and appropriate code enforcement	Wildfire	Fire; Water; Planning and Building	ongoing
A-9	Review open space land use to reduce incidence of human caused wildfire	Wildfire	Fire; Parks and Recreation; Police; Public Works	on-going
A-10	Require upgrade of sewer, water and other infrastructure to withstand seismic shaking and differential settlement	Earthquake	Public Works; Planning and Building; Water	ongoing
A-11	Reduce impacts of drought-related water shortages through increased water conservation activities and, if necessary, implementation of Water Shortage Contingency Plan	Drought	Water	ongoing
A-12	Provide significant improvement to the sufficiency and reliability of the Santa Cruz water supply by 2025 though passive or active recharge of regional aquifers	Drought	Water	3–5 years

	Action	Hazard	Department	Timeline
A-13	Protect water system infrastructure and reservoir from landslides and other failure—landslide monitoring and stabilization	Landslide	Water	Ongoing
A-14	Reduce risk of damage to water system infrastructure along San Lorenzo River	Flood	Water	ongoing

B = High Priority Action

	Action	Hazard	Department	Timeline
B-1	Periodically review structural integrity of bridges connecting the City's transportation routes	Multi-hazard	Public Works; [Caltrans]	ongoing
B-2	Protect and preserve coastline and infrastructure through permit review	Coastal Erosion	Public Works; Planning and Building	ongoing
B-3	Protect and preserve coastline and infrastructure through coastal restoration efforts — West Cliff Drive	Coastal Erosion	Public Works; Parks and Recreation	ongoing dependent on funds and as emergencies happen
B-4	Ensure early warning system for evacuation of areas susceptible to natural flooding, tsunami inundation, seiches or dam failure.	Flood; Tsunami	Emergency Operations; Police; Fire; Water	ongoing
B-5	Regulate development in floodplains and increase public awareness of flood hazards	Flood; Tsunami	Planning and Building; Public Works	ongoing
B-6	Encourage property owners, potential buyers and residents living in floodplains and coastal inundation areas to participate in Federal Flood Insurance Program	Flood; Tsunami	Planning and Building	ongoing
B-7	Reduce flooding hazards potential flood areas along Branciforte and Carbonera Creeks.	Flood	Public Works	ongoing
B-8	Rehabilitate and add to the City's storm drain system to reduce local flooding caused by inadequate storm drainage	Flood	Public Works	ongoing
B-9	Continue programs that promote installation, inspection, and testing of built-in fire extinguishing and early warning alarm systems	Wildfire	Fire; Planning and Building	ongoing
B-10	Abate hazardous conditions when identified and create programs that are proactive not reactive	Wildfire	Fire; Parks and Recreation; Police	ongoing

	Action	Hazard	Department	Timeline
B-11	Monitor Newell Creek Dam and infrastructure to preserve water resources and minimize risks to people and property resulting from dam failure; Replace or rehabilitate inlet/outlet works to meet Division of Safety of Dams operational requirements.	Dam Failure	Water; [outside agencies]	ongoing
B-12	Flood control maintenance on San Lorenzo River	Flood	Public Works	ongoing

C = Important Action

	Action	Hazard	Department	Timeline
C-1	Encourage and support the protection of cultural, historic and architecturally significant structures to preserve neighborhood and community character	Multi-hazard	Planning and Building; Parks and Recreation	ongoing
C-2	Update and enhance GIS systems and mapping for all hazards in the City	Multi-hazard	Information Technology; Economic Development	1–2 years
C-3	Appraise City-owned, information technology infrastructure for critical facilities	Multi-hazard	Information Technology; Economic Development	2–3 years
C-4	Discourage locating public facilities (other than those associated with open space uses) and above-ground utilities in high fire hazard areas	Wildfire	Fire	ongoing
C-5	Identify potential funding mechanisms to obtain fuel reduction grants	Wildfire	Fire	5–7 years
C-6	Continue programs to promote fire safety prevention programs for the schools, high occupancy institutional uses and commercial industrial	Wildfire	Fire	ongoing
C-7	Climate Change	Multi-hazard	Planning; City Manager	ongoing
C-8	Complete the ongoing efforts to retrofit all remaining non-complying unreinforced masonry buildings during repair or alteration including risk reduction from lateral spreading	Earthquake	Planning and Building	ongoing

	Action	Hazard	Department	Timeline
C-9	Working with appropriate agencies, upgrade the structural safety of all existing emergency use and critical structures, such as medical facilities, schools, police and fire stations and emergency response centers as necessary and appropriate	Multi-hazard	Planning and Building; Fire	5–7 years

All of the above mitigation actions identified by the City of Santa Cruz are presented below with suggestions for implementation, identification of lead departments in the City, preliminary estimates of resources required and timelines. These have been reviewed and updated (2017).

	Very High Priority Actions
A-1	**Hazard event planning**
Proposed Activities	Establish pre-event planning for post-disaster recovery as an integral element of the Emergency Operations Plan in all City departments including ongoing training.
Hazard	All
Environ Concerns	None
Lead Department	Emergency Operations/Fire; Operational Departments
Timeline	Ongoing
Resources Required	Unknown staff time
Funding Source	Regular staff salaries
Priority	Very high
A-2	**Emergency preparedness coordination**
Proposed Activities	Coordinate preparedness efforts with Santa Cruz County Office of Emergency Services, UCSC, and other cities and agencies in the region
Hazard	All
Environ Concerns	None
Lead Department	Emergency Operations/Fire; City Manager’s Office
Timeline	Ongoing
Resources Required	Unknown staff time
Funding Source	Regular staff salaries
Priority	Very high
A-3	**Community emergency preparation education**
Proposed Activities	Educate and inform the community about emergency preparedness options for hazard events
Hazard	All
Environ Concerns	None
Lead Department	Emergency Operations/Fire
Timeline	Ongoing
Resources Required	Staff time, materials production; website page development; social media
Funding Source	Staff salary
Priority	Very high

	Very High Priority Actions
A-4	**Emergency supply preparedness**
Proposed Activities	Ensure completeness and availability of identified emergency supplies such as water main repair parts, generators, pumps, sandbags, road clearing, medical and communications equipment
Hazard	All
Environ Concerns	None
Lead Department	Emergency Operations/Fire; Operational Departments
Timeline	Ongoing
Resources Required	Significant funds required to stock supplies
Funding Source	Water Fund, General Fund, unidentified outside funding
Priority	Very high
A-5	**Cellular services**
Proposed Activities	Add repeaters when needed to enhance cellular service to critical facilities
Hazard	All
Environ Concerns	Community concerns re: placement of cell towers
Lead Department	Emergency Operations/Fire; Information Technology
Timeline	Ongoing acquisition as needed
Resources Required	Outside funding — mutual aid during hazard events
Funding Source	General Fund — unidentified grants
Priority	Very high
A-6	**Encourage disaster resilience**
Proposed Activities	Encourage mitigation activities to increase the disaster resilience of institutions, private companies and systems essential to a functioning Santa Cruz through public outreach efforts and regulatory requirements.
Hazard	Multi-Hazard
Environ Concerns	Economic disruption
Lead Department	Planning and Building
Timeline	Ongoing
Resources Required	Unknown staff time for public outreach
Funding Source	Permit fees and unidentified grant funds
Priority	Very high
A-7	**Maintain cooperative agreements**
Proposed Activities	Continue cooperative fire protection agreements with UCSC, the County fire districts and the California Department of Forestry
Hazard	Wildfire
Environ Concerns	None
Lead Department	Fire
Timeline	Ongoing
Resources Required	Minimal administrative staff time
Funding Source	General Fund — regular staff
Priority	Very high

	Very High Priority Actions
A-8	**Vegetation management**
Proposed Activities	Increase efforts to reduce fire risk in wildland/urban interface; particularly steep canyons and arroyos through improved vegetation management and appropriate code enforcement
Hazard	Wildfire
Environ Concerns	Vegetation Management Plan approval
Lead Department	Fire; Parks and Recreation; Water
Timeline	Ongoing
Resources Required	Staff time; outside consultant services — funding
Funding Source	Staff budget and unidentified outside grants
Priority	Very high
A-9	**Open space monitoring**
Proposed Activities	Review and revise usage of open space to reduce incidence of human caused wildland fire
Hazard	Fire
Environ Concerns	Vegetation Management Plan approval
Lead Department	Fire; Parks and Recreation; Public Works; Police
Timeline	Ongoing
Resources Required	Additional assigned staff in all relevant departments
Funding Source	Staff budget and unidentified outside funding required
Priority	Very high
A-10	**Upgrade infrastructure for seismic shaking**
Proposed Activities	Require upgrade of sewer, water and other infrastructure to withstand seismic shaking and differential settlement
Hazard	Earthquake
Environ Concerns	None
Lead Department	Planning and Building; Public Works; Water
Timeline	Ongoing based on current standards
Resources Required	Staff time and unknown funds
Funding Source	State and federal grants, General Fund, building fees
Priority	Very high
A-11	**Conservation and Curtailment**
Proposed Activities	Reduce impacts of drought-related water shortages through increased water conservation activities and, if necessary, implementation of Water Shortage Contingency Plan
Hazard	Drought
Environ Concerns	None
Lead Department	Water
Timeline	Ongoing through 2035
Resources Required	$500,000 per year
Funding Source	Water Fund; Water System Development Fees Fund
Priority	Very high

	Very High Priority Actions
A-12	**Water Supply Reliability**
Proposed Activities	Provide significant improvement to the sufficiency and reliability of the Santa Cruz water supply by 2025 though passive or active recharge of regional aquifers.
Hazard	Drought
Environ Concerns	Water quality
Lead Department	Water — in conjunction with Scotts Valley Water District, Soquel Creek Water District, Santa Cruz Mid-County Groundwater Agency and Santa Margarita Groundwater Basin Advisory Committee
Timeline	Estimated time to be operational 2025 (tentative 2020 decision point)
Resources Required	Over $100 million; external funding required, grants and bond financing
Funding Source	Water Fund; Water System Development Fees Fund; City staff plus team of outside technical consultants (engineering and environmental)
Priority	Very high
A-13	**Rehabilitate/replace water system infrastructure**
Proposed Activities	Protect water system infrastructure and reservoir from landslides and other failure — landslide monitoring and slope stabilization
Hazard	Landslide, earthquake, liquefaction, flooding
Environ Concerns	Geologic and hydrologic
Lead Department	Water
Timeline	Ongoing
Resources Required	External funding required; from $5–$10 million per year; City staff plus outside consultants (geologists, geotechnical and civil engineers, environmental)
Funding Source	Grants, Water Fund and Water System Development Fees Fund
Priority	Very high
A-14	**Rehabilitate/replace water system infrastructure**
Proposed Activities	Reduce risk of damage to water system infrastructure along San Lorenzo River
Hazard	Flood
Environ Concerns	Hydrologic
Lead Department	Water
Timeline	Ongoing
Resources Required	External funding required; from $500K to $3 million per project; City staff plus outside consultants
Funding Source	Grants, Water Fund and Water System Development Fees Fund
Priority	Very high

	High Priority Actions
B-1	**Bridge integrity check**
Proposed Activities	Periodically review structural integrity of bridges connecting the city's transportation routes
Hazard	Flood, Earthquake, Tsunami, Dam failure, Multi-hazard
Environ Concerns	None
Lead Department	Public Works; Inspections done by Caltrans
Timeline	Every two years
Resources Required	Some City staff time
Funding Source	Caltrans funding
Priority	High
B-2	**Protect and preserve coastline**
Proposed Activities	Protect and preserve coastline and existing infrastructure through permit review
Hazard	Coastal erosion
Environ Concerns	Coastal Commission review and some community concerns regarding alteration of coastline
Lead Department	Planning and Building
Timeline	Ongoing
Resources Required	Staff time
Funding Source	Permit fees
Priority	High
B-3	**Protect coastline and infrastructure**
Proposed Activities	Protect and preserve coastline and infrastructure through coastal restoration efforts
Hazard	Coastal erosion
Environ Concerns	Coastal commission review and some community concerns regarding alteration of coastline
Lead Department	Public Works; Parks and Recreation
Timeline	Ongoing and event driven
Resources Required	Staff time
Funding Source	FEMA, Federal Highway Funds, General Fund
Priority	High
B-4	**Flood/Tsunami warning system**
Proposed Activities	Ensure early warning system for evacuation of areas at risk for flooding, tsunami inundation, seiches or dam failure
Hazard	Tsunami, Flood, Dam failure, Multi hazard
Environ Concerns	None
Lead Department	Emergency Operations/Fire/OES; Police; Water
Timeline	Under development [2018]
Resources Required	Staff time; coordination with county and other municipalities
Funding Source	General Fund
Priority	High

	High Priority Actions
B-5	**Regulate floodplain development**
Proposed Activities	Regulate development in floodplains and increase public awareness of flood hazards
Hazard	Floods
Environ Concerns	Flood inundation resulting in failed building and infrastructure, contamination, loss of businesses, homes and life.
Lead Department	Planning and Building
Timeline	Ongoing
Resources Required	Staff time; currently monitored between Planning and Building and Economic Development Departments
Funding Source	General Fund
Priority	High
B-6	**Federal Flood Insurance Program (FIP) participation**
Proposed Activities	Encourage property owners, potential buyers, and residents living in floodplains and coastal inundation areas to participate in the Federal Flood Insurance Program
Hazard	Flood and tsunami
Environ Concerns	Flood inundation resulting in failed building and infrastructure, contamination, loss of businesses, homes and life.
Lead Department	Planning and Building
Timeline	Ongoing; current regulations have been updated to bring local ordinances into compliance with federal regulations
Resources Required	Staff time
Funding Source	None
Priority	High
B-7	**Reduce creek flooding**
Proposed Activities	Reduce flooding hazard potential along creeks through implementation of Citywide Creeks and Wetlands Management Plan
Hazard	Flood
Environ Concerns	Land use issues
Lead Department	Planning and Building
Timeline	Ongoing
Resources Required	Staff time and funds
Funding Source	General Fund
Priority	High

	High Priority Actions
B-8	**Storm drain rehabilitation**
Proposed Activities	Rehabilitate the city's storm drain system to reduce local flooding caused by inadequate storm drainage
Hazard	Flood
Environ Concerns	None
Lead Department	Public Works
Timeline	Ongoing
Resources Required	$5–$10 million
Funding Source	Unidentified grant funds, General Fund, Storm Water Fund
Priority	High
B-9	**Promote early warning systems**
Proposed Activities	Promote installation, inspection and testing of built-in fire extinguishing and early warning fire alarm systems
Hazard	Wildfire
Environ Concerns	Addressed when building permit is issued
Lead Department	Fire/OES; Planning and Building
Timeline	Ongoing
Resources Required	Variable staff time
Funding Source	Permit fees
Priority	High
B-10	**Wildfire hazard abatement**
Proposed Activities	Abate hazardous conditions identified and create programs that are proactive not reactive
Hazard	Wildfire
Environ Concerns	Code compliance and public posting of fire danger
Lead Department	Fire
Timeline	Ongoing
Resources Required	Staff time and additional unidentified funding
Funding Source	Staff budget and grants
Priority	High
B-11	**Prevent dam failure**
Proposed Activities	Monitor Newell Creek Dam and infrastructure to preserve water resources and minimize risks to people and property resulting from dam failure; Replace or rehabilitate inlet/outlet works to meet Division of Safety of Dams operational requirements
Hazard	Landslide, earthquake, liquefaction, multi-hazard
Environ Concerns	Flooding
Lead Department	Water, California Department of Water Resources and Division of Safety of Dams
Timeline	Ongoing
Resources Required	Capital Improvement Investment of $40 million; City staff plus outside consultants (geologists, geotechnical and civil engineers)
Funding Source	Outside funding
Priority	High

	High Priority Actions
B-12	**Flood control maintenance**
Proposed Activities	Annual flood control maintenance on the San Lorenzo River as required by the Army Corps of Engineers consisting primarily of in-stream riparian vegetation management to prevent winter flows from exceeding capacity. Staff maintains the pump stations, gravity outlets and toe ditches as well.
Hazard	Flood
Environ Concerns	Habitat and Fish and Game
Lead Department	Public Works
Timeline	Annual (takes four to five weeks to complete)
Resources Required	Staff
Funding Source	Stormwater Fund
Priority	High

	Important Actions
C-1	**Preserve and protect historic structures**
Proposed Activities	Encourage and support the protection of cultural, historic and architecturally significant structures to preserve neighborhood and community character
Hazard	Multi-hazard
Environ Concerns	Asbestos and lead paint
Lead Department	Planning and Building, Parks and Recreation
Timeline	3–5 years as funding is available (priority structures have been addressed)
Resources Required	$4–$6 million dollars
Funding Source	Unidentified state and federal grants and private funds
Priority	Important
C-2	**Update GIS data systems and mapping**
Proposed Activities	Update and enhance the GIS data systems and mapping for all hazards in the city
Hazard	Multi-hazard including climate induced hazards
Environ Concerns	None
Lead Department	Economic Development and Information Technology/GIS
Timeline	Unknown — based on funding availability
Resources Required	.5 FTE GIS and 1 FTE Project Manager
Funding Source	Outside funding not yet identified
Priority	Important

	Important Actions
C-3	**Critical structure appraisal/estimates**
Proposed Activities	Obtain appraisals or engineering estimates for City owned Information Technology infrastructure for critical facilities
Hazard	Multi-hazard
Environ Concerns	None
Lead Department	Information Technology (IT/GIS) and Economic Development; Planning and Building.
Timeline	City facilities study to be done
Resources Required	Outside consultants (appraisers and engineers)
Funding Source	Budgeted
Priority	Important
C-4	**Fire protection land use**
Proposed Activities	Discourage locating public facilities (other than open space uses) and above ground utilities in high fire hazard areas
Hazard	Wildfire
Environ Concerns	Addressed in Planning and Building process
Lead Department	Fire; Planning and Building
Timeline	Ongoing
Resources Required	Unknown staff time
Funding Source	Permit fees
Priority	Important
C-5	**Adequate staffing**
Proposed Activities	Identify potential funding mechanisms to obtain fuel reduction grants
Hazard	Wildfire
Environ Concerns	None
Lead Department	Fire
Timeline	Ongoing
Resources Required	Additional staff
Funding Source	Unknown
Priority	Important
C-6	**Fire Safety Prevention Programs**
Proposed Activities	Continue fire safety prevention programs for schools, high occupancy uses and commercial and industrial facilities.
Hazard	Wildfire
Environ Concerns	None
Lead Department	Fire
Timeline	Ongoing
Resources Required	Regular staff time and additional funds required
Funding Source	Staff budget and grant funds
Priority	Important

	Important Actions
C-7	**Climate Change Policies**
Proposed Activities	Address climate change in General Plan Update — implement policies and programs to reduce impacts of global warming
Hazard	Multi-hazard including drought, wildfire, coastal erosion and flooding
Environ Concerns	Reduce emissions that contribute to climate change
Lead Department	City Manager's Office, Planning and Building
Timeline	General Plan Update adopted; Climate Adaptation (update underway 2017) and Climate Action Plans adopted; ongoing implementation
Resources Required	Staff time
Funding Source	Permit fees, General Fund, internal Carbon Reduction Fund as well as unidentified grants for special studies and implementation
Priority	Important
C-8	**Retrofit non-complying unreinforced masonry buildings (URM)**
Proposed Activities	Mandatory retrofit of identified structures; [NOTE: Commercial URMs have been completed]
Hazard	Earthquake
Environ Concerns	Asbestos and lead exposure, building collapse in earthquake
Lead Department	Planning and Building
Timeline	Two-story residential building currently in plan review
Resources Required	Some staff time
Funding Source	Building fees
Priority	Important
C-9	**Upgrade structural safety**
Proposed Activities	Working with appropriate agencies, upgrade the structural safety of all existing emergency use and critical structures, such as medical facilities, schools, police, fire and emergency response centers as necessary and appropriate
Hazard	Multi-hazard
Environ Concerns	Building failure/collapse and response disruption
Lead Department	Planning and Building
Timeline	Ongoing (public schools are state responsibility)
Resources Required	Unknown
Funding Source	General Fund and Capital Improvement Program
Priority	Important; Fire stations have recently been upgraded. Corporation Yard Main building will be complete in 2018

PART 5 — PLAN MAINTENANCE PROCESS

- Monitoring, Evaluating and Updating the Plan
- Incorporation into Existing Planning Mechanisms
- Continued Public Involvement

CHAPTER 14: PLAN MAINTENANCE PROCESS

14.5.1 MONITORING, EVALUATING AND UPDATING THE PLAN

> **5.1 Identification and Analysis of Mitigation Actions — Requirement §201.6(c)(4)(i):**
>
> The plan maintenance process **shall** include a section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

Title 44 of the *Code of Federal Regulations* (CFR) Section 201.6(c)(4)(i) requires a hazard mitigation plan to include a plan maintenance process that includes the following:

- A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.
- A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate.
- A discussion on how the community will continue public participation in the plan maintenance process.

The plan maintenance section of this document details the formal process that will ensure that the City of Santa Cruz hazard mitigation plan remains an active and relevant document. The maintenance process includes a schedule for monitoring and evaluating the plan annually each December in consultation with the Fire Department, Planning Department and Public Works Department. An updated plan will be produced every five years.

This chapter also describes how the City will integrate public participation throughout the plan maintenance and implementation process. Finally, this chapter explains how the City intends to incorporate the mitigation strategies outlined in this LHMP into existing planning mechanisms and programs, such as the General Plan, Capital Improvement Program, as well as building code enforcement and implementation. The LHMP's format allows the City to review and update sections when new data becomes available. New data can be easily incorporated, resulting in a plan that will remain current and relevant to the City of Santa Cruz.

Evaluation of the Plan

The minimum task of the ongoing annual hazard mitigation planning team meeting will be the evaluation of the progress of the LHMP and incorporating the actions into other plans.

This review will include the following:

- Summary of any hazard events that occurred during the prior year and their impact on the community.
- Review of successful mitigation initiatives identified in the LHMP (Appendix K: Successful Programs and Projects).

- Brief discussion about why targeted strategies were not completed.
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term project because of funding availability: Chapter 13: Mitigation Strategy).
- Recommendations for new projects.
- Changes in, or potential for, new funding options (grant opportunities).
- Integration of new data such as GIS data and mapping used to inform the Plan.
- Impact of any other planning programs or initiatives within the City that involve hazard mitigation.

The planning team will create a template to guide the LHMP committee in preparing a progress report.

The planning team will prepare a formal annual report on the progress of the LHMP. This report will be used as follows:

- Distributed to Department Heads for review.
- Posted on the City website on the page dedicated to the LHMP.
- Provided to the local media through a press release.
- Presented in the form of a council report to the Santa Cruz City Council.
- Provided as part of the Community Rating System (CRS) annual re-certification package. The CRS program requires an annual recertification to be submitted every year. To meet this recertification timeline, the planning team will strive to complete this progress report prior to the CRS recertification.

Method and Schedule for Updating the Plan within 5 Years

Section 201.6.(d)(3) of Title 44 of the *Code of Federal Regulations* requires that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits awarded under the Disaster Mitigation Act. The City of Santa Cruz intends to update the LHMP on a five-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than five years based on the following triggers:

- A Presidential Disaster Declaration that impacts the City of Santa Cruz.
- A hazard event that causes loss of life.

It will not be the intent of this update process to start from "scratch" and develop a new complete hazard mitigation plan for the City of Santa Cruz. Based on needs identified by the planning team, this update will, at a minimum, include the elements below:

- The update process will be convened through a committee appointed by the City Manager or designee in conjunction with Public Works and Planning Departments and will consist of at least one staff member from each of departments identified as lead departments in the mitigation action plan. This will ensure consistency between the LHMP and other city plans such as the General Plan and CIP.

- The hazard risk assessment will be reviewed and updated using best available information and technologies on an annual basis.
- The evaluation of critical structures and mapping will be updated and improved as funding becomes available.
- The action plan will be reviewed and revised to account for any actions completed, dropped, or changed and to account for changes in the risk assessment or new City policies identified under other planning mechanisms, as appropriate (such as the General Plan).
- The draft update will be sent to appropriate agencies for comment.
- The public will be given an opportunity to comment prior to adoption.
- The Santa Cruz City Council will adopt the updated plan.

Implementation Through Existing Programs

The effectiveness of the City's non-regulatory LHMP depends on the implementation of the plan and incorporation of the outlined action items into existing City plans, policies, and programs. The LHMP includes a range of action items that, if implemented, would reduce loss from hazard events in the City of Santa Cruz. Together, the action items in the LHMP provide the framework for activities that the City can choose to implement over the next five years. The planning team has prioritized the plan's goals and identified actions that will be implemented (resources permitting) through existing plans, policies, and programs.

The Public Works and Planning Departments have taken on the responsibility for overseeing the plan's implementation and maintenance through the City's existing programs. The two departments will work to facilitate LHMP implementation and maintenance meetings. Although these two departments will have primary responsibility for review, coordination, and promotion of the plan; plan implementation and evaluation will be a shared responsibility among all departments identified as lead departments in the mitigation action plan. The Public Works Department will continue to work closely with the Fire Department/OES Analyst to insure consistency in plans.

14.5.2 INCORPORATION INTO EXISTING PLANNING MECHANISMS

> **5.2 Identification and Analysis of Mitigation Actions — Requirement §201.6(c)(4)(ii):**
>
> The plan **shall** include a process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as the comprehensive or capital improvement plans when appropriate.

A PLANNING MECHANISMS FOR INCORPORATING THE REQUIREMENTS OF THE PLAN

The information on hazard, risk, vulnerability, and mitigation contained in this plan is based on the best information and technology available at the time the LHMP was prepared. As previously stated, the City's General Plan is considered to be an integral part of this plan. The City, through adoption of its General Plan (specifically, the Safety Element) goals, has planned for the impact of natural hazards.

The LHMP process and subsequent Five Year Updates, provided the City with the opportunity to review and expand on policies contained within the General Plan. The City views the General Plan and the LHMP as complementary planning documents that work together to achieve the ultimate goal of the reduction of risk exposure to the citizens of Santa Cruz. Many of the ongoing recommendations identified in the mitigation strategy are programs recommended by the General Plan, Urban Water Management Plan, Capital Improvement Program and other adopted plans.

The City will coordinate the recommendations of the LHMP with other planning processes and programs including the following:

- Emergency Operations Plan
- Capital Improvement Program
- City of Santa Cruz Municipal Code
- Community design guidelines
- Water conservation guidelines
- Stormwater Management Program

Most action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of educational programs, continued interdepartmental and interagency coordination, or improved public participation.

14.5.3 CONTINUED PUBLIC INVOLVEMENT

> **5.3 Continued Public Involvement — Requirement §201.6(c)(4)(iii):**
>
> The plan maintenance process **shall** include a discussion on how the community will continue public participation in the plan maintenance process.

The public will continue to be apprised of LHMP actions through the City website. Copies of the LHMP will be distributed to the Santa Cruz Library System. Upon initiation of the LHMP update process, a new public involvement strategy will be initiated based on guidance from the committee. This strategy will be based on the needs and capabilities of the City at the time of the update. At a minimum, this strategy will include the use of local media outlets within the planning area and the City's website.

CHAPTER 15: PUBLIC OUTREACH AND PLAN DEVELOPMENT

This chapter outlines the steps that were taken to update the City of Santa Cruz 2017–2022 Local Hazard Mitigation Plan and to describe how it was distributed for review and comment to our community stakeholders, emergency management personnel and partners. Comments, where appropriate, were incorporated into the body of the LHMP to correct errors, add relevant and important updated information. Public comments were gathered through a community-wide survey which is included and described below and, through public presentations at City Advisory Body meetings (Transportation and Public Works Commission [twice], Planning Commission and Downtown Commission). And, finally through presentations to the City Council.

STAKEHOLDERS

County of Santa Cruz: Emergency Management Council

The members of County of Santa Cruz Emergency Management Council EMC) were invited to review the LHMP update at their regular meeting on May 4, 2017. The EMC is staffed by our County Office of Emergency Services Administrator and meets every other month. The membership consists of over forty (40) emergency management partners including representatives from all of the incorporated cities in the county, from the American Red Cross, Fire, Law Enforcement, the business community, our hospitals, ham radio (ARES) operations personnel, schools and the University of California Santa Cruz, public information officers, Public Health, faith based representatives, and others. The EMC Chair also sits as the Chair of the Citizen Corps Council. EMC meetings are also attended by CERT representatives, the County of Santa Cruz Medical Reserve Corps, Volunteer (VOAD) agencies and Santa Cruz County Equine Evacuation Unit. More information on the EMC role can be found at this website: Santa Cruz County EMC.

2012–2017 LHMP Review by Emergency Management Council

The LHMP was distributed via memo and email links to the EMC members and that body was given over thirty (30) days to review, comment and reply. Other than a thorough review by County OES, comments received were few and minor in nature. For example, it was suggested that the City of Santa Cruz move forward with a Tsunami Ready plan. We have started that effort, as noted in the Tsunami chapter (Chapter 8). Other comments were congratulatory in nature but not substantive.

2017–2022 LHMP Review by Emergency Management Council

The LHMP was discussed at the EMC May 4, 2017 regular meeting. The project was outlined to the membership and a request was made for jurisdictional and agency stakeholder/members to review and comment back to the Project Manager. A DRAFT copy of the LHMP (approximately 90% complete) was later made available to the peer review members. It was distributed as a PDF email file attachment.

County of Santa Cruz Office of Emergency Services

The County of Santa Cruz Emergency Services Manager provided a high level review of this LHMP Update and her valuable comments and suggestions have been incorporated throughout this document.

Santa Cruz Neighbors: Community

The following is from the Santa Cruz Neighbors (SCN) website (Santa Cruz Neighbors):

> "Santa Cruz Neighbors is a city-wide 501(c)3 nonprofit organization representing a network of neighborhoods which partners with educational institutions, local government, local businesses, and non-profits dedicated to safer neighborhoods, community oriented government and provides a neighborhood voice for the residents of Santa Cruz."

A Citizen Survey concerning natural hazards awareness, issues and preparedness was sent out to members of the SCN by email link to their membership list. The same survey was posted on our City of Santa Cruz website for approximately two months. The email to SCN members encouraged them to reply to the survey. The survey results, including comments from our residents, are included later in this chapter.

City Departments: Project Team

A number of key individuals formed a Project Team that worked on the LHMP update. The work of this team was coordinated by the city's Management Professional and Technical Analyst working in conjunction with the city's Principal Management Analyst in charge of the City's OES Division within the Fire Department and with the City's Sustainability and Climate Action Coordinator. Other members worked independently — as subject matter experts — reviewing and updating their particular sections of the LHMP. They provided new, updated and revised information and data, all of which have been incorporated into the current update.

The LHMP Project Team included members from the Fire Department, Economic Development, Planning, Water, and Public Works departments. We also relied on, and greatly appreciate, the services of our Information Technology Systems Coordinator/GIS technician for updated mapping and HAZUS data, both of which contribute to the City's analysis and planning for long term mitigation strategy.

Many members of the team were familiar with the original plan from their work in 2012. Their contributions were invaluable in the formulation of the current plan. The work products and revisions were managed by the Management Professional and Technical Analyst who functioned as the Project Team Leader.

CONTINUITY AND CONNECTIONS AMONG PLANS

The author of the original City of Santa Cruz 2007 LHMP retired from city service. However, the bulk of the original plan was carried forward into the 2007–2012 update. The former Project Manager for the initial Five Year Update (2012–2017) had also retired, and was brought back in the position of Management Professional and Technical Analyst to manage this current 2017–2022 update. This adds a layer of continuity that was invaluable in getting the Project Team and the LHMP effort off to a quick and efficient start.

The current Project Team includes City staff who had contributed significantly to the 2007 and 2012 plans. It is worthwhile to note that our adopted Climate Adaptation Plan, which is cited throughout the LHMP and informs many aspects of the LHMP, was authored by the same person who wrote our 2007 LHMP. We continue to be grateful for the author's expertise which carries through from the original LHMP to the first update and to this update, as well as for her authorship of the Climate Adaptation Plan.

Climate Adaptation: The "Original" LHMP Update and Public Outreach/Review

The City of Santa Cruz broke new ground in our region and in the state when we completed and adopted a Climate Adaptation Plan. The work was accomplished through a Pre-Disaster Mitigation Grant. The final plan fulfilled the grant and was adopted by our City Council in 2011.

Our original intent was to have the Climate Adaptation Plan serve as our initial Five Year LHMP Update. Therefore, the Climate Adaptation Plan was written with a focus on the LHMP even while its subject matter was concentrated on climate change impacts. These impacts were prioritized so that the City would have a "roadmap" to mitigate potential problems in the future. In essence, the Climate Adaptation Plan is a companion mitigation document that expands upon the focus of the LHMP.

Extensive public reviews, public meetings, stakeholder meetings and outreach were undertaken in the process of preparing and adopting the Climate Adaptation Plan (*see* Appendix P).

As a result of CalOES' review of the Climate Adaptation Plan it was determined that it fell short as a formal LHMP update in that it did not address certain known vulnerabilities such as earthquakes and tsunamis. These were not considered by the authors as climate-related impacts and were thus not included in the Climate Adaptation Plan. CalOES' review was completed when the issues mentioned above were addressed, incorporating those non-climate change impacts, related vulnerabilities and their known risks to our community. This LHMP Update (2017–2022) — as did our first Five Year Update — includes the entire Climate Adaptation Plan Update and all of its valuable insights and direction.

OUTREACH MATERIALS

Following is a listing of materials used to gather insight, comment and in-depth peer and stakeholder review of the LHMP. This listing is not inclusive of all the email and phone conversations that went into this public outreach effort during plan development. However, they represent outreach to key stakeholders, residents in general and citizen groups.

- Email to city communications personnel and select Department Heads requesting Citizen Survey: "Are You Ready?" be posted on city websites and social media sites. (March 21, 2017)
- Media announcement of, and web link to, Citizen Survey: "Are You Ready?" sent to city communications personnel with request to post to media contacts. (March 21, 2017)
- In-house review (and comments back to Project Manager) re: Citizen Survey: "Are You Ready? Local Hazard Mitigation Public Survey" (March 21, 2017)
- Email to City Department Heads and web content managers; including links to Citizen Survey and LHMP requesting Facebook and web postings (March 22, 2017)
- Citizen Survey posted to city website home page and social media (March 22–24, 2017)
- Email to Santa Cruz Neighbors requesting they share the Citizen Survey with their members throughout the city. (March 22, 2017)
- Local newspaper publicizes the Citizen Survey (Santa Cruz Sentinel, March 29, 2017)
- Email to Chair of the County of Santa Cruz Emergency Management Council requesting peer reviewer suggestions from EMC membership (April 6, 2017)
- Meeting with Emergency Management Council personnel to solicit peer and stakeholder review and comment on DRAFT LHMP (May 4, 2017)
- City of Santa Cruz "City Hall to YOU" event included LHMP request for public comment (*see* flyer below) (May 4, 2017)
- Presentation to the Transportation and Public Works Commission Advisory Body (May 15, 2017)
- Citizen Survey and responses (provided below).
- Climate Adaptation Plan (LHMP Appendix P) presentation to the Transportation and Public Works Commission (July 17, 2017)

Santa Cruz Sentinel (local daily newspaper) "Coast Lines" printing
Announcing Citizen Survey and requesting local input and comments
March 29, 2017

SANTA CRUZ

3/29/2017

City issues hazard plan survey

The city of Santa Cruz is soliciting input with a Local Hazard Mitigation Public Survey from those who live and/or work within the city.

Feedback will be used to update the city's Local Hazard Mitigation Plan, which identifies risks from natural disasters. The city is also updating its Climate Adaptation Plan which identifies additional risk from climate related impacts.

Responses to the survey help evaluate major concerns and how well the community is prepared for the next natural disaster. It will also help determine how to mitigate the effects of natural disasters before they happen.

When the plan is adopted by the state and FEMA, the city can compete for grant funding to help prevent damage and reduce risks and vulnerabilities in neighborhoods throughout the city.

Survey: surveymonkey.com/r/LHMP_SURVEY.

Request for Public Input at "City Hall to YOU" event (City Hall to You)
May 4, 2017

2017 CLIMATE ADAPTATION PLAN + LOCAL HAZARD MITIGATION PLAN UPDATE

City Hall to YOU
May 4, 2017

CITY OF SANTA CRUZ
Climate Action Program

Provide your input NOW at our survey | Updates to be complete September, 2017

Sea Level Rise Vulnerability Assessment

- Central Coast Wetlands Group performing **GIS analysis**
- **New modeling and data** allows quantification of impacts (new to Plan)
- **Impacts assessed**: rising tides, coastal storm flooding + erosion
- **Scenarios analyzed** include
    - Existing conditions (2010 water level)
    - Low sea level rise (IPCC S1, where 41 cm rise by 2100)
    - Medium sea level rise (IPCC S2, where 88 cm rise by 2100)
    - High sea level rise (IPCC SS3, where 159 cm rise by 2100)
- **Time horizons analyzed** are 2010, 2030, 2060 and 2100
- **Outputs** include SLR impact maps at each time horizon, inventory and valuation of impacted facilities + infrastructure integrated into report narrative

Social Vulnerability Assessment

- **Technical Assistance** provided by Dr. Juliano Calil
- **New measure** to improve customization of adaptation strategies and actions
- **Social Vulnerability Score** includes
    - Poverty
    - Age > 65 years old
    - Crime incidence
    - English not spoken well or at all
- High Social Vulnerability Scores overlaid onto SLR and other impact maps

Climate Adaptation Plan Update

- Develop and prioritize adaptation strategies based on impacts and social vulnerability
- Update all narrative sections in report
- Update non coastal impacts with existing studies and new data available
- Stakeholder and technical advisor review and comment

What's Next

- Public Comment period ends on May 8, 2017 (see links to surveys)
- Integration with the Local Hazard Mitigation Plan over summer and crosswalk with other plans as needed
- Presentation to Planning Commission + Transportation and Public Works Commission in July
- Presentation to City Council in August
- Secure funding for Cost Benefit Analysis of business as usual vs. adaptation strategies, more public outreach and quantification of non-coastal impacts (e.g. urban wildfire potential and drought)
- Report on progress on Adaptation Plan update annually

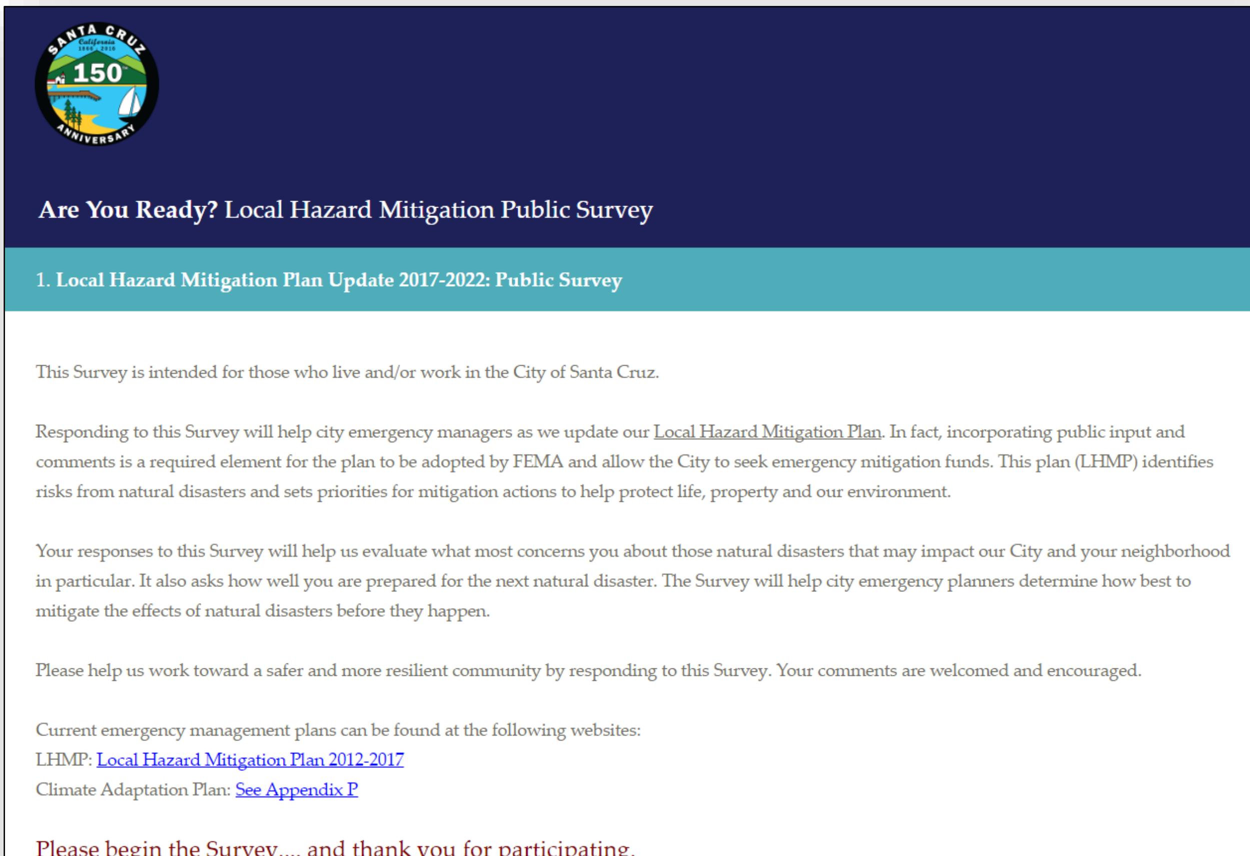
For more information: contact Dr. Tiffany Wise-West
Twise-west@cityofsantacruz.com | 831.420.5433

CITIZEN SURVEY: ARE YOU READY? LOCAL HAZARD MITIGATION SURVEY

On the following pages are the results of the Citizen Survey — "Are You Ready? Local Hazard Mitigation Public Survey." The survey was posted and distributed via internet links, social media and through the local community group in the City of Santa Cruz (Santa Cruz Neighbors). The survey was available for approximately two months. 386 responses were received which is three times as many as the 2012–2017 LHMP public survey.

The following image shows the introduction to our survey:

"Are You Ready? Local Hazard Mitigation Public Survey"



Are You Ready? Local Hazard Mitigation Public Survey

1. Local Hazard Mitigation Plan Update 2017-2022: Public Survey

This Survey is intended for those who live and/or work in the City of Santa Cruz.

Responding to this Survey will help city emergency managers as we update our Local Hazard Mitigation Plan. In fact, incorporating public input and comments is a required element for the plan to be adopted by FEMA and allow the City to seek emergency mitigation funds. This plan (LHMP) identifies risks from natural disasters and sets priorities for mitigation actions to help protect life, property and our environment.

Your responses to this Survey will help us evaluate what most concerns you about those natural disasters that may impact our City and your neighborhood in particular. It also asks how well you are prepared for the next natural disaster. The Survey will help city emergency planners determine how best to mitigate the effects of natural disasters before they happen.

Please help us work toward a safer and more resilient community by responding to this Survey. Your comments are welcomed and encouraged.

Current emergency management plans can be found at the following websites:
LHMP: Local Hazard Mitigation Plan 2012-2017
Climate Adaptation Plan: See Appendix P

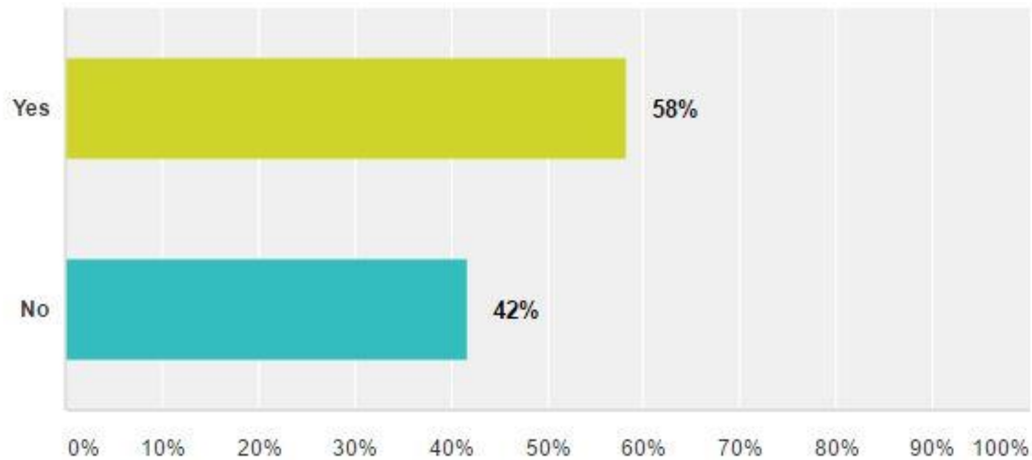
Please begin the Survey.... and thank you for participating.

NOTE: The following pages are screenshots taken from the final survey results. A closer look at these results follows the questions on the pages below.

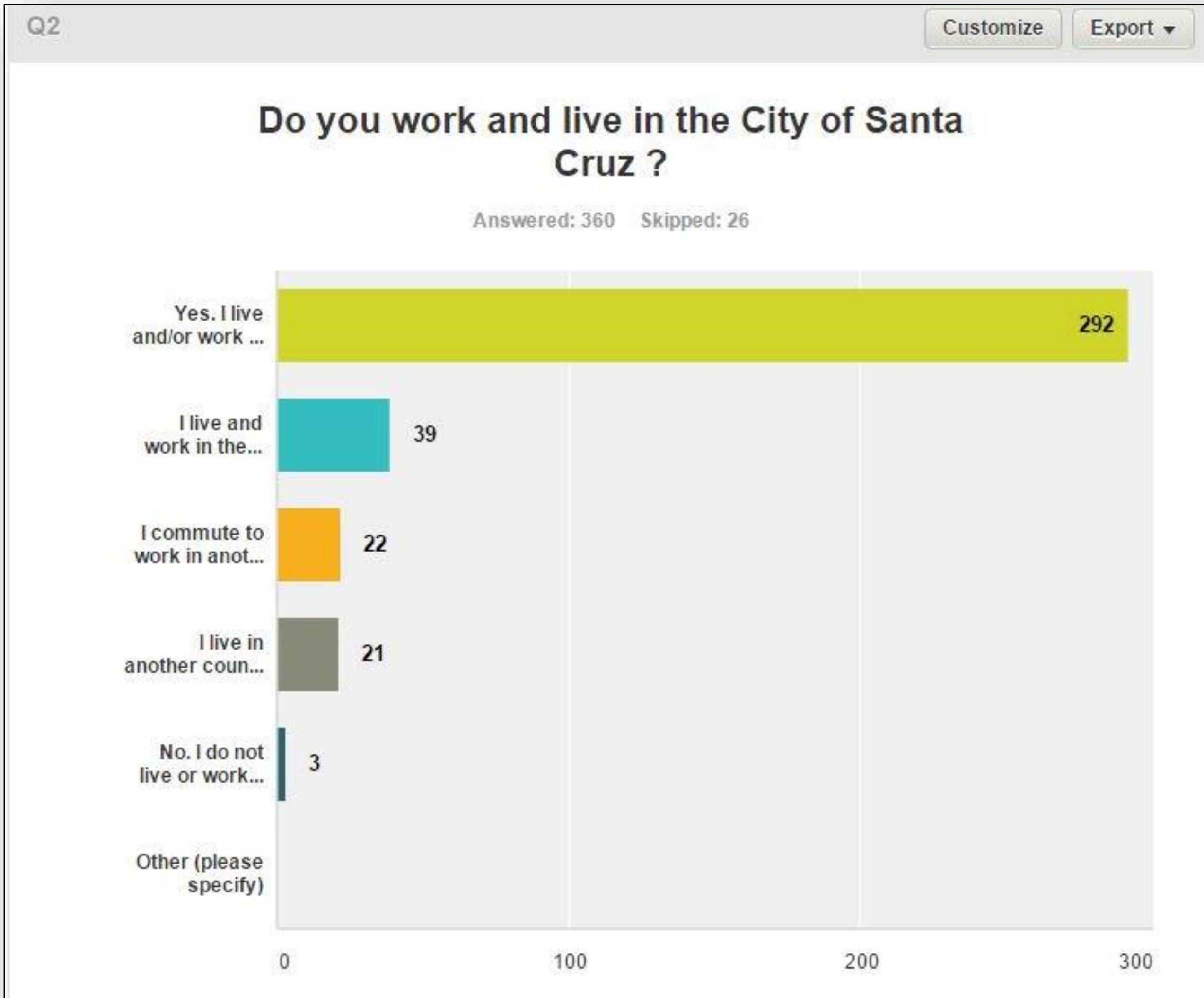
Q1 Customize Export ▾

Do you own property in the City of Santa Cruz?

Answered: 384 Skipped: 2



Answer Choices	Responses	
Yes	58%	224
No	42%	160
Total		384



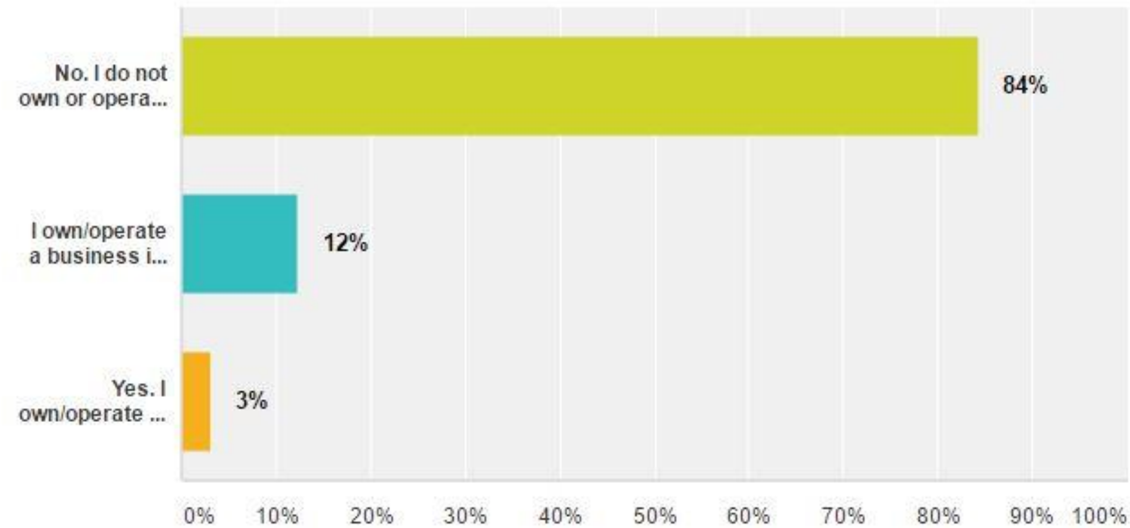
Answer Choices	Responses	
Yes. I live and/or work in the City of Santa Cruz	81%	292
I live and work in the unincorporated area of the County of Santa Cruz (Live Oak, Aptos, etc.)	11%	39
I commute to work in another county from the City of Santa Cruz.	6%	22
I live in another county and commute to the City of Santa Cruz for work.	6%	21
No. I do not live or work in the City or County of Santa Cruz	1%	3
Other (please specify) Responses	0%	0
Total Respondents: 360		

Q3

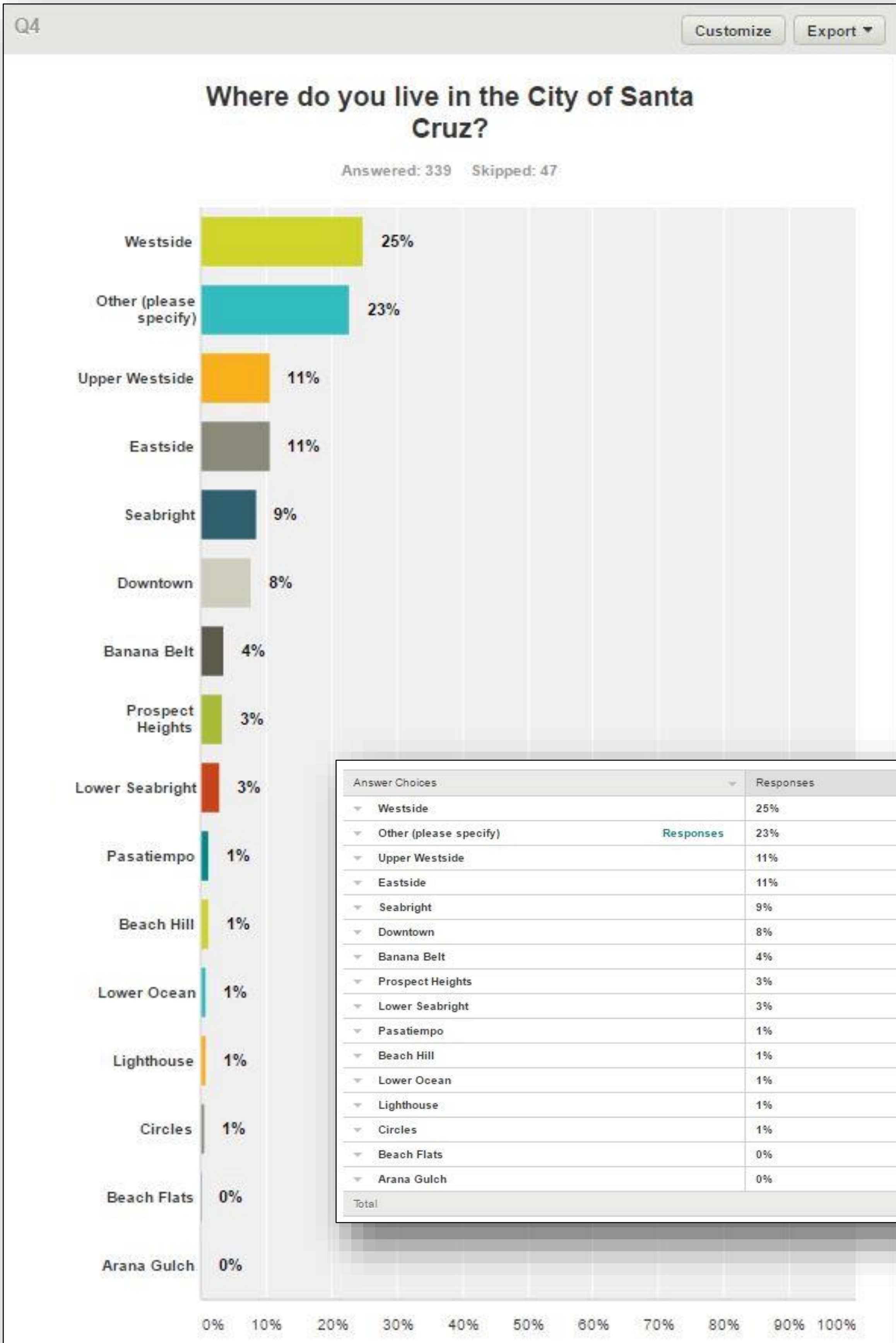
Customize | Export

Do you own/operate a business in the City of Santa Cruz

Answered: 347 Skipped: 39



Answer Choices	Responses	
No. I do not own or operate a business within the City of Santa Cruz	84%	293
I own/operate a business in the City, and I do live here	12%	43
Yes. I own/operate a business in the City, but do not live here	3%	11
Total		347



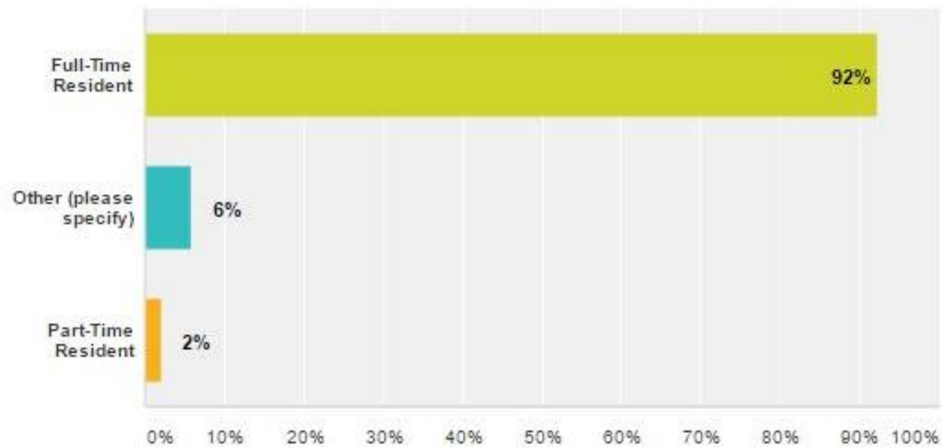
Answer Choices		Responses	
Westside		25%	84
Other (please specify)	Responses	23%	77
Upper Westside		11%	36
Eastside		11%	36
Seabright		9%	29
Downtown		8%	26
Banana Belt		4%	12
Prospect Heights		3%	11
Lower Seabright		3%	10
Pasatiempo		1%	4
Beach Hill		1%	4
Lower Ocean		1%	3
Lighthouse		1%	3
Circles		1%	2
Beach Flats		0%	1
Arana Gulch		0%	1
Total			339

Q5

Customize Export

Are you a full-time or part-time resident? If part-time please explain below.

Answered: 348 Skipped: 38



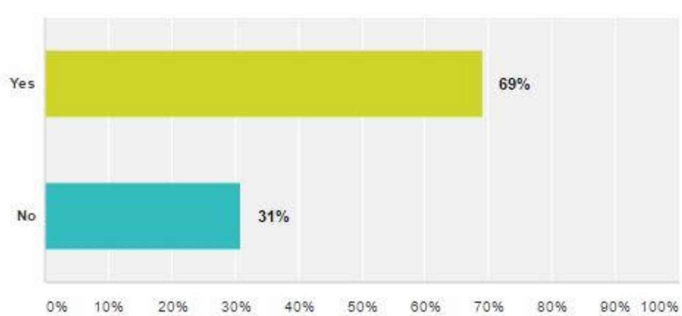
Answer Choices		Responses	
Full-Time Resident		92%	321
Other (please specify)	Responses	6%	20
Part-Time Resident		2%	7
Total			348

Q6

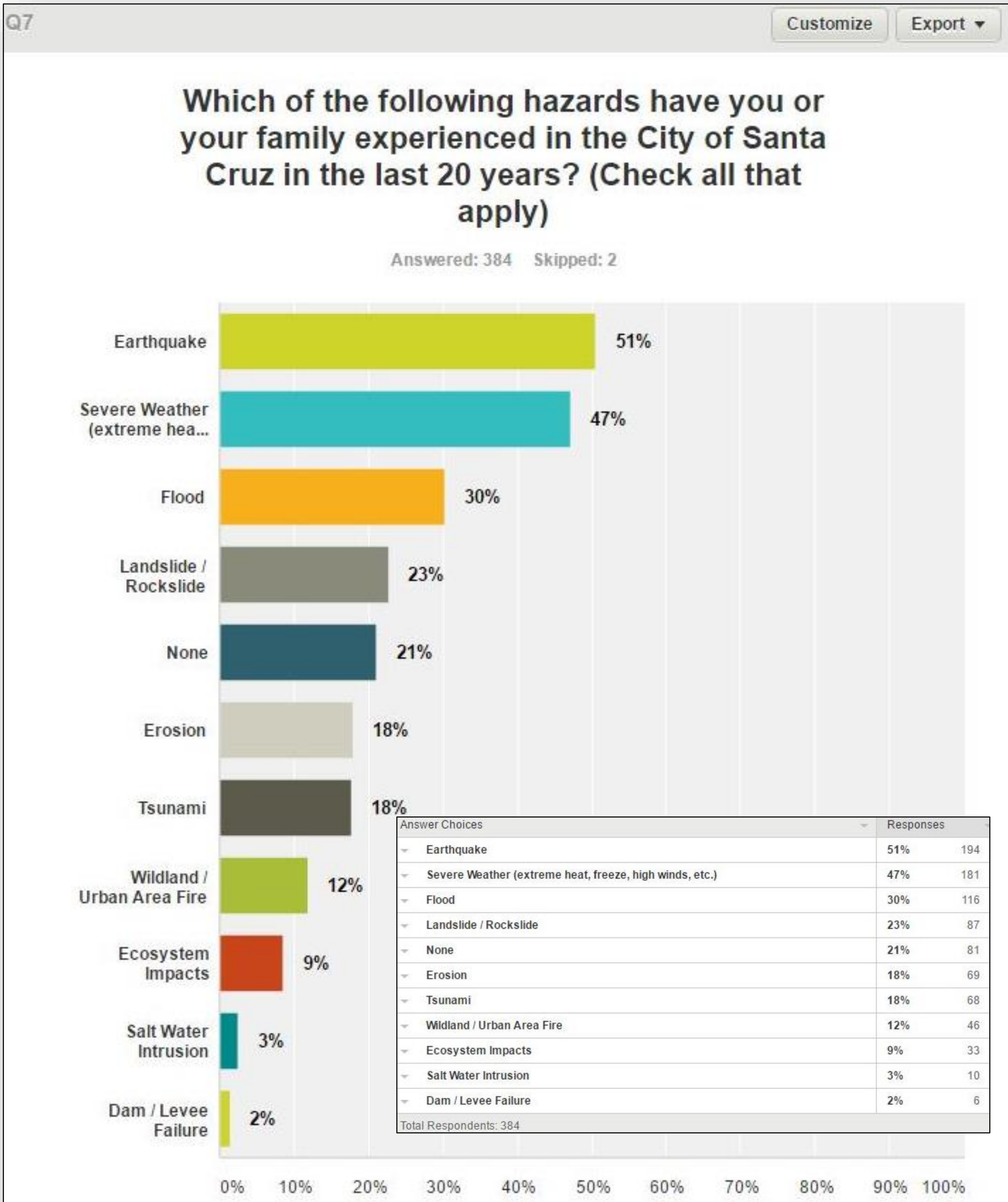
Customize Export

Do you work in the City of Santa Cruz?

Answered: 379 Skipped: 7



Answer Choices	Responses	
Yes	69%	262
No	31%	117
Total		379

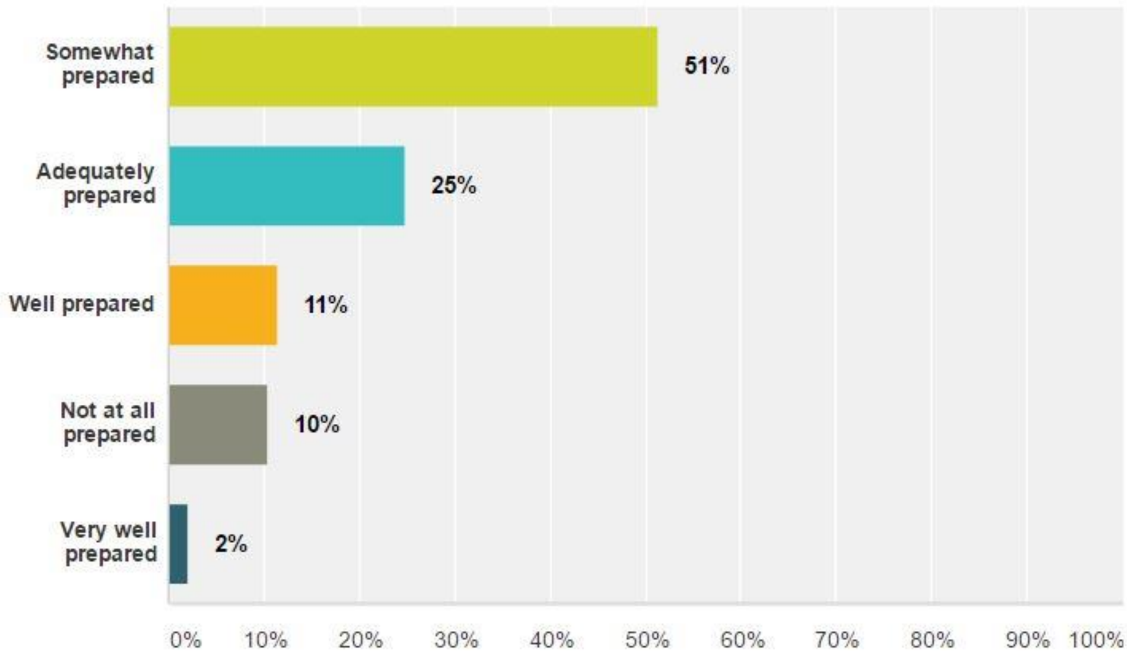


Answer Choices	Responses	
Earthquake	51%	194
Severe Weather (extreme heat, freeze, high winds, etc.)	47%	181
Flood	30%	116
Landslide / Rockslide	23%	87
None	21%	81
Erosion	18%	69
Tsunami	18%	68
Wildland / Urban Area Fire	12%	46
Ecosystem Impacts	9%	33
Salt Water Intrusion	3%	10
Dam / Levee Failure	2%	6
Total Respondents: 384		

Q8

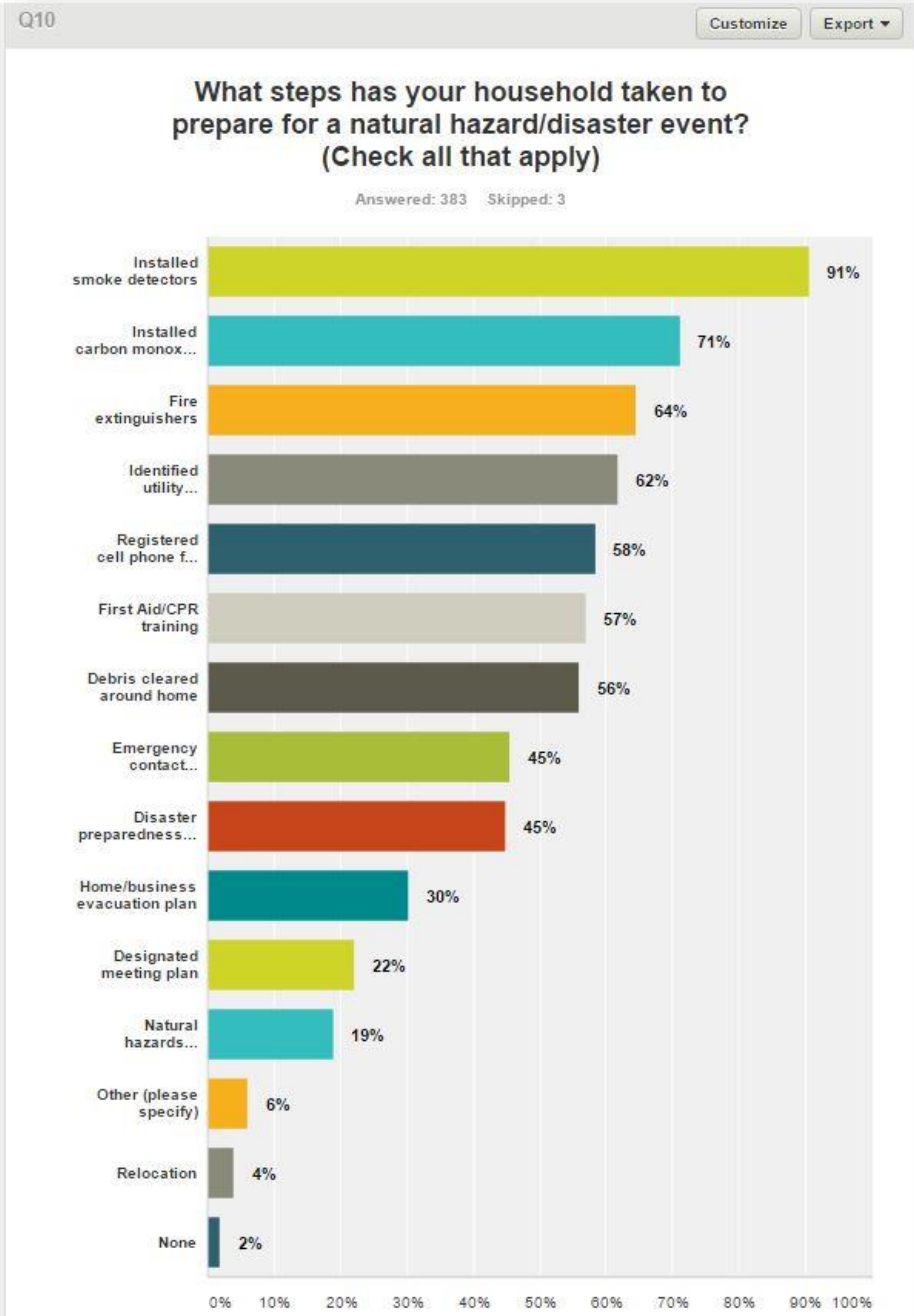
How prepared is your household for a natural hazard/disaster event?

Answered: 384   Skipped: 2



Answer Choices	Responses	
Somewhat prepared	51%	197
Adequately prepared	25%	95
Well prepared	11%	44
Not at all prepared	10%	40
Very well prepared	2%	8
Total		384


Q9
Customize
Export
How concerned are you about the possibility of your neighborhood and the community being impacted by a natural hazard/disaster event?
Answered: 381 Skipped: 5
Level of Concern
10%
72%
18%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Not concerned
Somewhat concerned
Extremely concerned


Q10
Customize
Export
What steps has your household taken to prepare for a natural hazard/disaster event? (Check all that apply)
Answered: 383 Skipped: 3
Installed smoke detectors
91%
Installed carbon monox...
71%
Fire extinguishers
64%
Identified utility...
62%
Registered cell phone f...
58%
First Aid/CPR training
57%
Debris cleared around home
56%
Emergency contact...
45%
Disaster preparedness...
45%
Home/business evacuation plan
30%
Designated meeting plan
22%
Natural hazards...
19%
Other (please specify)
6%
Relocation
4%
None
2%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

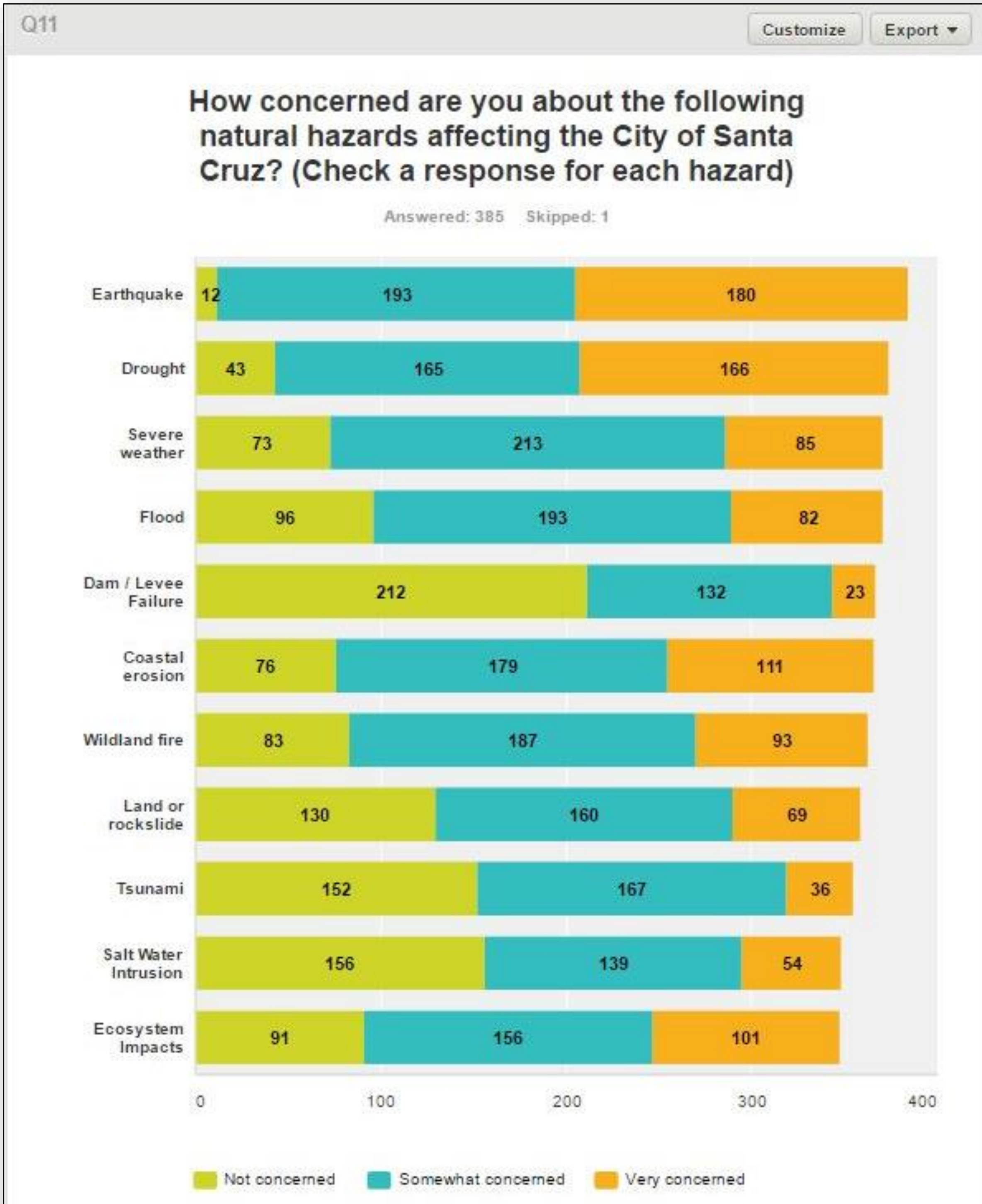
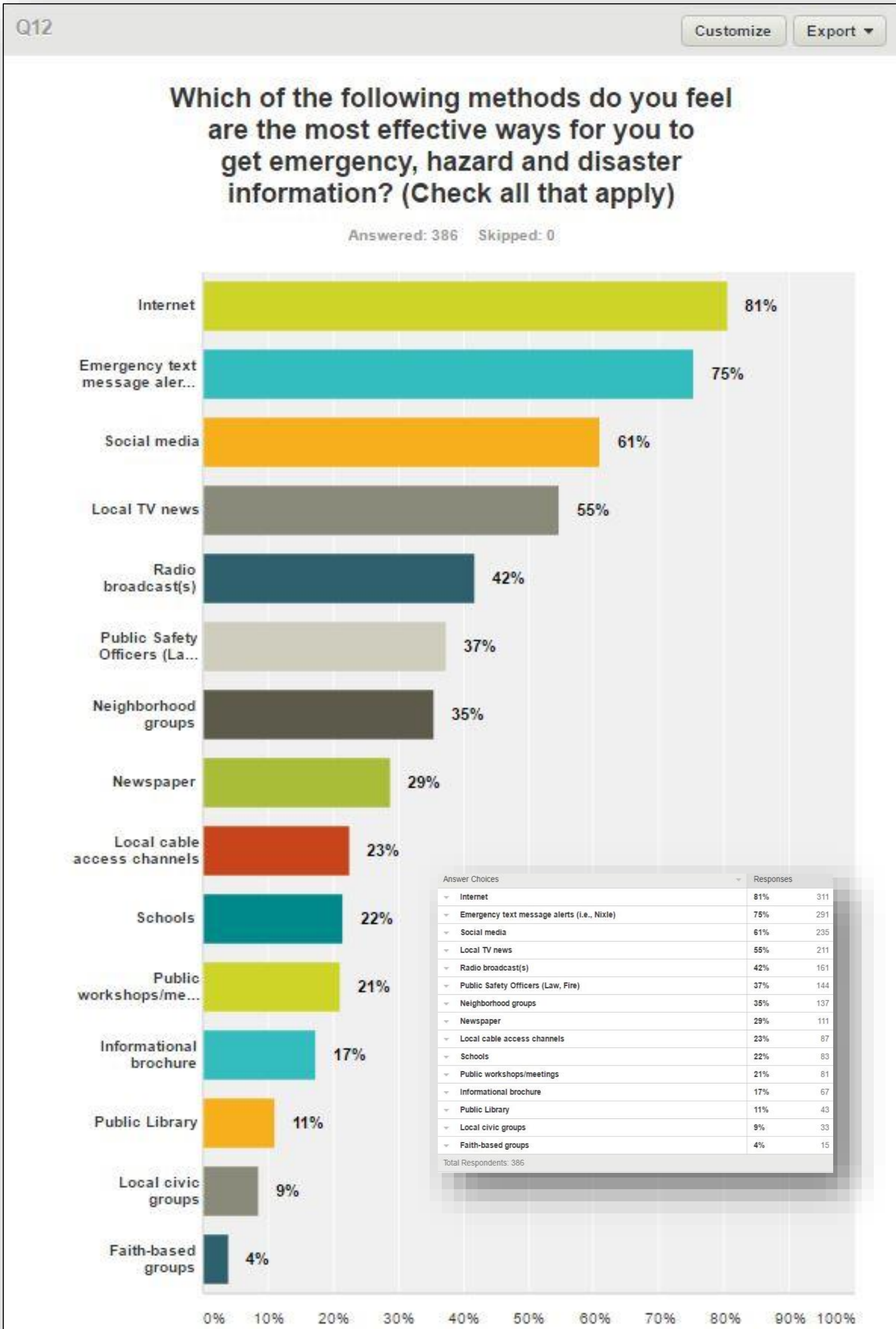
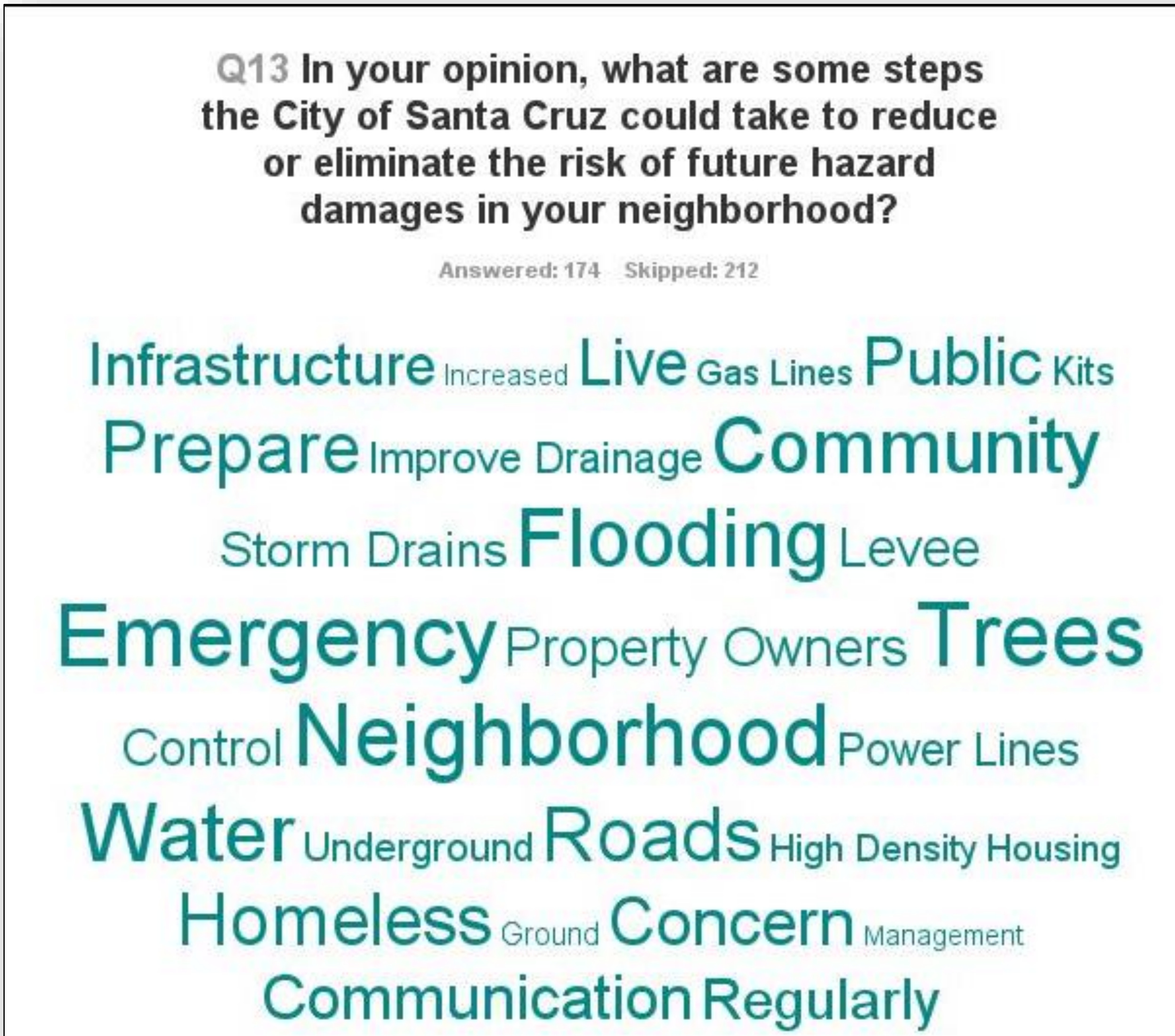


Chart Data = Number of Reponses

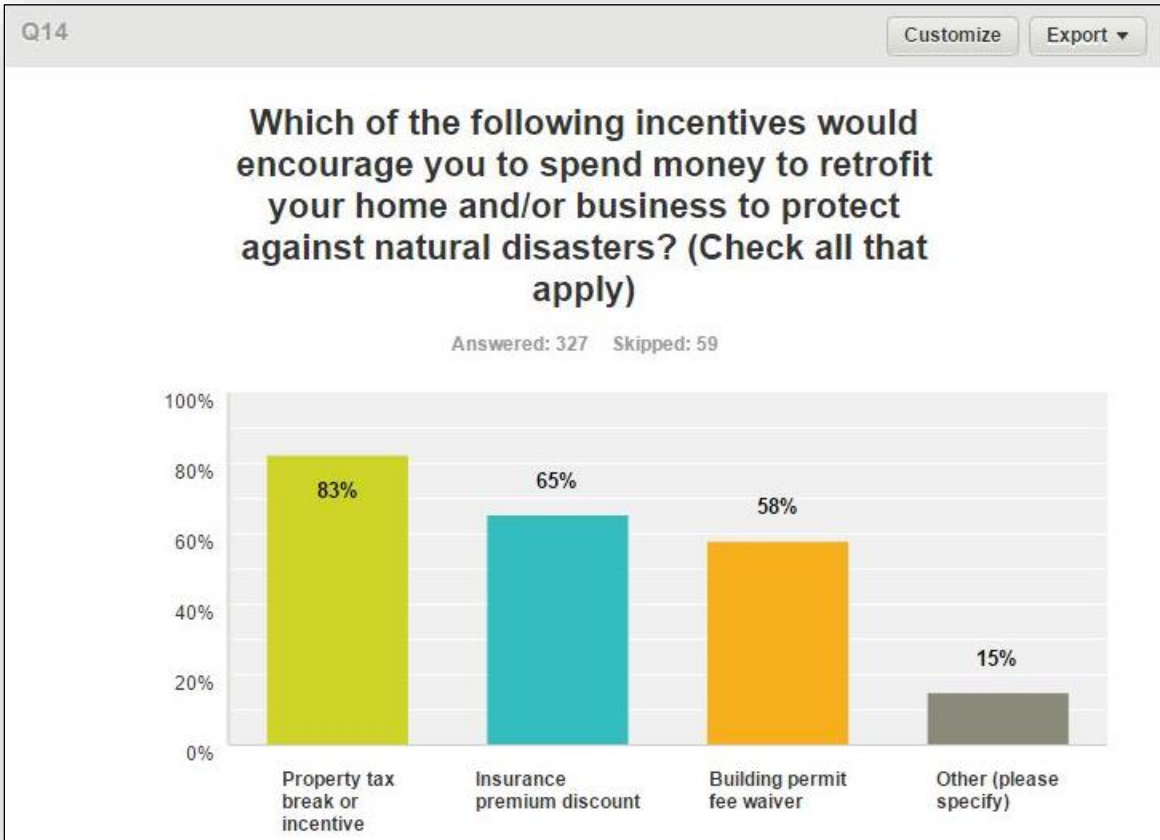


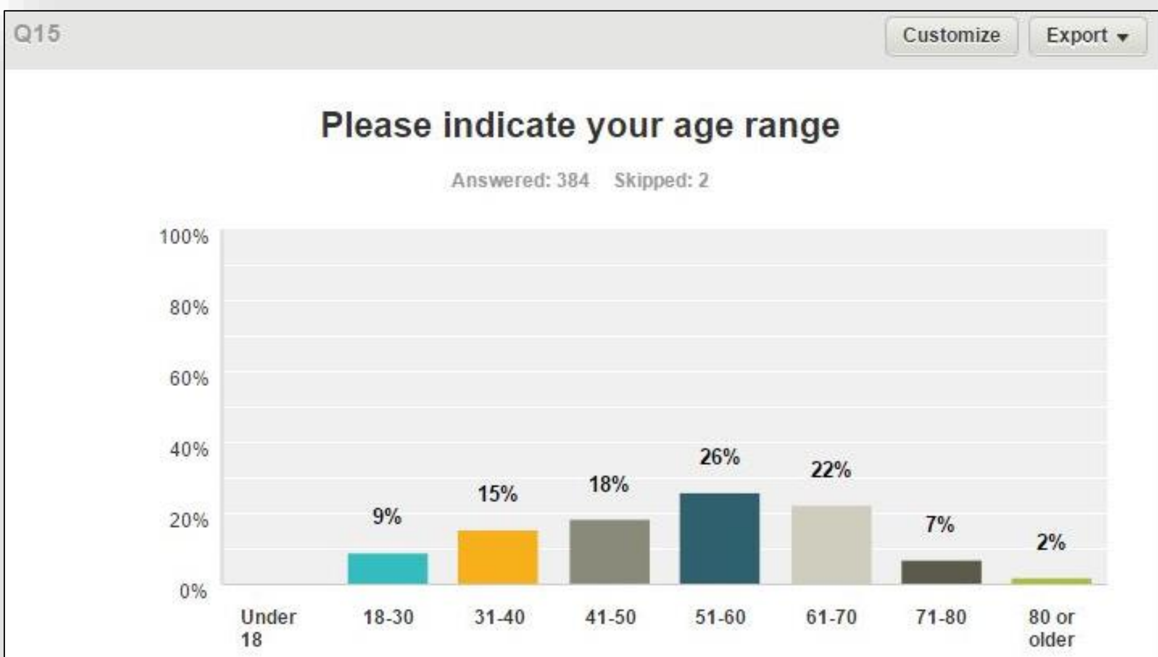
Answer Choices	Responses	
Internet	81%	311
Emergency text message alerts (i.e., Nixle)	75%	291
Social media	61%	235
Local TV news	55%	211
Radio broadcast(s)	42%	161
Public Safety Officers (Law, Fire)	37%	144
Neighborhood groups	35%	137
Newspaper	29%	111
Local cable access channels	23%	87
Schools	22%	83
Public workshops/meetings	21%	81
Informational brochure	17%	67
Public Library	11%	43
Local civic groups	9%	33
Faith-based groups	4%	15

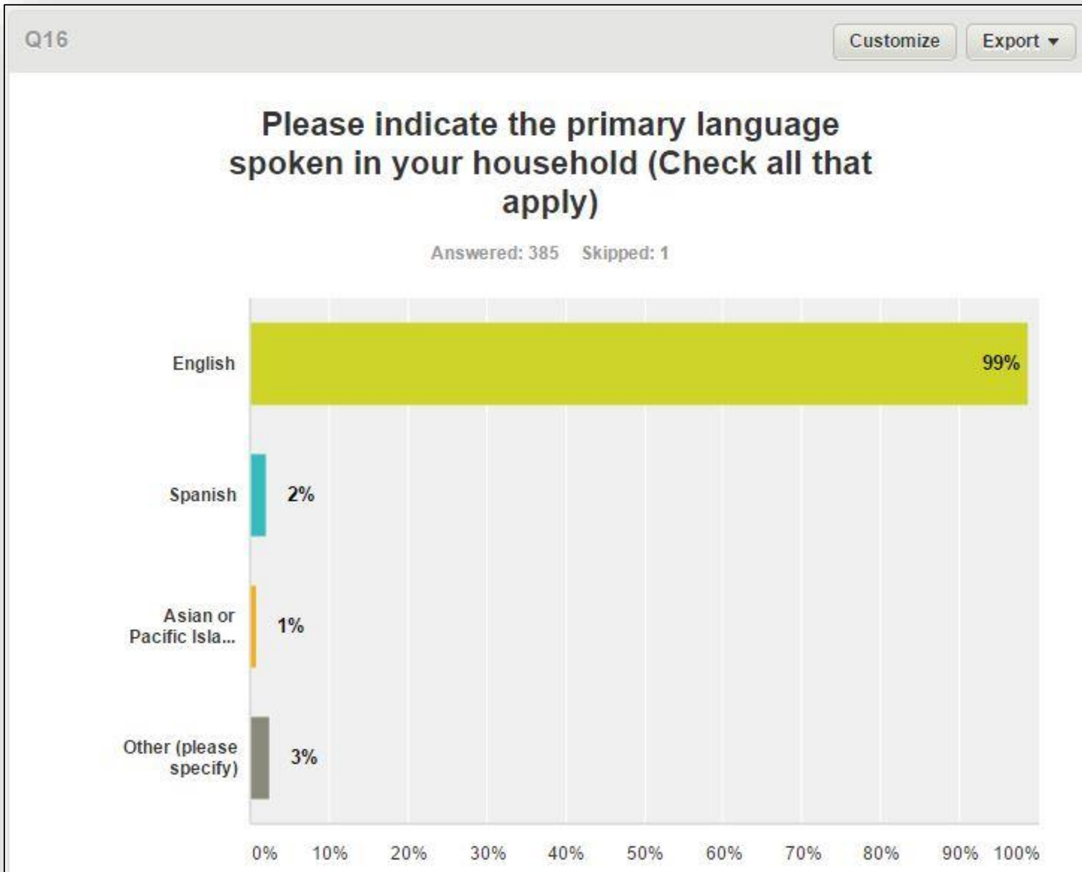
Total Respondents: 386

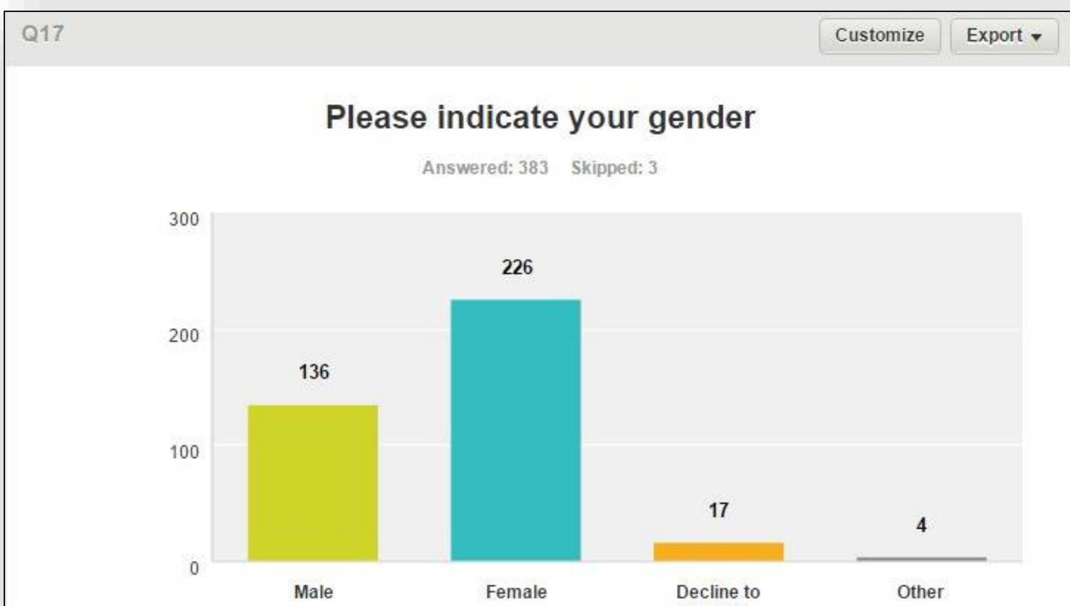


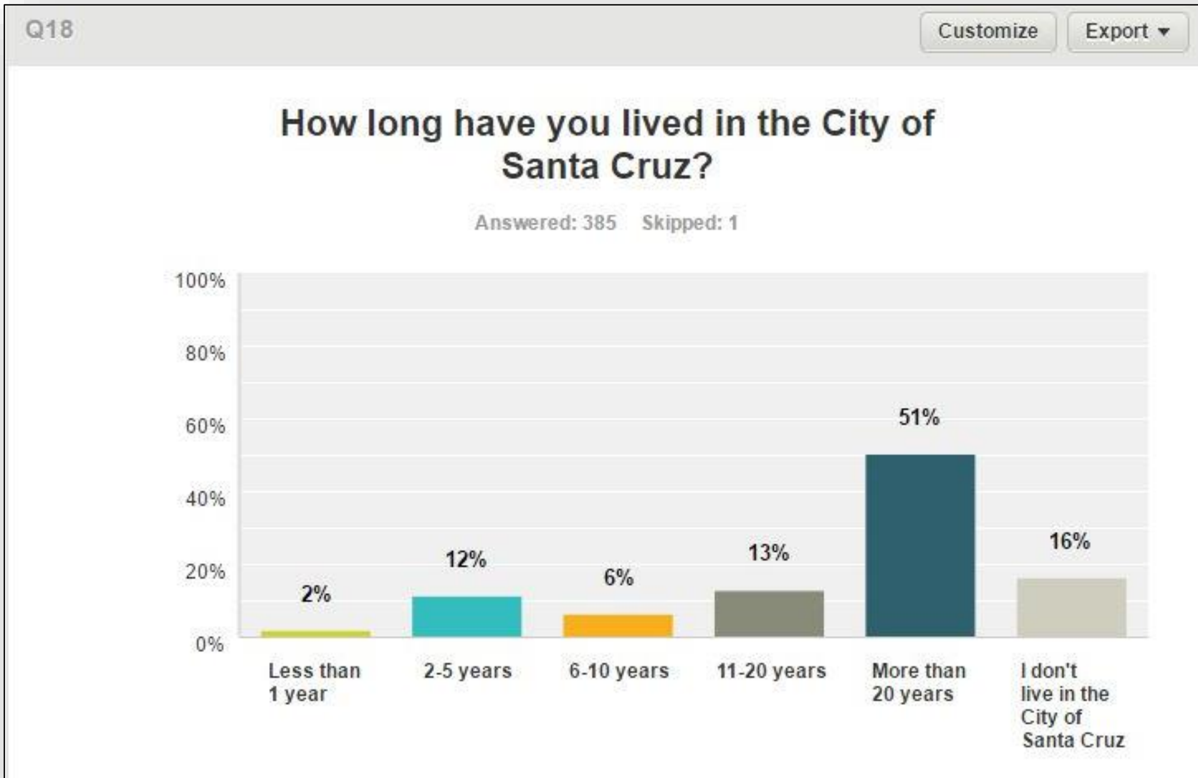
NOTE: There were 174 free form text responses. Comments in full are included within the Climate Adaptation Plan (Appendix P) The word cloud above is representative of the issues of concern and suggestions of respondents.


Q14
Customize
Export
Which of the following incentives would encourage you to spend money to retrofit your home and/or business to protect against natural disasters? (Check all that apply)
Answered: 327 Skipped: 59
100%
80%
60%
40%
20%
0%
83%
65%
58%
15%
Property tax break or incentive
Insurance premium discount
Building permit fee waiver
Other (please specify)


Q15
Customize
Export
Please indicate your age range
Answered: 384 Skipped: 2
100%
80%
60%
40%
20%
0%
9%
15%
18%
26%
22%
7%
2%
Under 18
18-30
31-40
41-50
51-60
61-70
71-80
80 or older


Q16
Customize
Export
Please indicate the primary language spoken in your household (Check all that apply)
Answered: 385 Skipped: 1
English
99%
Spanish
2%
Asian or Pacific Isla...
1%
Other (please specify)
3%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Q17
Customize
Export
Please indicate your gender
Answered: 383 Skipped: 3
300
200
100
0
136
226
17
4
Male
Female
Decline to
Other



Q19

Do you have regular access to the Internet?

Answered: 385 Skipped: 1

Answer Choices	Responses	
Yes	99%	383
No	1%	2
Total		385

END OF SURVEY

A Look at the Citizen Survey Responses

- Over five times as many responses were received compared to the 2012 Citizen Survey conducted for the 2012–2017 LHMP Five Year Update (386 total responses).
- Approximately 58% of respondents own property in the City of Santa Cruz.
- The largest group of respondents (120) live in the two Westside neighborhoods which includes the Upper Westside (University) neighborhood. This area is bounded by large wildland/urban interfaces. The next largest group are from neighborhoods considered as the Eastside of Santa Cruz (65).
- The Beach Flats and Lower Ocean neighborhoods (combined) had one response. Considering that many residents in these neighborhoods are either monolingual or predominately Spanish language speakers, this result points out the need for increased outreach to our Spanish speaking community. There was a Spanish language version of the Citizen Survey available. That version garnered four responses with three coming from and Eastside neighborhood with the age of respondents from 41–70.
- 81% of respondents live *and* work in the City of Santa Cruz (292 of 360 responses).
- 80% of respondents live in the City of Santa Cruz (339)
- 92% are full-time city residents (321of 348 responses)
- 31% of respondents work outside the City of Santa Cruz.
- The largest response percentages concerning hazards experienced by respondents include:
  - Earthquakes.................... 51%
  - Severe Weather 47%
  - Flood 30%
  - Landslide/Rockslide....... 23%
  - Erosion 18%
  - Tsunami.......................... 18%
- In terms of household preparedness for natural hazards, 87% have some degree of preparedness ranging from very well prepared to adequately prepared: 51% of the total (197) respondents noted they are somewhat prepared for natural hazards; 10% are not at all prepared; and, 25% consider themselves adequately prepared.
- Concern for natural hazard impacts to residents' neighborhood shows nearly 90% as "somewhat" or "extremely" concerned.
- Only 7 (2%) respondents out of 383 had made no preparations for emergencies.
- 47% of respondents are "very concerned" with another 50% "somewhat concerned" about the effects of earthquakes. 58% were somewhat concerned about severe weather; and in the same category ("somewhat…") the numbers were: Flooding (58%), Wildland Fire (52%), Tsunami (47%), Coastal Erosion (49%) — note that this is an ongoing concern with our west coast exposure, beaches and tourist attractions; Drought (44%), Land or Rockslides (45%), and Dam/Levee Failure (36%). More information related to these responses can be found in Question 11.

- The internet was the preferred method for getting emergency information (81%) followed by: emergency text messages and alerts (75%), social media (61%), local television (55%) closely followed by Radio (42%), Public Safety Officers (37%), then, Neighborhood groups (35%) and Newspapers (29%). Interestingly but not surprisingly, web-based (including social media) was chosen as the most effective means of communication.
- Among incentives to retrofit homes against disaster, respondents preferred property tax breaks (83%), insurance premium discounts (65%) and permit fee waivers (58%).
- As for survey demographics, the largest respondent groups were 51–70 year olds (48%) and 31–50 year olds (33%). Younger respondents (18–30 years old) made were 9% of survey respondents. The remaining group (71 and older) were 7% of respondents.
- Survey respondents were 59% female and 36% male while 4% declined to specify gender. And, 80% have lived in the city more than 10 years (11–20+ years), including 51% who stated that they have lived in the city more than 20 years.
- 99% of respondents have internet access.
- Open-ended questions garnered these responses concerning reducing risk in the community:
    - Request for specific brochures in print and web-based
    - Tree removal and requiring owners to regularly maintain their trees; provide more and better information for those living in the wildland/urban interface
    - Stronger enforcement of no-camping laws
    - Improving drainage and installation of storm drains
    - Stop development in areas subject to eventual sea level rise dangers
    - Add funds for civilian (CERT) training
    - Install evacuation route signage in areas prone to flooding; road maintenance
    - Increase training for government employees who have specialized roles in the disasters and emergencies
    - Manage the forest, remove dead/old trees and augment other ecosystem protections
    - Ensure adequate water supply in the event of emergencies by maintaining the water delivery infrastructure; build an additional reservoir
    - Increase dam inspections
    - Numerous concerns voiced over transient encampments near waterways (health hazard) and camping/homeless issues in general
    - Provide meetings for the public related to preparedness

LOCAL HAZARD MITIGATION PLAN PLACED AT MAIN BRANCH LIBRARY FOR PUBLIC REVIEW AND COMMENT

HAZARD MITIGATION PLAN

*** Requires Citizen Review & Comments ***

The City of Santa Cruz **Local Hazard Mitigation Plan** is being updated for submittal to the Federal Emergency Management Agency.

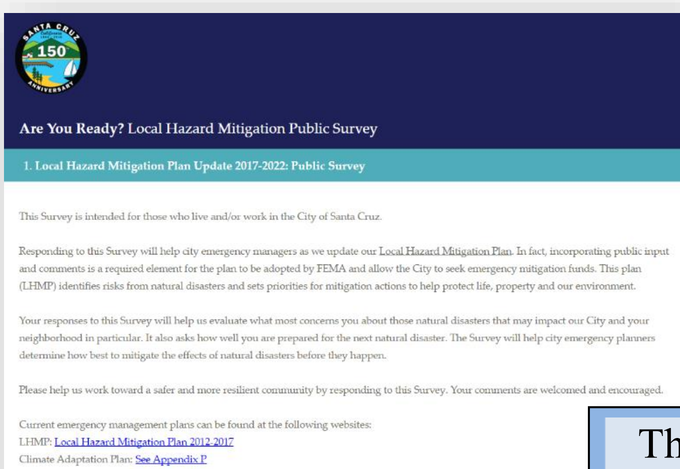
When FEMA approves the plan the city will become eligible to compete for money to fund projects that will help limit the damages from future natural disasters.

Please:

- Read this Local Hazard Mitigation Plan (LHMP)
- The entire LHMP is also on the City of Santa Cruz website at this location: http://www.cityofsantacruz.com/home/showdocument?id=34606
- The Appendices to the LHMP are on these web pages: http://www.cityofsantacruz.com/home/showdocument?id=36530 and http://www.cityofsantacruz.com/home/showdocument?id=36529

Comments:

- You can comment a number of ways:
  - By email to rsolick@cityofsantacruz.com
  - Take our **Citizen Survey** by going to this web page: https://www.surveymonkey.com/r/LHMP_SURVEY
    - Survey responses are confidential


Are You Ready? Local Hazard Mitigation Public Survey

1. Local Hazard Mitigation Plan Update 2017-2022: Public Survey

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Responding to this Survey will help city emergency managers as we update our Local Hazard Mitigation Plan. In fact, incorporating public input and comments is a required element for the plan to be adopted by FEMA and allow the City to seek emergency mitigation funds. This plan (LHMP) identifies risks from natural disasters and sets priorities for mitigation actions to help protect life, property and our environment.

Your responses to this Survey will help us evaluate what most concerns you about those natural disasters that may impact our City and your neighborhood in particular. It also asks how well you are prepared for the next natural disaster. The Survey will help city emergency planners determine how best to mitigate the effects of natural disasters before they happen.

Please help us work toward a safer and more resilient community by responding to this Survey. Your comments are welcomed and encouraged.

Current emergency management plans can be found at the following websites:
LHMP: Local Hazard Mitigation Plan 2012-2017
Climate Adaptation Plan: See Appendix P

Thank you for your interest and comments!

REQUEST FOR REVIEW BY EMERGENCY MANAGEMENT PARTNERS

On the following pages are scanned images of letters and email correspondence sent to, or received from, our community emergency management partners and others requesting their review and comment on the LHMP. Where appropriate and relevant, their corrections, suggestions and additions (also included) have been incorporated into the body of the LHMP.

List of Outreach materials to Emergency Stakeholders and Citizens

- Letter to County of Santa Cruz Emergency Management Council requesting peer and stakeholder review and comment on DRAFT LHMP (April 27, 2017)
- Screenshots of website posting of City Facebook page requesting input on posted "Are You Ready? Local Hazard Mitigation Public Survey" (originally adapted from King County, WA, LHMP outreach) (April 14, 2017)
- Email to Santa Cruz Neighbors requesting they share the Citizen Survey with their members throughout the city. (March 22, 2017)
- Email from Santa Cruz Neighbors to members requesting feedback on the draft LHMP. (May 11, 2017)
- Citizen Survey: "Are You Ready? Local Hazard Mitigation Public Survey" (Complete survey and responses are provided above.)
- Email (with attachment) to County of Santa Cruz Office of Emergency Services requesting peer review of LHMP at 95% completion (July 18, 2017)

Request to Santa Cruz County Emergency Management Council for peer and stakeholder review and comment
April 27, 2017

CITY OF SANTA CRUZ

PUBLIC WORKS DEPARTMENT
809 Center Street, Room 201, Santa Cruz, CA 95060 • 831 420-5160 • Fax: 831 420-5161

April 27, 2017

TO: Santa Cruz County Emergency Management Council

RE: Local Hazard Mitigation Plan Update: Peer and Citizen Review

The City of Santa Cruz needs your assistance in completing the 2017–2022 update to our Local Hazard Mitigation Plan. Our current 2012 FEMA-approved plan allows the city to compete for pre-disaster mitigation funding. Based on FEMA's five-year update requirement, we are reviewing and revising our LHMP and are asking for your peer review and comments on the DRAFT document. The Plan details hazards and risks and includes objectives, goals and specific actions that in turn provide direction for future mitigation activities.

A FEMA requirement for adoption of an LHMP is that it be widely disseminated and reviewed among stakeholders and within the community and, that it be reviewed during its development. Further, opportunities need to be provided for comment in a variety of settings — online, via surveys, at public meetings and through peer review. As jurisdictional stakeholders you are the emergency management partners that either work for, or assist, the City of Santa Cruz during disasters by providing direct support, mutual aid or other significant collaboration.

Stakeholder/Partner Review

- PDF versions of the DRAFT LHMP will be made available early in May 2017 (by email) for your review and comment.
- Your review should encompass the overall plan and, your comments should focus on how well the LHMP addresses local hazards and mitigation strategies. Your unique perspective as emergency management partners and mutual aid responders is valuable in completing and enhancing this Plan.

Deadline

We would appreciate having your comments back to me no later than June 2, 2017. Contact information is below. Our intention is to have the LHMP submitted to CalOES, for initial approval, by the end of July or early August.

Thank you for taking the time to review this important material and for returning your comments to me. My contact information is included below.

Sincerely,

Robert Solick

Robert Solick
LHMP PROJECT MANAGER
Management Professional and Technical Assistant
809 Center Street, Room 201• Santa Cruz, CA 95060
831-420-5169 • *email*: rsolick@cityofsantacruz.com

County of Santa Cruz Emergency Management Council Agenda — Presentation requesting peer and emergency managers' review of LHMP
May 4, 2017

County of Santa Cruz

THE GREAT SEAL OF THE COUNTY OF SANTA CRUZ 1850 SINE PRAEJUDICIO

EMERGENCY MANAGEMENT COUNCIL
Tel: (831) 454-2188 Fax: (831) 454-2350

Meeting: May 4, 2017
Time: 2:00–4:00 p.m.
Location: EOC—5200 Soquel Ave. Building C 2nd floor Santa Cruz, Ca 95062

AGENDA

1.0 Call to Order/Introductions
2.1 Roll Call (*Emergency Management Council Appointed Members*)
  2.2 Attendees:
  2.3 Absent:
  2.4 Absent with Notice: Patrick Goff, Rosemary Anderson, Brian Sherin
3.0 Additions and Deletions to the Agenda
4.0 Approval of Minutes: N/A
5.0 Correspondence (*All*)
6.0 Oral Communications: *Regarding items not on the Agenda*
7.0 Presentation: None scheduled
8.0 New Business:
9.1 Informational Reports
  9.2 County Office of Emergency Services/Update
  We are in the process of planning for a table top exercise on July 7 with a focus on mass care and sheltering. We will be inviting EMC members to participate.
  9.3 City Reports
    9.3.1 Capitola ....*Captain Tom Held*
    9.3.2 Santa Cruz ....*Paul Horvat/Robert Solick --EMC review of SC City LHMP*
    9.3.3 Scotts Valley ....*Lt. John Wilson*
    9.3.4 Watsonville..........*Chief Pablo Barreto*
  9.4 Grant Updates
    9.4.1 2015 State Homeland Security Grant –detailed project status as of 5/30/17 is due to us by 6/15/17 (Santa Cruz PD and Scotts Valley PD)
    9.4.2 2016 State Homeland Security Grant – approved 4.11.2016 – funding letters will be sent out by end of May.
    9.4.3 2017 State Homeland Security Grant – submitted, waiting for State approval
10.0 Citizen Corps Council
    11.1.1. CERT ....Todd Skrabak
    11.1.2. Medical Reserve Corp .... *Dave Newell*
    11.1.3. ARES ....*Cap Pennell*
    11.1.4. Equine Evacuation.......... *Donna Stidolph/Kali Haber*
    11.1.5. Volunteer Organizations Active in Disasters (VOAD) .... *Jim Uhey*
    11.1.6. County Office of Education.......... *Jim Howes*
11.0 Announcements (*All*)
12.0 Items for future meetings
13.0 Adjourn
14.0 Next Meeting: September 7, 2017 2-4 PM Location: EOC

For information on the Emergency Management Council use the following link:
Santa Cruz County Code: EMC

Request to Santa Cruz Neighbors for residents review and comment
March 22, 2017

Wed 3/22/2017 10:34 AM
Robert Solick
City of Santa Cruz Needs Your Members Help with Disaster Planning
To [redacted]arthlink.net'
Cc 'email@santacruzneighbors.com'

Hello Deborah,

The City of Santa Cruz is working on a **Five Year Update to our Local Hazard Mitigation Plan**. It is a FEMA requirement that the public has an opportunity to comment on the Plan and that we incorporate citizen concerns and comments into the Plan. With that in mind, we are asking for your group's help in getting the Citizen Survey: "Are You Ready?" to your members for their review and comment.

To increase our outreach to the public, it would be a great help to us if you make our Survey available on your website, and social media pages via your email list, or in any other ways you can to get this to your members.

Here is some suggested text you can use to introduce the survey to your City of Santa Cruz members.

> **Help Santa Cruz Prepare for Disasters Before They Happen**
> **Take the Survey: "Are You Ready?"**
>
> The City of Santa Cruz is asking residents to help them update the Local Hazard Mitigation Plan. The Plan identifies risks from natural disasters in order is to reduce the impacts to life, property and the environment from natural disasters when they occur. When the Plan is adopted by the state and FEMA the City can compete for grant funding to help prevent and reduce risks and vulnerabilities in your neighborhood.
>
> Please help the City of Santa Cruz work towards a safer and more resilient community by responding to their survey. Your comments are welcomed and encouraged. Responses are anonymous. To take the survey click this link: Citizen Survey - Are You Ready?

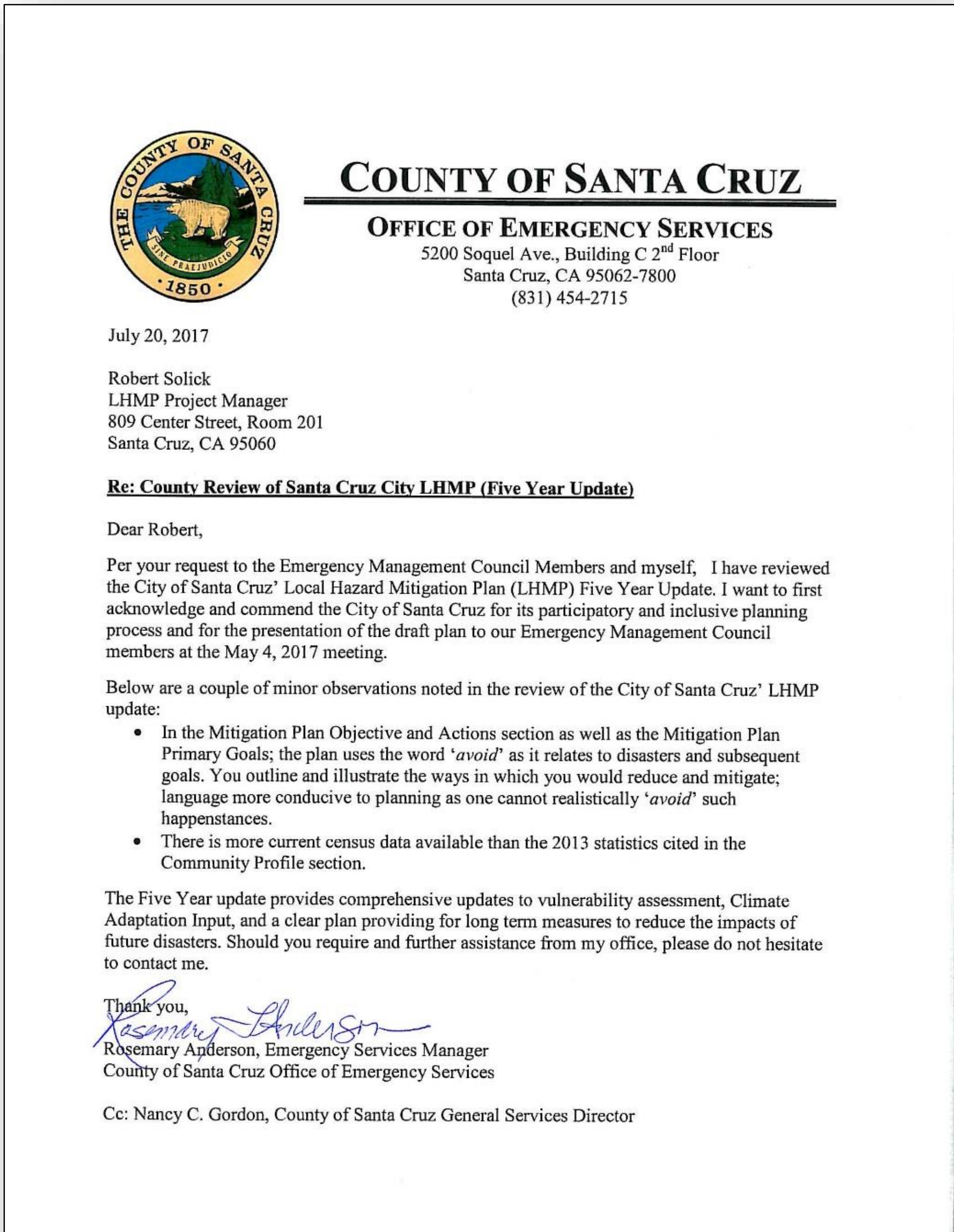
Thank you. You can contact me with any questions you or your members may have. We value your input!

Robert Solick

Robert Solick
Project Manager
City of Santa Cruz
Local Hazard Mitigation Plan: Update
831-420-5169 (w)

Santa Cruz Neighbors is a city-wide 501(c)3 nonprofit organization representing a network of neighborhoods which partners with educational institutions, local government, local businesses, and non-profits dedicated to safer neighborhoods, community oriented government and provides a neighborhood voice for the residents of Santa Cruz. (Santa Cruz Neighbors)

County of Santa Cruz OES/Emergency Services Manager Review
July 20, 2017



COUNTY OF SANTA CRUZ

OFFICE OF EMERGENCY SERVICES
5200 Soquel Ave., Building C 2nd Floor
Santa Cruz, CA 95062-7800
(831) 454-2715

July 20, 2017

Robert Solick
LHMP Project Manager
809 Center Street, Room 201
Santa Cruz, CA 95060

Re: County Review of Santa Cruz City LHMP (Five Year Update)

Dear Robert,

Per your request to the Emergency Management Council Members and myself, I have reviewed the City of Santa Cruz' Local Hazard Mitigation Plan (LHMP) Five Year Update. I want to first acknowledge and commend the City of Santa Cruz for its participatory and inclusive planning process and for the presentation of the draft plan to our Emergency Management Council members at the May 4, 2017 meeting.

Below are a couple of minor observations noted in the review of the City of Santa Cruz' LHMP update:

- In the Mitigation Plan Objective and Actions section as well as the Mitigation Plan Primary Goals; the plan uses the word '*avoid*' as it relates to disasters and subsequent goals. You outline and illustrate the ways in which you would reduce and mitigate; language more conducive to planning as one cannot realistically '*avoid*' such happenstances.
- There is more current census data available than the 2013 statistics cited in the Community Profile section.

The Five Year update provides comprehensive updates to vulnerability assessment, Climate Adaptation Input, and a clear plan providing for long term measures to reduce the impacts of future disasters. Should you require and further assistance from my office, please do not hesitate to contact me.

Thank you,

Rosemary Anderson, Emergency Services Manager
County of Santa Cruz Office of Emergency Services

Cc: Nancy C. Gordon, County of Santa Cruz General Services Director

Additional comments received:

- Patrick Goff, P.E. • Executive Director •Environmental Health and Safety Office of Emergency Services • University of California, Santa Cruz

City of Santa Cruz
Local Hazard Mitigation Plan Update: Facebook Posting of Citizen Survey
March 24, 2017

Below is a screenshot of the City of Santa Cruz Government Facebook page showing the posting (March 24, 2017) of the _Are You Ready? Local Hazard Mitigation Public Survey_. Note that the posting has a link for a Spanish language version of the survey

Santa Cruz Neighbors requests members to respond to the Citizen Survey
May 11, 2017

From:
Sent: Thursday, May 11, 2017 12:55 PM
To:
Subject: IMPORTANT - Please fill out for City EMERGENCY Managers

Responding to this Survey will help city emergency managers as we update our Local Hazard Mitigation Plan. In fact, incorporating public input and comments is a required element for the plan to be adopted by FEMA and allow the City to seek emergency mitigation funds. This plan (LHMP) identifies risks from natural disasters and sets priorities for mitigation actions to help protect ... life, property and our environment.
Your responses to this Survey will help us evaluate what most concerns you about those natural disasters that may impact our City and your neighborhood in particular. It also asks how well you are prepared for the next natural disaster. The Survey will help city emergency planners determine how best to mitigate the effects of natural disasters before they happen.
Please help us work toward a safer and more resilient community by responding to this Survey. Your comments are welcomed and encouraged.

GOTO:

http://www.cityofsantacruz.com/Home/Components/News/News/5427/

OR

Fill out ATTACHMENT and email to: rsolick@cityofsantacruz.com

Santa Cruz Neighbors, Inc.

15 years of Neighbors Helping Neighbors

www.santacruzneighbors.org
email@santacruzneighbors.org

LIKE and follow us on Facebook
https://www.facebook.com/santacruz.neighbors
Join your own Neighborhood at Nextdoor.com

Endnotes

1 City of Santa Cruz General Plan Safety Element October 25, 1994

2 City of Santa Cruz Downtown Recovery Program- Adopted 1991

3 UCSC LRDP (Long Range Development Plan) 2005–2020

4 http://lrdp.ucsc.edu/MonitoringReports/2015-16_Settlement_Report.pdf (http://lrdp.ucsc.edu/)

5 UCSC LRDP 2005–2020

6 Seismicity of the United States, 1568-1989 (Revised) by Carl W. Stover and Jerry L. Coffman, U.S. Geological Survey Professional Paper 1527, US Government Printing Office, Washington: 1993.

7 https://earthquake.usgs.gov/

8 https://www2.usgs.gov/science/science.php?term=302

9 https://www.ce.washington.edu/research/areas/geotechnical

10 http://eps.ucsc.edu/

11 http://eps.ucsc.edu/

12 Estimation of Future Earthquake Losses in California

13 http://www.conservation.ca.gov/cgs/rghm/loss/Pages/2016_Analysis.aspx

14 California Coastal Commission ReCAP Pilot Project Findings and Recommendations: Monterey Bay Region

15 Wildland Pre-Suppression Plan for the Mutual Threat Zone Areas; September 1990 Santa Cruz Fire Department and California Department of Forestry.

16 FEMA Flood Insurance Study Number 06087CV000A; March 2, 2006, Page 15

17 http://nwis.waterdata.usgs.gov/ca/nwis/peak

18 (Stormwater Public Works)

19 California Coastal Commission ReCAP Pilot Project Findings and Recommendations: Monterey Bay Region

20 Tsunamis Affecting the West Coast of the United States 1806-1992 NOAA (Dec 1993)

21 The Tsunami Hazard in California, California Seismic Safety Commission (Dec 2005)

22 Inundation maps for the State of California, Richard K Eisner, Jose C. Borrero, and Costas E. Synolakis (Governor's Office of Emergency Services).

23 Inundation maps for the State of California, Richard K Eisner, Jose C. Borrero, and Costas E. Synolakis (Governor's Office of Emergency Services).

24 San Jose Mercury News Little is known about damage giant wave could cause By Glennda Chui (June 25, 2005)

25 California Coastal Commission ReCAP Pilot Project Findings and Recommendations: Monterey Bay Region

26 Evaluation of Erosion hazards - Heinz Center Coastal Erosion Mapping and Management - Journal of Coastal Research)

27 Draft Review of California Coastal Erosion Planning and Response: A Strategy for Action Gary D. Nichols, California Resources Agency March 2003

28 Living with The Changing California Coast by G.B. Griggs, K, Patsch and L. E. Savoy- University of California Press

29 California Coastal Commission ReCAP Pilot Project Findings and Recommendations: Monterey Bay Region

30 City of Santa Cruz General Plan

31 https://www.ready.gov/landslides-debris-flow

32 Santa Cruz County Office of Emergency Services

33 City of Santa Cruz 2005 Urban Water Management Plan, February 2006

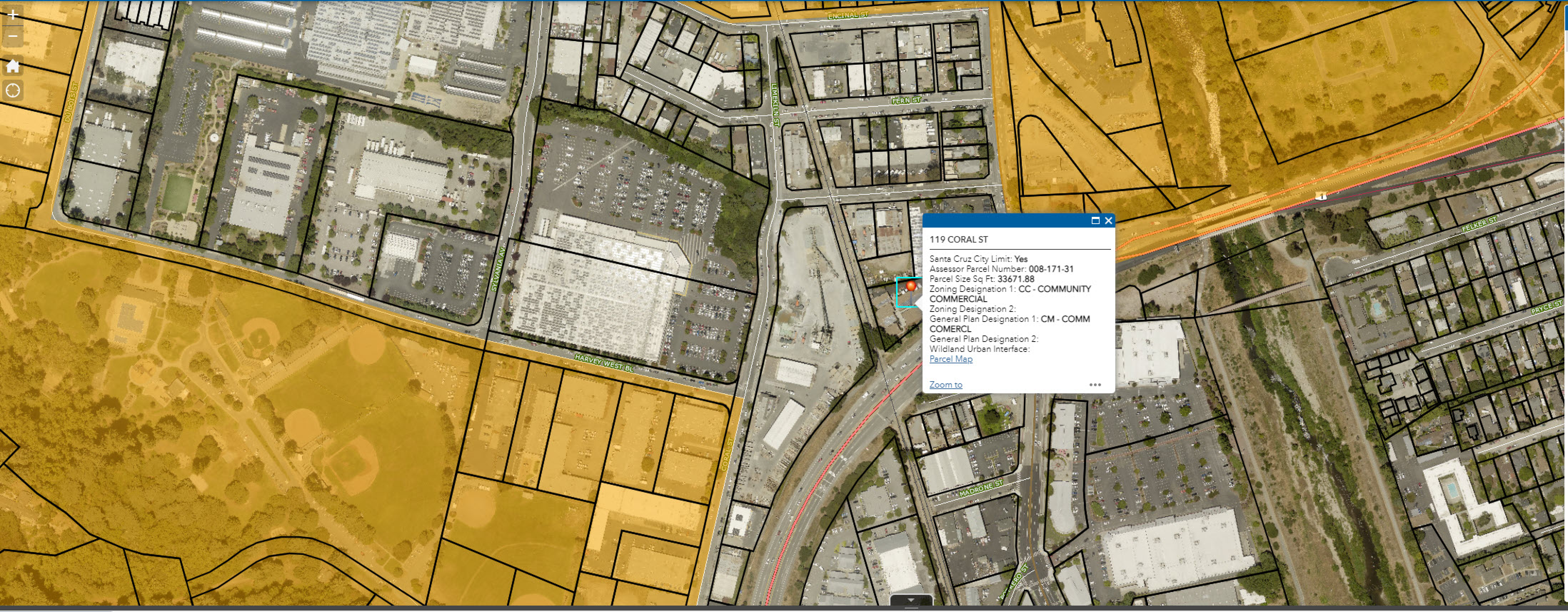
34 City of Santa Cruz 2005 Urban Water Management Plan, February 2006

35 http://landslides.usgs.gov/


ZONEHAVEN AWARE
119 Coral Street, Santa Cruz, C
Santa Cruz County
BRN-E010
SCZ-E010
SCZ-E011
SCZ-E007
SCZ-E009
SCZ-E008
SCZ-E019
SCZ-E020
SCZ-E017
SCZ-E018
SCZ-E024
SCZ-E025
SCZ-E016
ZONE SCZ-E008
STATUS Normal
No current knowledge of active public safety incidents affecting your area.
REASON -
SUMMARY -
DESCRIPTION * South of Encinal Street, Pioneer Street and Vernon Street, West of San Lorenzo River, Northwest of Cabrillo Hwy 1, North of Evergreen Street and Havey W Blvd, East of Du Bois Street.
USEFUL LINKS -
EVACUATION INFO
FIRE AND POLICE INFO
Temporary Evacuation Points -
Last changed on Wed Jul 21 2021 03:22 AM. Current as of Thu Nov 04 2021 07:22 PM
Satellite
500 ft
2021-11-04 07:23:20 PM (EST) | Terms | Feedback

Zoning/Land Use/Wildland Urban Interface

Planning and Community Development



119 CORAL ST

Santa Cruz City Limit: **Yes**
Assessor Parcel Number: **008-171-31**
Parcel Size Sq Ft: **33671.88**
Zoning Designation 1: **CC - COMMUNITY COMMERCIAL**
Zoning Designation 2:
General Plan Designation 1: **CM - COMM COMERCL**
General Plan Designation 2:
Wildland Urban Interface:
Parcel Map

Zoom to

Address or Parcel Search

By Value | Results

Features selected: 1

119 CORAL ST
Santa Cruz City Limit: **Yes**
Assessor Parcel Number: **008-171-31**
Parcel Size Sq Ft: **33671.88**
Zoning Designation 1: **CC - COMMUNITY COMMERC**
Zoning Designation 2:
General Plan Designation 1: **CM - COMM COMERCL**
General Plan Designation 2:
Wildland Urban Interface:
Parcel Map

Search Results: Address

Options | Filter by map extent | Zoom to | Clear selection | Refresh

Assessor Parcel Number	Address	Parcel Size Sq Ft	Zoning Designation 1	Zoning Designation 2	General Plan Designation 1	General Plan Designation 2	Wildland Urban Interface	Santa Cruz City Limit	HLINK
008-171-31	119 CORAL ST	33671.88	CC - COMMUNITY COMMERCIAL		CM - COMM COMERCL			Yes	https://gis.santacruzcounty.us/gisweb/Scans/

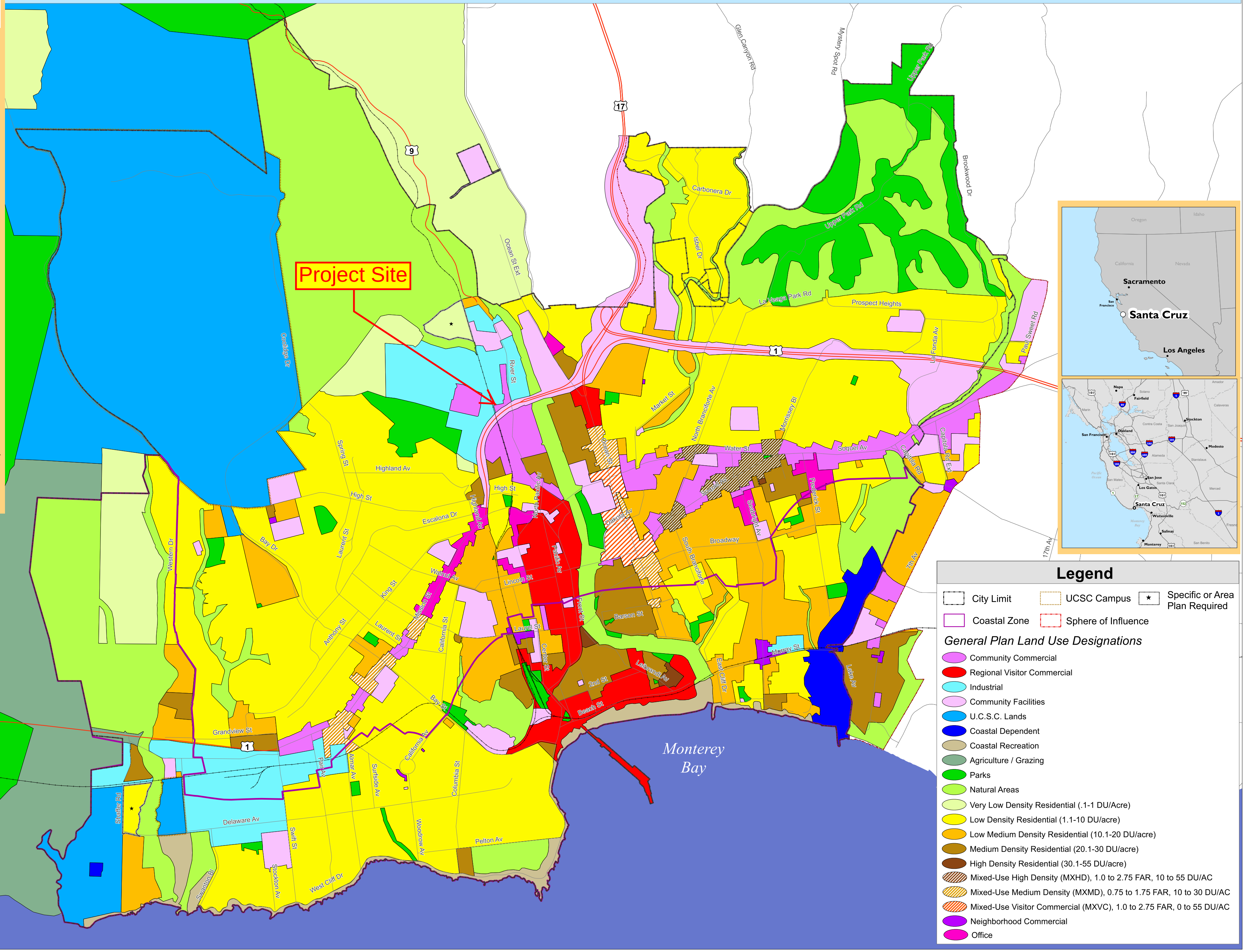
General Plan Land Use Designations

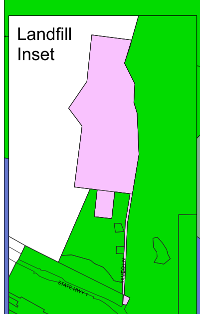
City of Santa Cruz
Planning Department
809 Center St. Room 206
Santa Cruz, CA 95060
Ph: 420-5100

SANTA CRUZ 2030

The Land Use Diagram is intended to be used in conjunction with the General Plan 2030 Goals, Policies and Programs Document. The document describes the guidelines, standards, and description of the land use designations on the map.

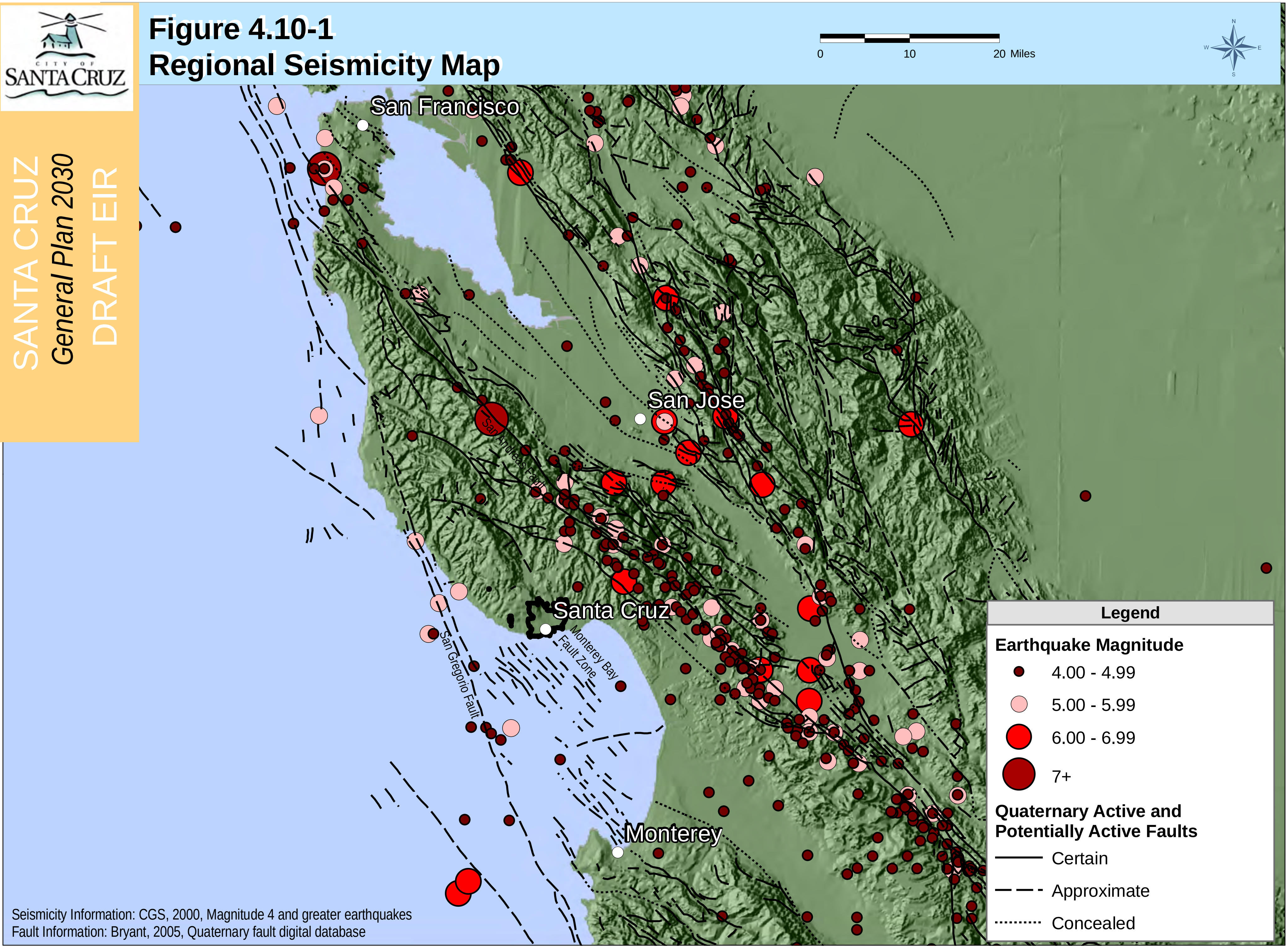
Projection: California State Plane Nad 83 Zone 3 (Feet)





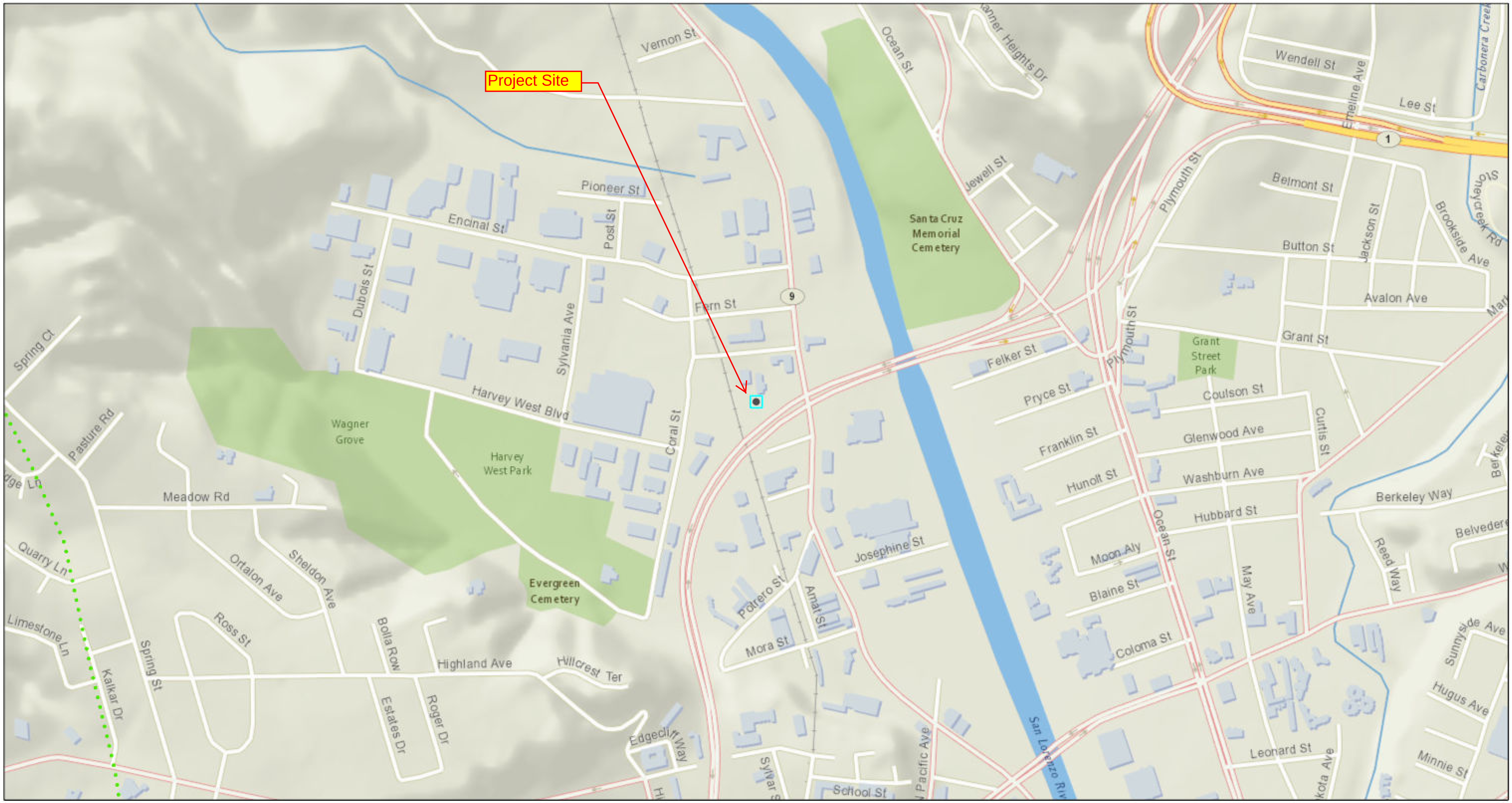
SANTA CRUZ
General Plan 2030
DRAFT EIR

Figure 4.10-1
Regional Seismicity Map



Seismicity Information: CGS, 2000, Magnitude 4 and greater earthquakes
Fault Information: Bryant, 2005, Quaternary fault digital database

U.S. Geological Survey Quaternary Faults



11/4/2021, 7:11:02 PM

1:9,028

0 0.07 0.15 0.3 mi

0 0.13 0.25 0.5 km

Fault Areas

- Class B
- historic
- late Quaternary
- latest Quaternary
- middle and late Quaternary

National Database

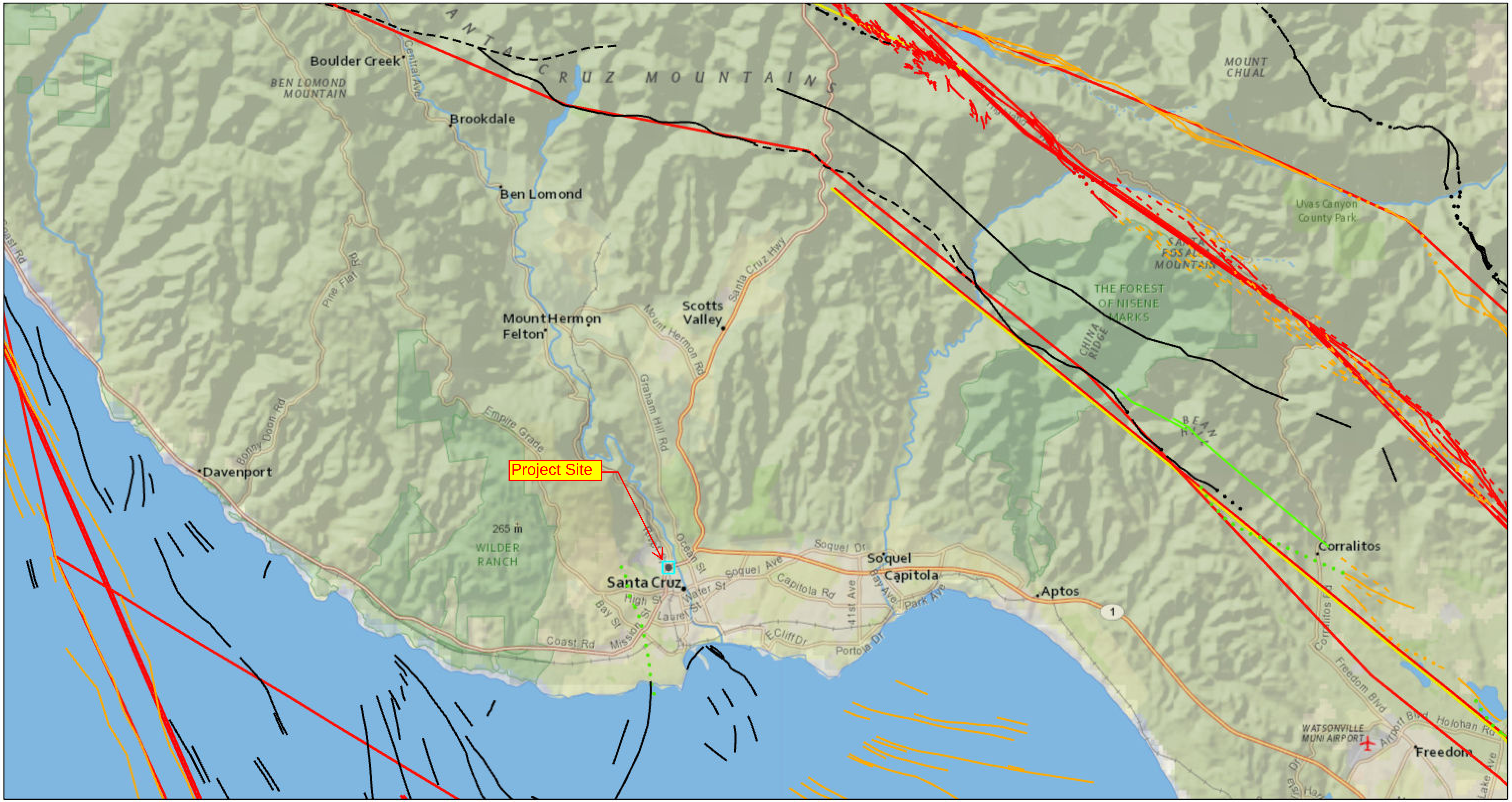
- Historic (< 150 years), well constrained location
- Historic (< 150 years), moderately constrained location
- Historic (< 150 years), inferred location
- Latest Quaternary (<15,000 years), well constrained location
- Latest Quaternary (<15,000 years), moderately constrained location
- Latest Quaternary (<15,000 years), inferred location
- Late Quaternary (< 130,000 years), well constrained location
- Late Quaternary (< 130,000 years), moderately contrained location
- Late Quaternary (< 130,000 years), inferred location
- Middle and late Quaternary (< 750,000 years), well constrained location
- Middle and late Quaternary (< 750,000 years), moderately constrained location
- Middle and late Quaternary (< 750,000 years), inferred location
- Undifferentiated Quaternary (< 1.6 million years), well constrained location
- Undifferentiated Quaternary (< 1.6 million years), moderately constrained location
- Undifferentiated Quaternary (< 1.6 million years), inferred location
- Unspecified age, well constrained location
- Unspecified age, moderately constrained location

National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

USGS

National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. | USGS |

U.S. Geological Survey Quaternary Faults



11/4/2021, 7:43:10 PM

1:144,448

0 1.5 3 6 mi

0 2.25 4.5 9 km

Fault Areas

- Class B
- historic
- late Quaternary
- latest Quaternary
- middle and late Quaternary

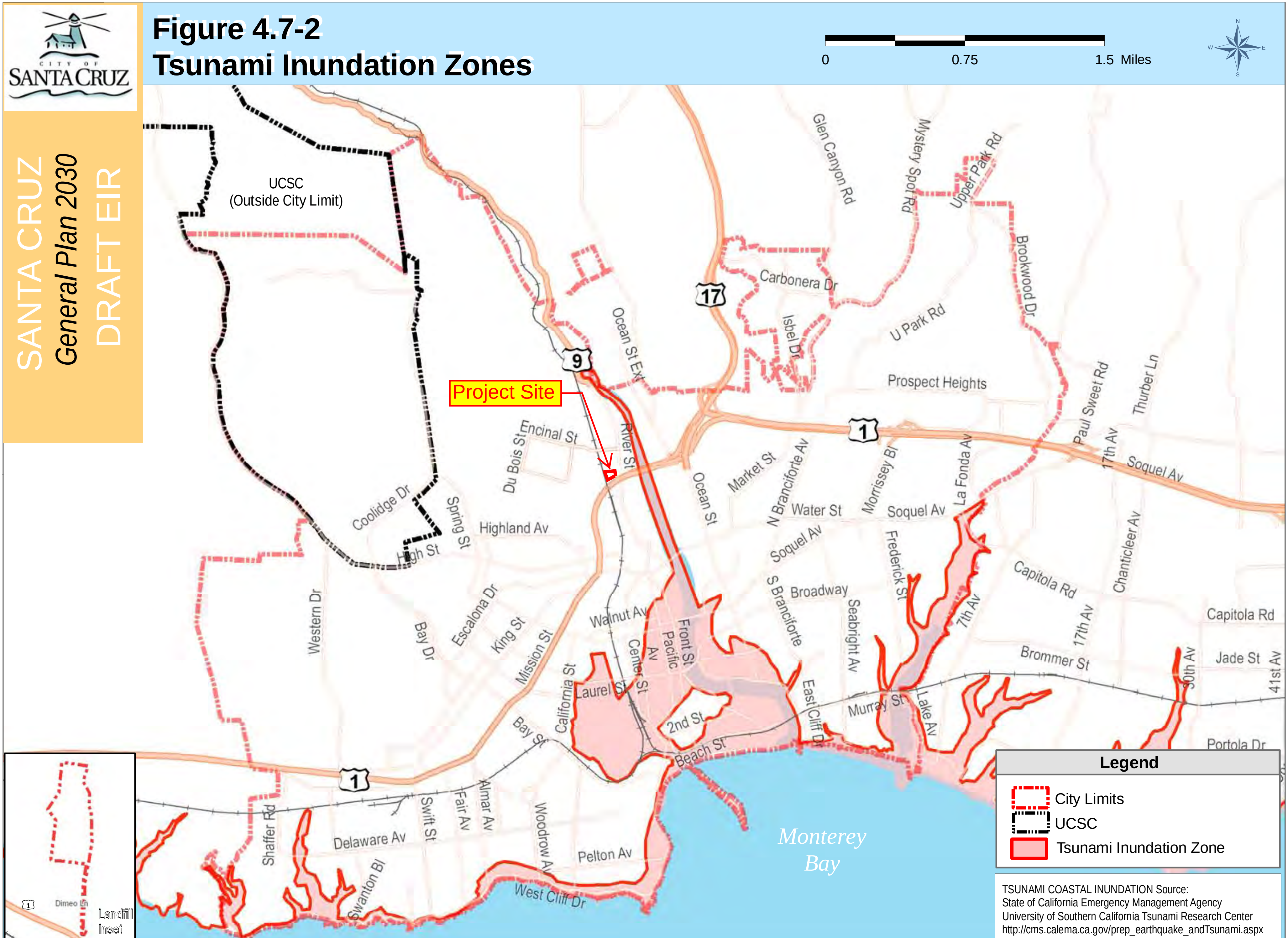
National Database

- Historic (< 150 years), well constrained location
- Historic (< 150 years), moderately constrained location
- Historic (< 150 years), inferred location
- Latest Quaternary (<15,000 years), well constrained location
- Latest Quaternary (<15,000 years), moderately constrained location
- Latest Quaternary (<15,000 years), inferred location
- Late Quaternary (< 130,000 years), well constrained location
- Late Quaternary (< 130,000 years), moderately contrained location
- Late Quaternary (< 130,000 years), inferred location
- Middle and late Quaternary (< 750,000 years), well constrained location
- Middle and late Quaternary (< 750,000 years), moderately constrained location
- Middle and late Quaternary (< 750,000 years), inferred location
- Undifferentiated Quaternary (< 1.6 million years), well constrained location
- Undifferentiated Quaternary (< 1.6 million years), moderately constrained location
- Undifferentiated Quaternary (< 1.6 million years), inferred location
- Unspecified age, well constrained location
- Unspecified age, moderately constrained location

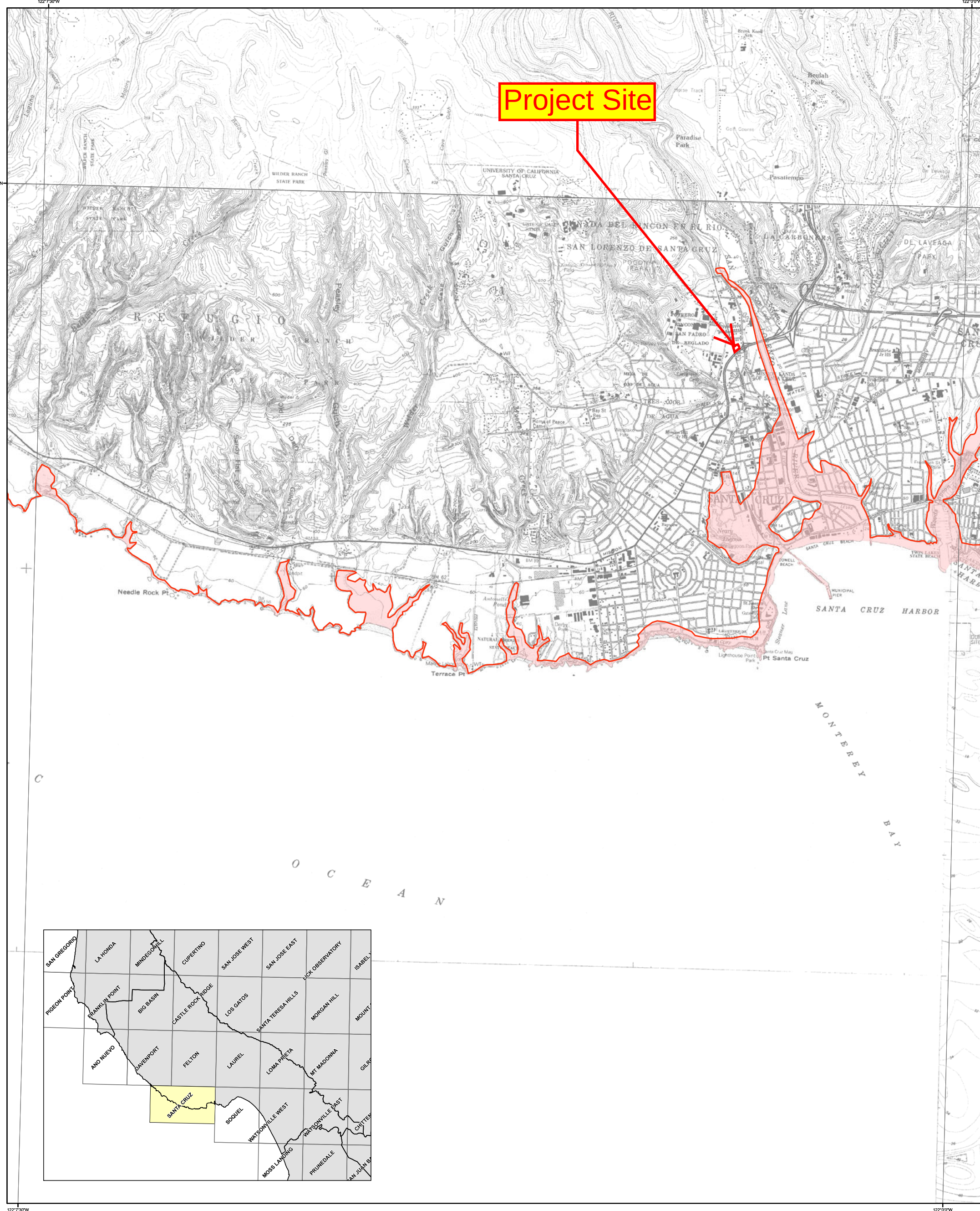
USGS, National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

USGS
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. | USGS |

Figure 4.7-2
Tsunami Inundation Zones



Tsunami Inundation Map for Emergency Planning
Santa Cruz Quadrangle



METHOD OF PREPARATION

Initial tsunami modeling was performed by the University of Southern California (USC) Tsunami Research Center funded through the California Emergency Management Agency (CalEMA) by the National Tsunami Hazard Mitigation Program. The tsunami modeling process utilized the MOST (Method of Splitting Tsunamis) computational program (Version 0), which allows for wave evolution over a variable bathymetry and topography used for the inundation mapping (Titov and Gonzalez, 1997; Titov and Synolakis, 1998).

The bathymetric/topographic data that were used in the tsunami models consist of a series of nested grids. Near-shore grids with a 3 arc-second (75- to 90-meters) resolution or higher, were adjusted to "Mean High Water" sea-level conditions, representing a conservative sea level for the intended use of the tsunami modeling and mapping.

A suite of tsunami source events was selected for modeling, representing realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides (Table 1). Local tsunami sources that were considered include offshore reverse-thrust faults, restraining bends on strike-slip fault zones and large submarine landslides capable of significant seafloor displacement and tsunami generation. Distant tsunami sources that were considered include great subduction zone events that are known to have occurred historically (1960 Chile and 1964 Alaska earthquakes) and others which can occur around the Pacific Ocean "Ring of Fire."

In order to enhance the result from the 75- to 90-meter inundation grid data, a method was developed utilizing higher-resolution digital topographic data (3- to 10-meters resolution) that better defines the location of the maximum inundation line (U.S. Geological Survey, 1993; Intermap, 2003; NOAA, 2004). The location of the enhanced inundation line was determined by using digital imagery and terrain data on a GIS platform with consideration given to historic inundation information (Lander, et al., 1993). This information was verified, where possible, by field work coordinated with local county personnel.

The accuracy of the inundation line shown on these maps is subject to limitations in the accuracy and completeness of available terrain and tsunami source information, and the current understanding of tsunami generation and propagation phenomena as expressed in the models. Thus, although an attempt has been made to identify a credible upper bound to inundation at any location along the coastline, it remains possible that actual inundation could be greater in a major tsunami event.

This map does not represent inundation from a single scenario event. It was created by combining inundation results for an ensemble of source events affecting a given region (Table 1). For this reason, all of the inundation region in a particular area will not likely be inundated during a single tsunami event.

References:

Intermap Technologies, Inc., 2003, Intermap product handbook and quick start guide: Intermap NEXTmap document on 5-meter resolution data, 112 p.

Lander, J.F., Lockridge, P.A., and Kozuch, M.J., 1993, Tsunamis Affecting the West Coast of the United States 1806-1992: National Geophysical Data Center Key to Geophysical Record Documentation No. 29, NOAA, NESDIS, NGDC, 242 p.

National Atmospheric and Oceanic Administration (NOAA), 2004, Interferometric Synthetic Aperture Radar (IfSAR) Digital Elevation Models from GeoSAR platform (EarthData): 3-meter resolution data.

Titov, V.V., and Gonzalez, F.I., 1997, Implementation and Testing of the Method of Tsunami Splitting (MOST): NOAA Technical Memorandum ERL PMEL – 112, 11 p.

Titov, V.V., and Synolakis, C.E., 1998, Numerical modeling of tidal wave runup: Journal of Waterways, Port, Coastal and Ocean Engineering, ASCE, 124 (4), pp 157-171.

U.S. Geological Survey, 1993, Digital Elevation Models: National Mapping Program, Technical Instructions, Data Users Guide 5, 48 p.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Santa Cruz

SANTA CRUZ QUADRANGLE

July 1, 2009

SCALE 1:24,000

Table 1: Tsunami sources modeled for the Santa Cruz County coastline.

Sources (M = moment magnitude used in modeled event)		Areas of Inundation Map Coverage and Sources Used		
		Pescadero	Santa Cruz	Monterey Bay Big
Local Source	Monterey Canyon Landslide			X
Distant Sources	Cascadia Subduction Zone-full rupture (M9.0)		X	
	Central Aleutians Subduction Zone #1 (M8.9)	X	X	X
	Central Aleutians Subduction Zone #2 (M8.9)		X	
	Central Aleutians Subduction Zone #3 (M9.2)	X		X
	Chile North Subduction Zone (M9.4)		X	
	1960 Chile Earthquake (M9.3)		X	
	1964 Alaska Earthquake (M9.2)	X	X	X
	Japan Subduction Zone #2 (M8.8)		X	
	Kuril Islands Subduction Zone #2 (M8.8)		X	
	Kuril Islands Subduction Zone #3 (M8.8)		X	
	Kuril Islands Subduction Zone #4 (M8.8)		X	
	Marianas Subduction Zone (M8.6)	X		X

MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

PURPOSE OF THIS MAP

This tsunami inundation map was prepared to assist cities and counties in identifying their tsunami hazard. It is intended for local jurisdictional, coastal evacuation planning uses only. This map, and the information presented herein, is not a legal document and does not meet disclosure requirements for real estate transactions nor for any other regulatory purpose.

The inundation map has been compiled with best currently available scientific information. The inundation line represents the maximum considered tsunami runup from a number of extreme, yet realistic, tsunami sources. Tsunamis are rare events; due to a lack of known occurrences in the historical record, this map includes no information about the probability of any tsunami affecting any area within a specific period of time.

Please refer to the following websites for additional information on the construction and/or intended use of the tsunami inundation map:

State of California Emergency Management Agency, Earthquake and Tsunami Program:
http://www.oes.ca.gov/WebPage/oeswebsite.nsf/Content/B1EC51BA215931768825741F005E8D80?OpenDocument

University of Southern California – Tsunami Research Center:
http://www.usc.edu/dept/tsunamis/2005/index.php

State of California Geological Survey Tsunami Information:
http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/index.htm

National Oceanic and Atmospheric Agency Center for Tsunami Research (MOST model):
http://nctr.pmel.noaa.gov/time/background/models.html

MAP BASE

Topographic base maps prepared by U.S. Geological Survey as part of the 7.5-minute Quadrangle Map Series (originally 1:24,000 scale). Tsunami inundation line boundaries may reflect updated digital orthophotographic and topographic data that can differ significantly from contours shown on the base map.

DISCLAIMER

The California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS) make no representation or warranties regarding the accuracy of this inundation map nor the data from which the map was derived. Neither the State of California nor USC shall be liable under any circumstances for any direct, indirect, special, incidental or consequential damages with respect to any claim by any user or any third party on account of or arising from the use of this map.

Cal EMA
CALIFORNIA EMERGENCY MANAGEMENT AGENCY

CGS
CALIFORNIA GEOLOGICAL SURVEY

USC
UNIVERSITY OF SOUTHERN CALIFORNIA


FHSZ Viewer
Legend
City Boundaries
Incorporated Area
FHSZ in LRA
VHFHSZ
FHSZ in SRA
Very High
High
Moderate
SRA
Local Responsibility Area (LRA)
State Responsibility Area (SRA)
Federal Responsibility Area (FRA)
Project Site
Santa Cruz
Soquel
Capitola
Twin Lakes
Cabrillo Hwy
Coast Rd
Highland Ave
High St
Water St
Soquel Ave
Morrissey Blvd
Portola Dr
Delaware Ave
0 0.2 0.4mi

SANTA CRUZ COUNTY

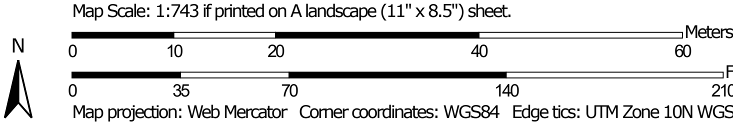
CAL FIRE
FRAP
Fire and Resource Assessment Program
California Department of Forestry and Fire Protection

Obtain FRAP maps, data, metadata and publications on the Internet at http://frap.cdf.ca.gov
For more information, contact CAL FIRE-FRAP, PO Box 944246, Sacramento, CA 94244-2460, (916) 327-3939.

Arnold Schwarzenegger, Governor,
State of California
Mike Chrisman, Secretary for Resources,
The Resources Agency
Ruben Grijalva, Director,
Department of Forestry and Fire Protection

MAP ID: FHSZL06_1_MAP
DATA SOURCES
CAL FIRE Fire Hazard Severity Zones (FHSZL06_1)
CAL FIRE State Responsibility Areas (SRA05_4)
CAL FIRE Incorporated Cities (Incorp07_2)
PLSS (1:100,000 USGS, Land Grants with CAL FIRE grid)

Map Scale: 1:743 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

0 - 5

5 - 15

15 - 45

45 - 60

60 - 100

Not rated or not available

Soil Rating Lines

0 - 5

5 - 15

15 - 45

45 - 60

60 - 100

Not rated or not available

Soil Rating Points

0 - 5

5 - 15

15 - 45

45 - 60

60 - 100

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Santa Cruz County, California
Survey Area Data: Version 15, Sep 9, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 13, 2020—Apr 24, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Representative Slope

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
170	Soquel loam, 0 to 2 percent slopes	1.0	1.0	85.9%
171	Soquel loam, 2 to 9 percent slopes	6.0	0.2	14.1%
Totals for Area of Interest			**1.1**	**100.0%**

Description

Slope gradient is the difference in elevation between two points, expressed as a percentage of the distance between those points.

The slope gradient is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Rating Options

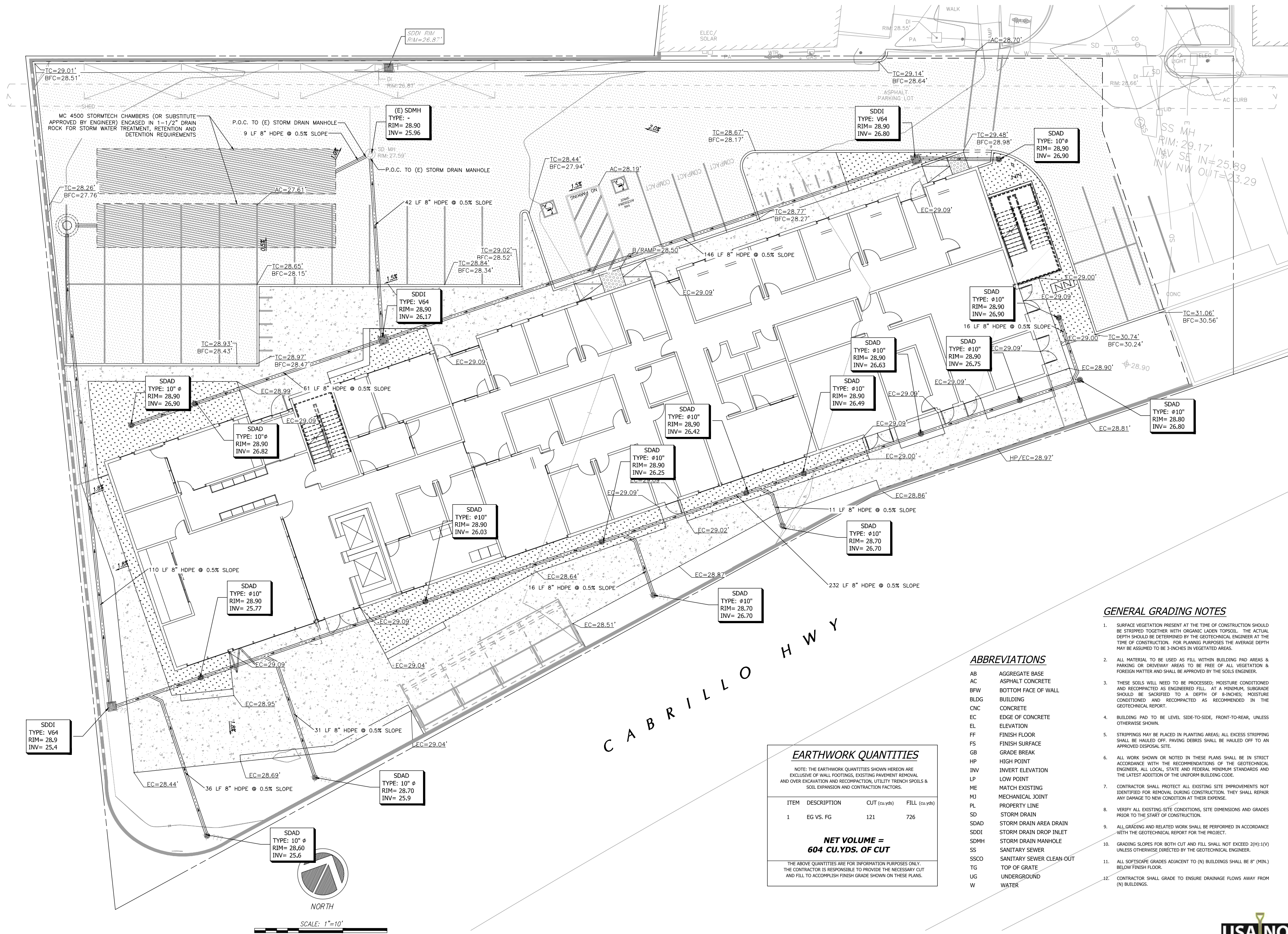
Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No



GENERAL GRADING NOTES

1. SURFACE VEGETATION PRESENT AT THE TIME OF CONSTRUCTION SHOULD BE STRIPPED TOGETHER WITH ORGANIC LADEN TOPSOIL. THE ACTUAL DEPTH SHOULD BE DETERMINED BY THE GEOTECHNICAL ENGINEER AT THE TIME OF CONSTRUCTION. FOR PLANNIG PURPOSES THE AVERAGE DEPTH MAY BE ASSUMED TO BE 3-INCHES IN VEGETATED AREAS.
2. ALL MATERIAL TO BE USED AS FILL WITHIN BUILDING PAD AREAS & PARKING OR DRIVEWAY AREAS TO BE FREE OF ALL VEGETATION & FOREIGN MATTER AND SHALL BE APPROVED BY THE SOILS ENGINEER.
3. THESE SOILS WILL NEED TO BE PROCESSED; MOISTURE CONDITIONED AND RECOMPACTED AS ENGINEERED FILL. AT A MINIMUM, SUBGRADE SHOULD BE SACRIFIED TO A DEPTH OF 8-INCHES; MOISTURE CONDITIONED AND RECOMPACTED AS RECOMMENDED IN THE GEOTECHNICAL REPORT.
4. BUILDING PAD TO BE LEVEL SIDE-TO-SIDE, FRONT-TO-REAR, UNLESS OTHERWISE SHOWN.
5. STRIPPINGS MAY BE PLACED IN PLANTING AREAS; ALL EXCESS STRIPPING SHALL BE HAULED OFF. PAVING DEBRIS SHALL BE HAULED OFF TO AN APPROVED DISPOSAL SITE.
6. ALL WORK SHOWN OR NOTED IN THESE PLANS SHALL BE IN STRICT ACCORDANCE WITH THE RECOMMENDATIONS OF THE GEOTECHNICAL ENGINEER, ALL LOCAL, STATE AND FEDERAL MINIMUM STANDARDS AND THE LATEST ADDITION OF THE UNIFORM BUILDING CODE.
7. CONTRACTOR SHALL PROTECT ALL EXISTING SITE IMPROVEMENTS NOT IDENTIFIED FOR REMOVAL DURING CONSTRUCTION. THEY SHALL REPAIR ANY DAMAGE TO NEW CONDITION AT THEIR EXPENSE.
8. VERIFY ALL EXISTING SITE CONDITIONS, SITE DIMENSIONS AND GRADES PRIOR TO THE START OF CONSTRUCTION.
9. ALL GRADING AND RELATED WORK SHALL BE PERFORMED IN ACCORDANCE WITH THE GEOTECHNICAL REPORT FOR THE PROJECT.
10. GRADING SLOPES FOR BOTH CUT AND FILL SHALL NOT EXCEED 2(H):1(V) UNLESS OTHERWISE DIRECTED BY THE GEOTECHNICAL ENGINEER.
11. ALL SOFTSCAPE GRADES ADJACENT TO (N) BUILDINGS SHALL BE 8" (MIN.) BELOW FINISH FLOOR.
12. CONTRACTOR SHALL GRADE TO ENSURE DRAINAGE FLOWS AWAY FROM (N) BUILDINGS.

ABBREVIATIONS

AB	AGGREGATE BASE
AC	ASPHALT CONCRETE
BFW	BOTTOM FACE OF WALL
BLDG	BUILDING
CNC	CONCRETE
EC	EDGE OF CONCRETE
EL	ELEVATION
FF	FINISH FLOOR
FS	FINISH SURFACE
GB	GRADE BREAK
HP	HIGH POINT
INV	INVERT ELEVATION
LP	LOW POINT
ME	MATCH EXISTING
MJ	MECHANICAL JOINT
PL	PROPERTY LINE
SD	STORM DRAIN
SDAD	STORM DRAIN AREA DRAIN
SDDI	STORM DRAIN DROP INLET
SDMH	STORM DRAIN MANHOLE
SS	SANITARY SEWER
SSCO	SANITARY SEWER CLEAN OUT
TG	TOP OF GRATE
UG	UNDERGROUND
W	WATER

EARTHWORK QUANTITIES

NOTE: THE EARTHWORK QUANTITIES SHOWN HEREON ARE EXCLUSIVE OF WALL FOOTINGS, EXISTING PAVEMENT REMOVAL AND OVER EXCAVATION AND RECOMPACTION, UTILITY TRENCH SPOILS & SOIL EXPANSION AND CONTRACTION FACTORS.

ITEM	DESCRIPTION	CUT (cu.yds)	FILL (cu.yds)
1	EG VS. FG	121	726

NET VOLUME = 604 CU.YDS. OF CUT

THE ABOVE QUANTITIES ARE FOR INFORMATION PURPOSES ONLY. THE CONTRACTOR IS RESPONSIBLE TO PROVIDE THE NECESSARY CUT AND FILL TO ACCOMPLISH FINISH GRADE SHOWN ON THESE PLANS.

USA NORTH 811
Call 811 Before You Dig

REVISIONS	BY

GRADING AND DRAINAGE PLAN

REGISTERED PROFESSIONAL ENGINEER
TODD R. CREAMER
No. C 64561
Exp. 6/30/21
CIVIL
STATE OF CALIFORNIA

C2G /CIVIL CONSULTANTS GROUP, INC.
Engineers/Planners
4444 Scotts Valley Drive / Suite 6
Scotts Valley, CA 95066
T (831) 438-4420 F (831) 438-4420

180 SANTA CRUZ PERMANENT SUPPORTIVE HOUSING
115 CORAL STREET SANTA CRUZ, CALIFORNIA

Date:	02.07.20
Scale:	1" = 10'
Drawn:	TC/JB
Job:	498-00
Sheet:	C3.1

Of 8 Sheets

Drawing: W:\498-00 – Permanent Housing\Design\CAD\Sheets\498-00 – C3.1 – GRADING AND DRAINAGE.dwg Layout: C3.1 – GRADING AND DRAINAGE Last Saved: Thu Feb 06, 2020 – 5:21pm Last Plotted: Fri Feb 07, 2020 – 7:11am By: jamie

GEOTECHNICAL INVESTIGATION
For
Emergency Housing Shelter and Homeless Service Center
119C Coral Street
APN 008-171-31
Santa Cruz, California

Prepared For
180 SUPPORTIVE HOUSING, LLC
Santa Cruz, California

Prepared By
HARO, KASUNICH & ASSOCIATES, INC.
Geotechnical & Coastal Engineers
Project No. SC11174.1
August 2021

Project No. SC11174.1
6 August 2021

180 SUPPORTIVE HOUSING, LLC.
1040 Mystery Spot Road
Santa Cruz, California 95065

Attention: Brit Charlebois

Subject: Geotechnical Investigation

Reference: Proposed Emergency Housing Shelter and Homeless Services Center
119C Coral Street
APN 008-171-31
Santa Cruz, California

Dear Ms. Charlebois:

In accordance with your authorization, we have performed a Geotechnical Investigation for the referenced property in Santa Cruz, California. The accompanying report presents our geotechnical recommendations and design criteria, along with the results and methodology of our investigation. If the recommendations in our geotechnical report are followed during project design and construction, the project will be subject to “ordinary risks” as defined in the Scale of Acceptable Risks From Geologic Hazards” in Appendix F of this report. If this level of risk is unacceptable, more extensive mitigation of the hazards can be recommended.

In summary, the project site is underlain with a submerged deep deposit of soft clay soil subject to consolidation from building surcharge with interbedded layers of silt subject to liquefaction from seismic shaking. The primary geotechnical concern with these soils is vertical ground settlement from consolidating clays under gravity loads and vertical settlement from liquefied silts after seismic events that can damage the new building. The clay soils are estimated to consolidate up to 8 inches over the life of the building and seismic liquefaction induced settlement could increase this estimate another 1 inch. The near surface clay soils above the groundwater table have potential for shrink and swell movement from wetting and drying cycles which could also cause defects to the building in the form of upward heave and vertical settlement. Based on our experience in the area and results of our laboratory testing vertical movement from shrink and swell is estimated to be on the order of 1 to 4 inches.

To mitigate potential damage to the building from these concerns the new 5-story structure should be supported by a grid of driven pre-cast concrete piles that penetrate the soft clay soil deposit and are embedded into the dense to very dense Santa Margarita Formation sand. Based on our field exploration the bearing soils will be encountered 45 to 55 feet below the ground surface. The driven pile foundations system should be capable of withstanding the estimated forces and displacement from consolidation (static) settlement in addition to liquefaction related (seismic) ground settlement. To ensure a driven pile system that is compatible with site conditions and in conformance with the recommendations of this report working meetings should be coordinated between the contractor, structural designer, geotechnical engineer, and the pre-cast concrete supplier. A test pile should be installed at the project site prior to mass delivery and installation of the driven pile foundation system.

If you have any questions concerning our conclusions or recommendations, presented in this report please contact our office.

Respectfully Submitted,

HARO, KASUNICH AND ASSOCIATES, INC.

Ashton Buckner
Staff Engineer

Moses Cuprill
C.E. 78904

AJB/MC/mc

Attachments: Appendix A-F

Copies: 2 to Addressee, plus email (alyssa@encisionhousing.us)
1 pdf to Brit Charlebois (bcharlebois@housingmatterssc.org)
1 pdf to Sibley Simon (sibley@180santacruz.org)

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Project No. SC11174.1
6 August 2021

GEOTECHNICAL INVESTIGATION

Introduction

This report presents the results of our Geotechnical Investigation for the proposed construction of a new Emergency Housing Shelter and Homeless Services Center at 119C Coral Street, Santa Cruz, CA. HKA reviewed preliminary designs prepared by David Baker Architects (dated 2-7-2020, 29 pages) and C2G Civil Consultants Group, Inc. (dated 12 June 2020, Sheets C3.1, C3.2, and C6.2) to develop an understanding of the proposed improvements.

Purpose and Scope

The purpose of the geotechnical investigation is to develop geotechnical design parameters for design and construction of a new 5-story housing shelter and service center. The ground floor will consist of support offices, kitchen, laundry, and additional facilities. The upper four floors will support 120 residential units.

We completed a consolidation time rate settlement analysis using relatively undisturbed soil samples from potentially compressible clay stratums at the site. We also completed a liquefaction analysis on select cone penetration test (CPT) profiles at the site.

Specifically, we did the following:

A. Document review of information in our files pertinent to the site and region.

Schedule drilling and cone penetrometer testing, mark borings for underground service alert (USA), schedule private utility locater, and project administration. Review of previous work performed at the site including our Geotechnical Investigation, dated 26 November 2001, at 115 Coral Street, and our Addendum Geotechnical Recommendations, dated 26 August 2003, at 115 Coral Street.

B. Subsurface exploration consisting of logging and interval sampling of soils encountered in two (2) test bore holes using truck mounted drilling equipment. Test bore holes ranged between 46.5 to 50.0 feet deep. The soil samples obtained were sealed and returned to the laboratory for testing.

C. Subsurface exploration with two (2) cone penetrometer test probes (CPT) using a 25-ton CPT rig. Test probes were advances to 44 and 60 feet deep.

D. Laboratory testing of select samples obtained consisted of; moisture content and dry density tests for selected samples to evaluate the consistency of the in situ soils; soil strength parameters were derived from in-situ field penetration tests (SPT) and laboratory unconfined compression tests on select samples; consolidation tests were performed on select samples to quantify soil swell and axial strain and Atterberg limits tests were performed on select samples to index the expansion potential and plasticity.

E. Consolidation time rate settlement analysis was performed on four (4) potentially compressible soil samples collected at different depths below the ground surface.

F. Liquefaction analysis was completed on the profiles of test probes CPT-1 and CPT-2. The analysis identified potentially liquefiable soil layers and as part of the results estimated ground settlement from a design seismic event that triggers liquefaction.

G. Analysis of soil structure interaction of driven pile using LPILE software.

H. Analysis of field, laboratory, and office data to develop geotechnical related recommendations for design and construction of the proposed improvements.

I. Preparation of this report summarizing our findings, conclusions, and recommendations.

Site Location and Project Description

The site address is 119C Coral Street in Santa Cruz, California and is approximately 0.77 acres parcel at the southwest corner of River Street and Highway One (see Figure 1 in Appendix A). The site is currently accessible by a paved driveway with frontage onto Coral Street. The site is near level and currently improved with facilities, offices, housing, asphalt concrete driveway and parking, infrastructure, and other improvements. A sound wall borders the property line and Highway One to the south.

Based on our review of architectural plans prepared by David Baker Architects (dated 2-7-2020, 29 pages) and civil plans prepared by C2G Civil Consultants Group, Inc. (dated 12 June 2020, Sheets C3.1, C3.2, and C6.2) the new, 5-story, housing and service center will consist of support offices, kitchen, laundry, and additional facilities on the ground floor and 120 residential units on the upper four floors. Parking and general site improvements are also included in the project scope.

Field Exploration

Subsurface conditions were investigated on 23 and 25 March 2021. Two (2) exploratory test bore holes were advanced at the project site. The approximate location of the test bore holes are indicated on the Boring Site Plan (see Figure 3 in Appendix A). The test holes were advanced using a truck mounted drill rig with hollow stem augers and Geoprobe track rig with hollow stem augers.

Subsurface conditions were also investigated on 18 March 2021 using a cone penetrometer test prob. Two (2) exploratory probes were advanced at the site. The approximate location of the CPT probes is indicated on the Boring Site Plan (see Figure 3 in Appendix A).

Representative soil samples were obtained from the exploratory boring at selected depths, or at major strata changes. These samples were recovered using the 2.5-inch O.D. Modified California Sampler (MC) or the Standard Terzaghi Sampler (SPT). The penetration resistance blow counts noted on the boring logs were obtained as the sampler was dynamically driven into the in-situ soil. The process was performed by dropping a 140-pound hammer a 30-inch free fall distance and driving the sampler 6 to 18 inches and recording the number of blows for each 6-inch penetration interval. The blows recorded on the boring logs represent the accumulated number of blows that were required to drive the last 12 inches.

Laboratory Testing

The laboratory testing program was directed toward determining pertinent soil engineering and index properties.

The natural moisture content was determined on select samples and is recorded on the Logs of Test Borings at the appropriate depths. Since water has a significant influence on soil, the natural moisture content provides a rough indicator of the soil's compressibility, strength, and potential expansion characteristics. Atterberg limits tests and consolidation tests were performed on select clay samples to index the expansion potential and to quantify soil swell and settlement.

Un-confined compression tests were run on select samples to determine undrained strength parameters. Direct shear test was run on one sample to determine the soil shear strength.

The results of the field and laboratory testing appear on the "Logs of Test Boring" opposite the sample tested or in the respective graph attached as part of the appendix of this report.

Subsurface Conditions

Based on our investigation, and consistent with our Geotechnical Investigation dated 26 November 2001, the site is underlain with lagoon deposits consisting of soft clays and silts. In both borings we did not encounter bedrock at a depth explored of 46.5 and 50.0 feet below ground surface. In our CPT borings we encountered refusal at 44 feet (CPT-2) and dense sand at 60 feet (CPT-1). Our borings consisted of firm to soft, lean to fat clay and silt in the upper 9 to 10 feet underlain by soft fat clay, silty clay, elastic silt, and sandy silt to the depths explored of 46.5 and 50.0 feet bgs.

Expansive Clays

Clay soil with plasticity index (PI) between 21 and 33 were encountered at the site within the top 5 feet and a PI of 39 at deeper depths. Clay soil with a PI greater than 15 is considered potentially expansive or moderately expansive. Clay soils with PI's greater than 30 and liquid limit greater than 50 percent is considered fat clay and highly expansive. Both lean and fat clays were encountered at various depths within 50 feet bgs. The expansion potential of these soils should be considered when designing pools, pavements, slab-on-ground, and landscaping.

Groundwater

Groundwater was encountered during our subsurface exploration within each of our test bore holes at depths between 9 feet and 11 feet bgs. It should be noted groundwater levels may fluctuate due to variations in rainfall or other factors not evident during our investigation.

Seismicity

The site is in the seismically active Monterey Bay area, but not within any of the Alquist-Priolo Earthquake Fault Zones established by the Alquist-Priolo Earthquake Fault Zoning Act of 1972, or in any of the Santa Cruz County fault zones. The following is a general discussion of seismicity in the project area. Detailed studies of geologic hazards are beyond the scope of this study.

The known active faults nearest to the site are the San Andreas Fault which passes approximately 10.6 miles to the northeast, and the potentially active Zayante-Vergeles Upper Fault passes approximately 8.3 miles to the northeast.

The San Andreas is a major fault zone of active displacement which extends from the Gulf of California to the vicinity of Point Arena, where the fault leaves the California coastline. Between these points, the fault is about 700 miles long. The fault zone is a break or series of breaks along the earth's crust, where shearing movement has taken place. This fault movement is primarily horizontal.

Historically, the San Andreas Fault has been the site of large earthquakes, and consequently large earthquakes can be expected in the future. The largest of the historic quakes in Northern California occurred on 18 April 1906 (mag. 8.3+). The recent 17 October 1989 earthquake was also associated with the San Andreas Fault system. This event was the second largest earthquake in Northern California this past century.

Geologic hazards review is beyond the scope of our services. The above information is general in nature and is provided only to illustrate that the property lies within a complex geologic area subject to strong seismic shaking during the design life of the planned improvements.

California Building Code (2019) Seismic Design Parameters

The improvements should be designed in conformance with the most current California Building Code (2019 CBC). Based on the Standard Penetration Test (SPT) blow count information obtained from our previous borings and cone penetrometers as well as the liquefaction study performed as part of this study, we classify the site as potentially liquefiable site, "Site Class F," as defined in Section 1613.2.2 in the 2019 CBC that refers to Chapter 20 of ASCE 7. However, we anticipate that the fundamental period of the structure will be less than 0.5 seconds. The ASCE Standard 7-16 (*"Minimum Design Loads and Associated Criteria for Buildings and Other Structures*") states in Section 20.3.1 that if liquefiable soils are present, a site-specific response analysis will be performed for Site Class F. However, for structures with a fundamental period of 0.5

seconds or less, a site-specific response analysis is not required to determine the spectral accelerations and the site class is permitted to be determined in accordance with Section 20.3. with the corresponding values of F_a and F_v and determined using Tables 11.4-1 and 11.4-2. Therefore, for seismic design, the soil properties at the site are classified as **Site Class "E"** based on definitions presented in Section 1613.2.2 in the 2019 CBC that refers to Chapter 20 of ASCE 7. The longitude and latitude were determined using a satellite image generated by Google Earth. These coordinates were taken from the approximate middle of the area of the proposed improvements:

Longitude = -122.0308923, Latitude = 36.9843587

The coordinates listed were used as inputs in the OSHPD Seismic Design Maps created by California's Office of Statewide Health Planning and Development (OSHPD) to determine the ground motion associated with the maximum considered earthquake (MCE) S_M and the reduced ground motion for design S_D. The results are as follows:

Site Class E

S_S= 1.658 g
S_1= 0.636 g
S_{MS}= 1.990 g
refer to section 11.4.8 ASCE7-16 for site specific ground motions and exceptions[1]
S_{M1}= 1.272 g
refer to section 11.4.8 ASCE7-16 for site specific ground motions and exceptions[2]
S_{DS}= 1.327 g
refer to section 11.4.8 ASCE7-16 for site specific ground motions and exceptions[1]
S_{D1}= 0.848 g

---

1 "EXCEPTION: A ground motion hazard analysis is not required for structures other than seismically isolated structures and structures with damping systems where: … [Exception] 1. Structures on Site Class E sites with S_s greater than or equal to 1.0, provided the site coefficient F_a is taken as equal to that of Site Class C." ASCE7-16

refer to section 11.4.8 ASCE7-16 for site specific ground motions and exceptions[2]

A maximum considered earthquake geometric mean (MCE_G) peak ground acceleration (PGA) was estimated using the Figure 22-9 of the ASCE Standard 7-16. The mapped PGA was 0.696 g and the site coefficient F_{PGA} for Site Class E is 1.1. The MCE_G peak ground acceleration adjusted for Site Class effects is $PGA_M = F_{PGA} * PGA$

$$PGA_M = 1.1 * 0.696 \text{ g} = 0.766 \text{ g}$$

Based on these considerations, the risk of substantial structural damage from earthquakes appears relatively low for well-built structures which incorporate lateral shear bracing and current California Building Code (CBC) requirements into their design and construction.

Site Specific Response Analysis

Since our analysis showed the potential for liquefaction, we also performed a site-specific response analysis using the computer program SHAKE2000. Soils were modeled as C4 (Clay PI = 40-80, Sun et al. 1998) and the bedrock was modeled as Rock 50-120 feet (EPRI, 1993). The soil column properties were modeled based on Boring B-2. The shear wave velocities for the soil column were estimated using the correlation equation for SPT blow counts to shear wave velocity (Ohta & Goto, 1978). Input motion was based on Loma Prieta 10/18/89 00:05, Anderson Dam Downstream, 270 (USGS Station 1652) with the maximum acceleration value scaled to 0.696 g on the rock outcrop (i.e. using Site Class B on top of the rock outcrop) located 60 feet below the base of the dam, estimated based on the CPT test data. The horizontal spectral acceleration (HSA) was calculated using Abrahamson & Silva (2008 and 2013) NGA –

Strike Slip – V_S 760 m/s – Mw: 7.5 – Rrup: 16 kilometers and Campbell and Bozorgnia (2008 and 2013) NGA Strike Slip – VS: 760 m/s – Mw: 7.5 – Rrup: 16km. The results of our analysis are presented in Appendix E, herein.

We used the PGA_M of 0.766g as the pre-factored peak ground acceleration value for our liquefaction analysis based on OSHPD.

Building Codes and Site Class

Project design and construction should conform to the following current building codes:

-2019 California Building Code (CBC); and

-2019 Green Building Standards Code (CAL Green)

In accordance with section 1613.2.2 of the 2019 CBC, the project site should be assigned the Site Class E.

Consolidation Time Rate Settlement

The project site was simplified into two distinct silt/clay layers with potential for compression under the proposed loading conditions. It is HKA's understanding that the elevation of the site is to remain at or near its current elevation. HKA assumed an allowable bearing capacity of 1,500 psf for the foundation loads.

Our consolidation time rate settlement analysis was completed in accordance with 2020 ASTM Standard D2435 and Chapter 17 of "Soil Engineering" (Spangler and Handy 1982). The consolidation theory proposed by Terzaghi was utilized for this analysis to estimate primary consolidation settlement. Other techniques by Cassagrande and Schmertman were utilized to interpret void ratio vs. log-stress data. Consolidation test loads of 250, 500, 1000, 2000, 4000, 8000, and 16000 pounds per square foot were applied. The loads were taken off in the reverse order they were applied. The raw data was plotted using log-time method and t_{50} and D_{50} were determined graphically. These values were used to determine the void ratio and coefficient of consolidation at each respective load. The resulting values from this process was used to estimate the consolidation and time rate settlement of Soil 1 and Soil 2 for Boring B-1 and B-2.

Using the bearing capacity of 1500 psf for dead plus live loading, the total settlement is anticipated to be in the order of 8.7 inches total settlement. The variation in settlement will depend on the degree of uniformity of the underlying soft clay and silty clay strata with respect to depth. From our preliminary consolidation data, it is our opinion that most of the consolidation settlement will occur in the upper 45 feet of clay.

Time rate will be in the range of 7 to 145 years for 50 percent of this estimated settlement to occur and 14 to 262 years for 90 percent of this estimated settlement to occur. The actual time rate settlement will be different from our estimates is subsurface drainage conditions vary across the site from the assumptions of our models. Our data suggest that the path for excess hydrostatic pressure to dissipate itself approaches a single drainage model. Meaning the excess hydrostatic pressure may have to travel 35 feet vertically to dissipate itself.

The magnitude of the estimated settlement and the size of the structure will require mitigation in the form of a deep foundation system bearing on the dense to very dense Santa Margarita Formation sand located 40 (CPT-2) to 60 feet bgs (CPT-1).

Liquefaction Potential

Liquefaction is a phenomenon where the loose or medium dense sand or in some cases firm silt deposited below the groundwater table experience a loss of shear strength while cyclically loaded by the ground shaking during an earthquake. Modern geotechnical engineering practice assumes ground failures can occur from soil deposits liquefying within 50 to 60 feet of the ground surface. Groundwater was encountered at the site between 9 and 10 feet bgs. Soil deposits that are susceptible to liquefaction were also encountered below the groundwater table and within the upper 60 feet of the ground surface.

In general, the upper 10 to 55 feet bgs at the site consist of lean to fat clay interbedded with silt, sandy silt, and clayey silt, or a combination there of. These clay type soils had measured plasticity index (PI) between 21 and 39, natural moisture content less than 85 percent of the liquid limit, and fines content of 68 to 100 percent. Cohesive type soils with these properties have very low potential for liquefaction and related effects (SP117A).

Liquefaction analysis was performed using Liquefy Pro Version 5.8d by Civiltech Software. The software allows users to input ground acceleration and soil profiles with field and laboratory test results. The software determines a factor of safety (FS) against liquefaction. Soil layers with FS < 1.0 are considered to have liquefied and related settlement of the soil layer is estimated. Liquefaction analysis was performed on the profile of CPT-1 and CPT-2.

In CPT-1, interbedded layers of sandy silt, silt, and clayey silt liquefied resulting in an estimated 1.02 inches of settlement. In CPT-2, interbedded layers of sandy silt, silt, and clayey silt liquefied resulting in an estimated 0.37 inches of settlement. We note the above settlements are are estimates from calculated results and the actual settlement may vary.

Ishihara (1985) presented criteria for assessing the potential for ground disruption at liquefaction sites. Those criteria are based on relationship between thickness of liquefiable layers beneath a site and corresponding thickness of the overlying non-liquefiable soil. The criteria was graphically summarized as boundary curves for discriminating between occurrence and non-occurrence of surface effects of liquefaction. A copy of these curves is included in Appendix B of this report.

Based on the results of our liquefaction analysis for this site liquefiable layers ranged between 1 to 4 feet thick. Non-liquefiable soil layers overlying the liquefiable soil layers ranged between 18 and 38 feet thick. Using Ishihara's criteria, the potential for occurrence of surface effects from the liquefiable soils at 18 and 38 feet bgs is low.

To err on the side of conservatism, we will assume that liquefaction related settlement in the areas of CPT-1 and CPT-2 will reflect to the surface through the non-liquefiable soil layers. We do not anticipate ground failures to occur in the form of sand boils or ground cracking, however the ground surface may settle or depress between up to 1.0 inch of total and 0.75 inches differentially.

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our investigation, the proposed improvements at the referenced site will be subject to “ordinary risks”, as defined in the “Scale of Acceptable Risks From Geologic Hazards” in Appendix E of this report provided the design criteria and recommendations presented in this report are incorporated into the design and construction of the proposed project and maintained for the life of the development.

The primary geotechnical considerations at the site include strong seismic shaking, high groundwater, adequate foundation support of new buildings, moderate to highly expansive clays, settlement from consolidation of clay soils, potentially liquefiable soils and related ground settlement, and control of concentrated surface runoff.

In general, the project site is underlain with a submerged deep deposit of soft clay soil subject to consolidation from building surcharge with interbedded layers of silt subject to liquefaction from seismic shaking. The primary geotechnical concern with these soils is vertical ground settlement from consolidating clays under gravity loads and vertical settlement from liquefied silts after seismic events that can damage the new building. The clay soils are estimated to consolidate up to 8 inches over the life of the building and seismic liquefaction induced settlement could increase this estimate another 1 inch. The near surface clay soils above the groundwater table have potential for shrink and swell movement from wetting and drying cycles which could also cause defects to the building in the form of upward heave and vertical settlement. Based on our experience in the area and results of our laboratory testing vertical movement from shrink and swell is estimated to be on the order of 1 to 4 inches.

To mitigate potential damage to the building from these concerns the new 5-story structure should be supported by a grid of driven pre-cast concrete piles that penetrate the soft clay soil deposit and are embedded into the dense to very dense Santa Margarita Formation sand. Based on our field exploration the bearing soils will be encountered 45 to 55 feet below the ground surface. The driven pile foundations system should be capable of withstanding the estimated forces and displacement from consolidation (static) settlement in addition to liquefaction related (seismic) ground settlement. To ensure a driven pile system that is compatible with site conditions and in conformance with the recommendations of this report working meetings should be coordinated between the contractor, structural designer, geotechnical engineer, and the pre-cast concrete supplier.

The shrink and swell movement of the near surface clay soil can damage concrete slab-on-ground floors including cracking and displacement. Any utilities embedded into the concrete floor will also be subject to damages from this nuisance. To mitigate the potential damage to concrete slab-on-ground floors from shrink and swell movement the slab-on-ground floor for the building area should be supported by a mat of select granular engineered fill extending a minimum 24 inches below the bottom of a 12 inch thick gravel capillary break.

The following recommendations should be used as guidelines for preparing project plans and specifications, and assume that **Haro, Kasunich & Associates, Inc.** will be commissioned to review project grading and foundation plans before construction and to observe, test and advise during earthwork and foundation construction. This additional opportunity to examine the site will allow us to compare subsurface conditions exposed during construction with those inferred from this investigation. Unusual or unforeseen soil conditions may require supplemental evaluation by the geotechnical engineer.

General Site Grading

1. The geotechnical engineer should be notified **at least four (4) working days prior to any grading or foundation excavating** so the work in the field can be coordinated with the grading contractor and arrangements for testing and observation can be made. The recommendations of this report assume that a representative from HKA will perform the required testing and observation during grading and construction. It is the owner's responsibility to make the necessary arrangements for these required services.

2. Where referenced in this report, Percent Relative Compaction and Optimum Moisture Content shall be based on ASTM Test Designation D1557.

3. Areas to be graded or to receive proposed improvements should be cleared of all obstructions and fill materials, including trees not designated to remain and other unsuitable material. Existing depressions or voids created during site clearing should

be backfilled with engineered fill. Any surface or subsurface obstructions, or questionable material encountered during grading, should be brought immediately to our attention for proper exposure, removal and processing as directed.

4. Cleared areas should then be stripped of organic-laden topsoil. Stripping depth is anticipated to be from 2 to 4 inches, although the actual depth of stripping should be determined in the field by a representative from HKA. Strippings should be wasted off-site or stockpiled for use in landscaped areas if desired.

5. Following clearing and stripping of the building area, existing fill underlying any of the building areas should be completely removed until firm, native soil is encountered. Following subexcavation of fill, the base of the excavations should be scarified, moisture conditioned (or allowed to dry as necessary) to produce a moisture content about 4 to 8 percent above the laboratory optimum value and uniformly compacted at 85 to 88 percent relative compaction. The moisture content should be maintained until the soil is capped with the subsequent lift of engineered fill or concrete.

6. On-site clay soil re-used as engineered fill within the parking facilities should be properly moisture conditions prior to use. The moisture content should be maintained until the soil is capped with the subsequent lift of engineered fill or asphalt/concrete. Select granular fill for slabs should be placed in thin lifts not exceeding 8 inches in loose thickness, water conditioned to a moisture content about 2 to 4 percent above optimum

and compacted to at least 90 percent relative compaction. Aggregate base below pavements should likewise be compacted to at least 95 percent relative compaction.

7. If grading is performed during or shortly after the rainy season, the grading contractor may encounter compaction difficulty with the wet soils. If compaction cannot be achieved after adjusting the soil moisture content, it may be necessary to use imported fill or gravel and stabilize the bottom of the excavation with stabilization geotextile. Chemical treatment with lime and Portland cement could also be used as an alternative.

8. Provided they can be adequately moisture conditioned (or dried back) prior to use, the on-site soils appear generally suitable for use as engineered fill. Select fill is recommended for use as engineered fill under slabs. This material which must be imported should be free of organic and deleterious material, contain no rocks or clods over 4 inches in dimension, and should contain no more than 15 percent by weight of rocks larger than 2½ inches. Imported select fill should also have a Plasticity Index of less than 15 and should have sufficient binder to allow excavations to stand without caving. Prior to delivery to the site, a representative sample of proposed import should be sent to our laboratory for evaluation.

9. We estimate shrinkage factors of about 15 and 25 percent for the import select fill and on-site materials respectively when used in engineered fills.

Cut Slopes

10. Temporary excavations should be properly shored and braced during construction to prevent sloughing and caving at sidewalls. The contractor should be aware of CAL-OSHA and local safety requirements and codes dealing with excavations and trenches.

11. Temporary cut slopes into native soils should be inclined no steeper than 1:1(horizontal to vertical) up to 10 feet in height. The geotechnical engineer should approve the actual gradient of the cut slope based on conditions of the soils observed in the field. Temporary cut slopes are considered those that will remain from 24 hours up to the following rain season. Permanent cut slopes should be inclined no steeper than 3:1. Cut slopes with a height greater than 10 feet must be observed by a civil or geotechnical engineer with HKA so that additional recommendations can be provided as needed. The top of cut slopes should be rounded off to remove topsoil and reduce soil sloughing. If seepage is observed, HKA should be notified immediately. Cut slopes with these recommended gradients may require periodic maintenance to remove minor soil sloughing and will be subject to creep.

12. In order to maintain stable cut slopes at the recommended gradients, it is imperative that surface runoff, subsurface seepage forces, and accompanying hydrostatic pressure be relieved by adequate drainage features including curtain drains. Curtain drains are required to extend the full depth of the cut and/or fill slopes at this site. This can be accomplished by constructing 5-foot-deep curtain drains along the

inboard side of several benches during fill slope construction. The locations of drains and outlets will be determined by a representative of HKA in the field during grading.

13. Following grading, exposed soil should be planted as practicable with erosion-resistant vegetation.

14. After the earthwork operations have been completed and HKA has made the required observations of the work, no further earthwork operations shall be performed without the direct observation of HKA.

Soil Settlement

15. Total settlement from the surcharge loads is estimated to be up to 8 inches for static loads and up to 1 inch for a design seismic induced liquefaction event. Differential settlements should be estimated as 2/3 of the total settlement. Foundation elements should penetrate the submerged soft clay layer and be embedded into the underlying dense sands. Foundation elements should be selected and designed to withstand this movement.

LPile Analysis

The program Lpile 2019.11.08 by Ensoft, Inc., dated 2019, was used for the structural analysis for the design of the proposed deep foundation driven piles. LPile analyzes the behavior of flexible piles using the non-linear soil-structure-interaction concept based on the modified subgrade reaction analysis method (p-y method). One case of a reinforced concrete driven pile was analyzed. The case consisted of 60 feet deep square pile.

Soil properties were based on the results of our in-situ field penetration tests during drilling, CPT results, our saturated laboratory direct shear test, and our unconfined compression test on selected samples of the subgrade soil.

Based on discussions with project structural engineer, Steven F. Curry, with Murphy Burr Curry, Inc., pile spacing is assumed to be 10 feet on-center, maximum vertical loading of 75 kips per pile, and maximum lateral loading of 15 kips per pile.
Pile properties were defined as 24 square inch concrete pile section with two rows of 5 US Std. # 10 rebar in both the x and y-direction.

The results of our LPile analyses, show the selected soil property inputs, the beam deflection, bending moment, and shear as a function of depth below top of pile (pile cap) are presented in Appendix D.

<u>End Bearing Concrete Driven Pile Foundation System</u>

16. A deep end bearing driven pile foundation system is recommended to support the new structure. The deep pile foundation must satisfy the following criteria:

- Penetrate through overburden soil mantle.
- Piers should be embedded into dense to very dense sand located approximately 45 to 55 feet below ground surface.

17. Piers satisfying all criteria above can use an end-bearing capacity of 30,000 psf for piers embedded at least 3 feet deep into dense sand. The bearing capacity value

may be increased by 1/3 to accommodate short-term seismic and wind loads.

18. We recommend working meetings between the structural designer, HKA, the contractor, and the pre-cast concrete company to confirm compatibility of the selected concrete piles and the actual site conditions. A test pile should be scheduled as part of this selection process and monitored by HKA during its installation. The test pile should be located such that it can be used as part of the actual building foundation.

19. We recommend the initial piles placed at the project site be monitored during driving by dynamic pile driving analysis to verify vertical bearing capacity, pile driving hammer efficiency, and protect the pile from driving damage such as tension cracking.

20. Pile spacing should be no closer than 4 feet measured on center and have a maximum spacing of 10 feet. Actual spacing and depth of piers will be determined by the structural engineer.

21. Consolidation of the submerged clay layer should not occur if the new building is supported by the driven concrete piles that penetrate the submerged clay soils and is seated into the underlying dense sand.

22. To resist uplift, an average surface friction value of 300 psf may be applied over the surface of the driven concrete piles embedded from existing grade down to at least 55 to 60 feet bgs.

23. The pile driving must operation **be observed (from top to bottom) by HKA <u>during placement</u>** to verify subsurface soil conditions are consistent with the anticipated soil conditions. Contact HKA at least 4 days prior to drilling operations so that we can schedule our staff accordingly.

<u>Concrete Slab-On-Ground General</u>

24. In any proposed concrete slab-on-ground areas the excavation should be such that 2 feet of select granular fill can be placed below the concrete slab gravel capillary break. If the floor designer chooses to place the concrete slab over a blotter layer it should consist of a 4-inch-thick layer of Class 2 aggregate baserock that is moisture conditioned and compacted over the top of a vapor barrier.

25. To reduce the potential for cracking and curling as well as other undesirable defects the concrete slab-on-grade design, placement, and curing should be done in accordance with the most recent version of ACI 302.

26. HKA presumes floor wetness would be unacceptable for the buildings for reasons such as moisture sensitive floor covering and interior humidity control just to name a few. To minimize potential for floor wetness the interior concrete slab floor should be underlain with a minimum 20 mil thick vapor barrier. Vapor barriers should be overlapped a minimum of 6 inches at the joints and carefully fitted around service openings. Whether to locate the vapor barrier in direct contact with the slab or beneath

a blotter layer of Class 2 aggregate baserock should be made with careful considerations to many factors directly and indirectly related to concrete construction. Such factors include but are not limited to, whether a watertight roof membrane is in place prior to slab construction, sequence of slab construction in relation to other construction activities requiring water, and the floor covering manufacturer's recommendations. Proposed installation should be independently evaluated as to the moisture-related sensitivity of subsequent floor finishes, project conditions, schedule, and the potential effects of slab curling and cracking.

27. If a blotter layer of granular fill over the vapor barrier is selected it should be a minimum of 4 inches thick, trimmable, and compactible Class 2 aggregate baserock placed at low moisture content (4 to 5 percent). **A layer of clean sand should not be used as a blotter layer over the vapor barrierl**. The blotter layer of granular fill should be compacted to a minimum 95 percent relative compaction in accordance with ASTM D1557.

28. Groundwater was encountered at the time of our field drilling operation and found as shallow as 9 to 10 feet bgs. Considering the reduced permeability of the redensified on-site soils and the possibility of consistent irrigation of landscaping around the structure a free draining granular material to act as capillary break is recommended below the slab. The granular material should be comprised of a minimum 12-inch-thick layer of ¾ inch, or 1 inch nominal drain rock. After placement of the vapor barrier over the gravel capillary break it should be inspected for punctures and if any are found they

should be repaired following manufacturer guidelines. Concrete slabs in basements should also be equipped with a perforated pipe that conveys moisture from below the slab to a suitable discharge location.

29. We recommend the specifications for slab-on-grade floors require moisture emission tests be performed on the slab prior to the installation of flooring. No flooring should be installed until safe moisture emission levels are recorded for the type of flooring to be used.

Surface Drainage

30. An engineered drainage plan to handle surface runoff should be developed for this site. Site drainage should be adequately controlled both during and after construction.

31. All exposed soil should be landscaped and permanently protected against erosion as soon as possible after grading.

32. We recommend that full gutters be used along all roof down eaves to collect storm runoff water and channel it through closed rigid conduits to a suitable discharge point away from all structural improvements.

33. Surface runoff should **not** be allowed to flow onto graded or natural slopes. Consideration should be given to catch basins, berms, concrete v-ditches, or drainage

swales at the top of all slopes to intercept runoff and direct it to a suitable discharge point.

34. Surface drainage should include provisions for positive gradients so that surface runoff is not permitted to pond adjacent to foundations and on pavements. Surface drainage should be directed away from the building foundations, at a minimum gradient of 5 percent for a distance of at least 10 feet to an adequate discharge point. Concentrations of surface water runoff should be handled by providing necessary structures, solid pipes, catch basins, etc.

35. Irrigation activities at the site should be done in a controlled and reasonable manner. Moderate to highly expansive near surface clay should be considered when planning landscape features. Planter areas should not be sited adjacent to walls; otherwise, measures should be implemented to contain irrigation water and prevent it from seeping into walls and under foundations.

36. The migration of water or spread of extensive root systems below foundations, slabs, or pavements may cause undesirable differential movements and subsequent damage to these structures. Landscaping should be planned accordingly.

37. Drainage patterns approved at the time of fine grading should be maintained throughout the life of proposed structures.

Utility Trenches

38. High groundwater at the site may require shoring and dewatering to maintain stable trench walls during construction. Where groundwater is encountered during construction the bottom of the trench should be over excavated 12 to 24 inches and a control density fill (CDF) placed back up to bottom of trench. The CDF should be sloped to pump that can routinely remove the seepage. Trenches must be properly shored and braced during construction or laid back at an appropriate angle to prevent sloughing and caving at sidewalls. The project plans and specifications should direct the attention of the contractor to all CAL OSHA and local safety requirements and codes dealing with excavations and trenches.

39. Utility trenches that are parallel to the sides of buildings should be placed so that they do not extend below an imaginary line sloping down and away at a 2:1 (horizontal to vertical) slope from the bottom outside edge of footing elements. The structural design professional should coordinate this requirement with the utility layout plans for the project.

40. Trenches should be backfilled with engineered fill prepared in accordance with this document.

41. We strongly recommend placing a 3-foot concrete plug in each trench where it passes under the exterior foundations. Care should be taken not to damage utility lines.

42. Trenches should be capped with 1.5 feet of relatively impermeable soil.

Plan Review, Construction Observation and Testing

43. Our firm should be provided the opportunity for a general review of the project plans prior to construction so that our geotechnical recommendations may be properly interpreted and implemented. The purpose is to determine if this preliminary report is adequate and complete for the final planned grading and construction. It is not intended that the geotechnical engineer approve or disapprove the plans, but to provide an opportunity to update the preliminary report and include additions or qualifications as necessary. If our firm is not accorded the opportunity of making the recommended review, we can assume no responsibility for misinterpretation of our recommendations.

44. We recommend that our office review the project plans prior to submittal to public agencies, to expedite project review. The recommendations presented in this report require our review of final plans and specifications prior to construction and upon our observation and, where necessary, testing of the earthwork and foundation excavations. Observation of grading and foundation excavations allows anticipated soil conditions to be correlated to those encountered in the field during construction.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. The conclusions and recommendations noted in this report are based on probability and in no way imply that the proposed improvements will not possibly be subjected to ground failure or seismic shaking so intense they will be severely damaged or destroyed.

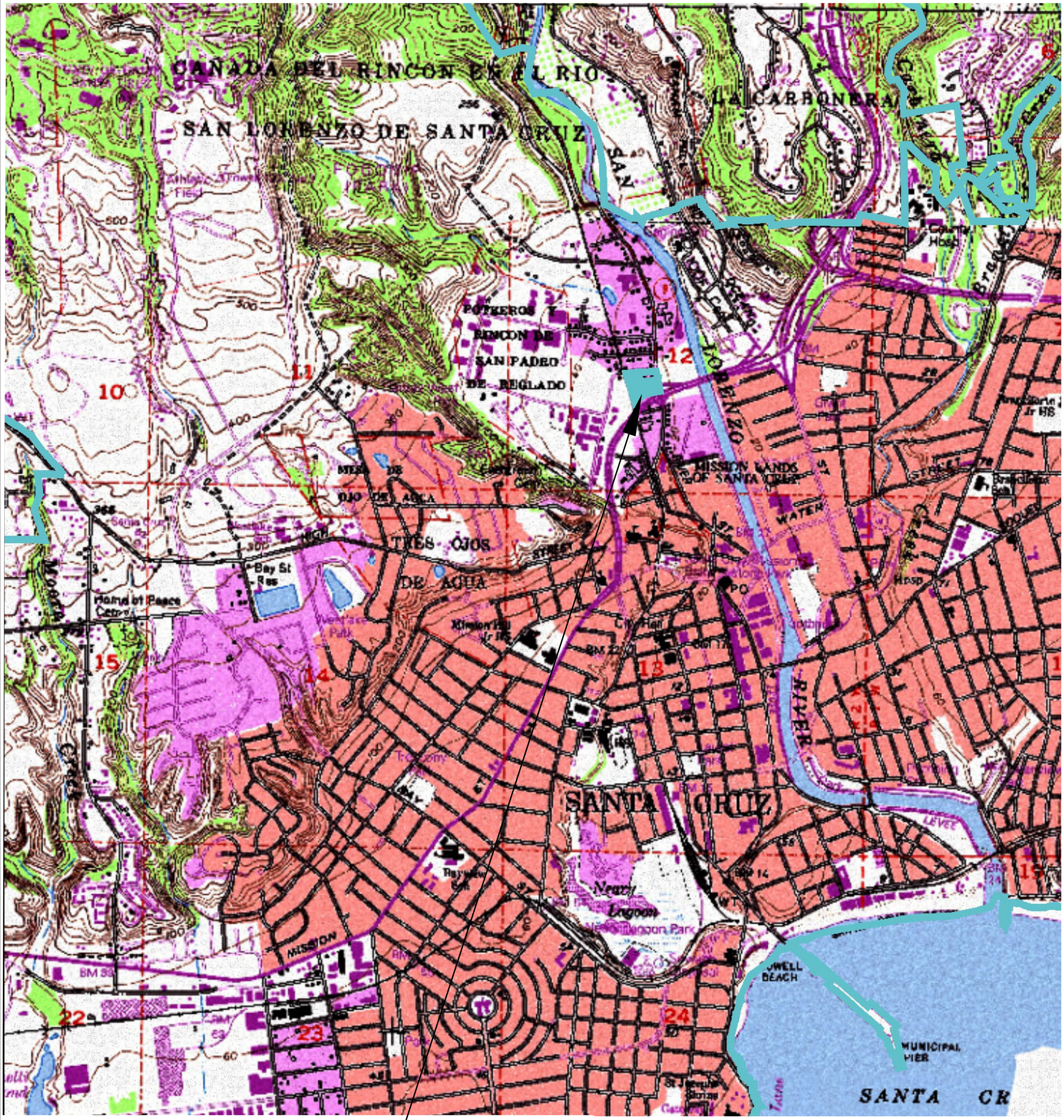
2. This report is issued with the understanding that it is the duty and responsibility of the owner or his representative or agent to ensure that the recommendations contained in this report are brought to the attention of the architects and engineers and contractors for the project, incorporated into the plans and specifications, and that the necessary steps are taken to see that the contractor and subcontractors carry out such recommendations in the field.

3. The conclusions and recommendations contained herein are professional opinions derived in accordance with current standards of professional practice in the Santa Cruz County area. No other warranty, expressed or implied, is made.

4. If any unexpected variations in soil conditions, or if adverse soil conditions are encountered during construction, or if the proposed construction will differ from that planned at the present time, Haro, Kasunich and Associates should be notified so that supplemental recommendations can be given.

5. The findings of this report are valid as of the present date. However, changes in the conditions of a property can occur with the passage of time, whether they are due to natural processes or to the works of man, on this or adjacent properties. In addition, changes in applicable or appropriate standards occur whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this report may be invalidated, wholly or partially, by changes outside our control. Therefore, this report should not be relied upon after a period of three years without being reviewed by a geotechnical engineer.

APPENDIX A



SITE LOCATION

1:24,120

0 0.275 0.55 1.1 mi

0 0.425 0.85 1.7 km

FROM:

SANTA CRUZ COUNTY GIS, DATED JUNE 2021.

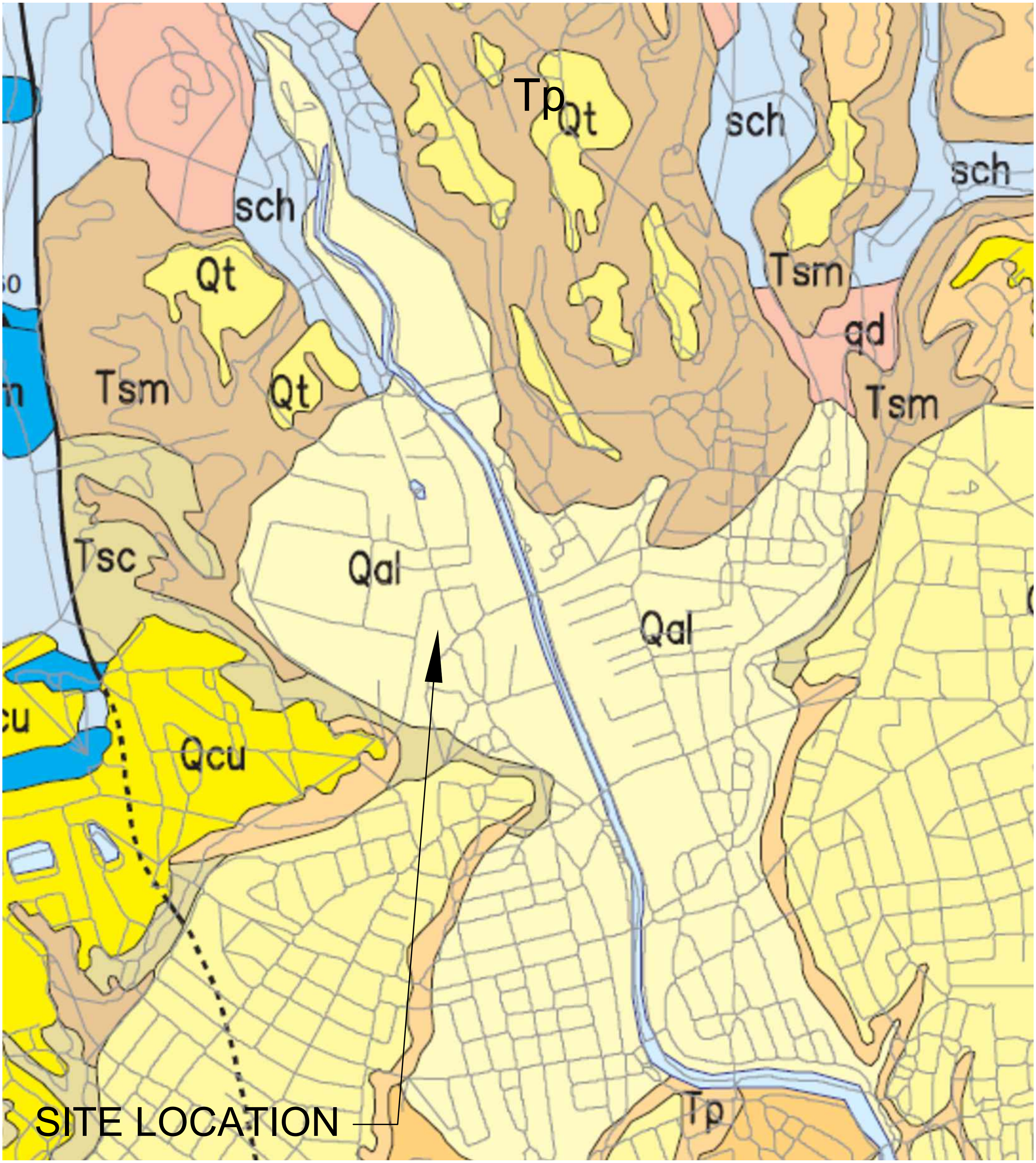
SITE VICINITY MAP
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE:	AS SHOWN
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
GEOTECHNICAL AND COASTAL ENGINEERS
116 E. LAKE AVENUE, WATSONVILLE, CA 95076
(831) 722-4175

FIGURE NO. 1

SHEET NO.



KEY:
Qcl: LOWEST EMERGENT COASTAL DEPOSITS (PLEISTOCENE)
Qcu: COASTAL TERRACE DEPOSITS, UNDIFFERENTIATED (PLEISTOCENE)
Tsm: Santa Margarita Formation (UPPER MIOCENE)

FROM:

GEOLOGIC MAP OF SANTA CRUZ COUNTY, CALIFORNIA
COMPILED BY
EARL E. BRABB
DIGITAL DATABASE PREPARED BY S. GRAHAM, C. WENTWORTH, D. KNIFONG, R. GRAYMER AND J. BLISSENBACHH
1997

REGIONAL GEOLOGIC MAP
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE: NTS
DRAWN BY: AJB
DATE: MAR 2021
REVISED:
JOB NO. SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
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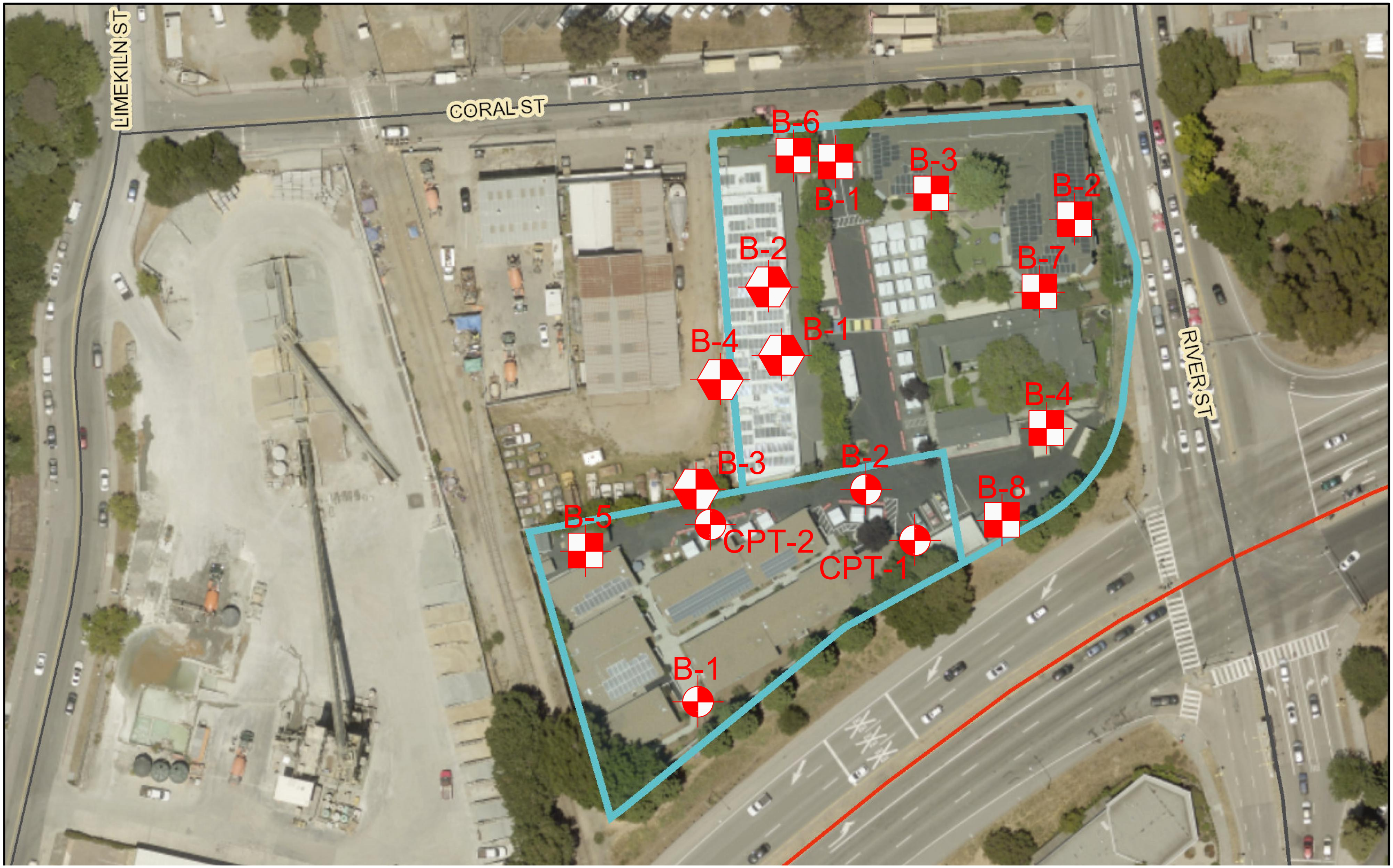
FIGURE NO. 2
SHEET NO.



KEY:

B-1 = SOIL BORING LOCATION

= SOIL BORING LOCATION 2001 BORINGS

= SOIL BORING LOCATION 1994 BORINGS

NOTES:

1. MAP FROM COUNTY OF SANTA CRUZ, DATED MARCH 2021.

BORING SITE PLAN
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE:	NTS
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
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SHEET NO.

FIGURE NO. 3

PRIMARY DIVISIONS				GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRADED SOILS	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
				GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
			GRAVEL WITH FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES, NON-PLASTIC FINES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES, PLASTIC FINES.
		SAND MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
				SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
			SANDS WITH FINES	SM	SILTY SANDS, SAND-SILT MIXTYRES, NON-PLASTIC FINES.
				SC	CLAYEY SANDS, SAND-CLAY MIXTYRES, PLASTIC FINES.
FINE GRADED SOILS	MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50%		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
		SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
HIGHLY ORGANIC SOILS				Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS.

U.S. STANDARD SERIES SIEVE **GRAIN SIZES** CLEAR SQUARE SIEVE OPENINGS

	200	40	10	4	3/4"	2"	12"
SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

RELATIVE DENSITY

SANDS AND GRAVELS	BLOWS PER FOOT*
VERY LOOSE	0 - 4
LOOSE	4 - 10
MEDIUM DENSE	10 - 30
DENSE	30 - 50
VERY DENSE	OVER 50

CONSISTENCY

SILTS AND CLAYS	STRENGTH (TSF)**	BLOWS PER FOOT*
VERY SOFT	0 - 1/4	0 - 2
SOFT	1/4 - 1/2	2 - 4
FIRM	1/2 - 1	4 - 8
STIFF	1 - 2	8 - 16
VERY STIFF	2 - 4	16 - 32
HARD	OVER 4	OVER 32

SAMPLING METHOD

STANDARD PENETRATION TEST	T	
MODIFIED CALIFORNIA	MC	
PITCHER BARREL	P	
SHELBY TUBE	S	
BULK	B	

WATER

FINAL	▽
INITIAL	▼
WATER LEVEL DESIGNATION	

KEY TO LOGS
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE:	NTS
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
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116 E. LAKE AVENUE, WATSONVILLE, CA 95076
(831) 722-4175

FIGURE NO. 4

SHEET NO.

Haro, Kasunich and Associates, Inc.
114 East Lake Avenue
Watsonville, CA 95076
Telephone: 831-722-4175

BORING NUMBER 1

Figure No.: 1

CLIENT 180 Supportive Housing, LLC		**PROJECT NAME** 119C Coral Street	
PROJECT NUMBER SC11174.1		**PROJECT LOCATION** Santa Cruz, CA	
DATE STARTED 3/23/21	**COMPLETED** 3/23/21	**GROUND ELEVATION** 27 ft	**HOLE SIZE** 8"
DRILLING CONTRACTOR Cenozoic Exploration		**GROUND WATER LEVELS:**	
DRILLING METHOD Geoprobe (Hollow Stem)		**AT TIME OF DRILLING** ---	
LOGGED BY AJB	**CHECKED BY** MC	▼ **AT END OF DRILLING** 11.00 ft / Elev 16.00 ft	
NOTES		**AFTER DRILLING** ---	

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	USCS	SAMPLE TYPE NUMBER	BLOW COUNTS	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	SIEVE ANALYSIS GRAVEL %	SIEVE ANALYSIS SAND %	SIEVE ANALYSIS FINES %	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTIC LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	Phi (deg)	COHESION (psf)
0		(CH) Dark brown/black Sand FAT CLAY, moist, firm, organic chips and roots	CH	MC 1-1-1	2-3-4 (7)	84	28	14	32	54					
				SPT 1-2	2-3-4 (7)		49				58	25	33		
5		(MH) Mottled grey black brown elastic SILT, very moist, soft	MH												
				MC 1-3-1	2-3-3 (6)	81	35	0	5	95					
10		(CH) Black brown CLAY, wet, very soft ▼	CH	MC 1-4-1	0-1-2 (3)	62	60								
15		(CH) black FAT CLAY, wet, very soft	CH	MC 1-5-1	1-1-2 (3)	32	153				76	37	39		
20				MC 1-6-1	0-2-2 (4)										
25															

(Continued Next Page)

Haro, Kasunich and Associates, Inc.
114 East Lake Avenue
Watsonville, CA 95076
Telephone: 831-722-4175

BORING NUMBER 1

Figure No.: 2

CLIENT 180 Supporitive Housing, LLC **PROJECT NAME** 119C Coral Street

PROJECT NUMBER SC11174.1 **PROJECT LOCATION** Santa Cruz, CA

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	USCS	SAMPLE TYPE NUMBER	BLOW COUNTS	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	SIEVE ANALYSIS GRAVEL %	SIEVE ANALYSIS SAND %	SIEVE ANALYSIS FINES %	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTIC LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	Phi (deg)	COHESION (psf)
25		(CH) Gray FAT CLAY, wet, very soft with decomposed roots/leaves, moderate odor	CH	MC 1-7-1	0-2-2 (4)										
30				MC 1-8-1	1-2-2 (4)										
35		No roots/leaves slight odor		MC 1-9-1	0-3-3 (6)										
40		Decomposed roots and leaves		MC 1-10-2	1-2-4 (6)										
45		(SP) Gray SAND, wet, medium dense	SP	MC 1-11-1	3-7-11 (18)										

Bottom of borehole at 46.5 feet.

Haro, Kasunich and Associates, Inc.
114 East Lake Avenue
Watsonville, CA 95076
Telephone: 831-722-4175

BORING NUMBER 2

Figure No.: 3

CLIENT 180 Supporitive Housing, LLC
PROJECT NAME 119C Coral Street
PROJECT NUMBER SC11174.1
PROJECT LOCATION Santa Cruz, CA
DATE STARTED 3/25/21 **COMPLETED** 3/25/21
GROUND ELEVATION 29 ft **HOLE SIZE** 8"
DRILLING CONTRACTOR Exploration Geo Services
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem
AT TIME OF DRILLING ---
LOGGED BY AJB **CHECKED BY** MC
▼ **AT END OF DRILLING** 9.00 ft / Elev 20.00 ft
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	USCS	SAMPLE TYPE NUMBER	BLOW COUNTS	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	SIEVE ANALYSIS GRAVEL %	SIEVE ANALYSIS SAND %	SIEVE ANALYSIS FINES %	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTIC LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	Phi (deg)	COHESION (psf)
0	(CL) Brown/black Sandy Lean CLAY, moist, stiff	CL	MC 2-1-1	12-12-13 (25)	108	19	12	17	72					
	Firm, Concrete Fill in Sample		SPT 2-2	2-2-5 (7)		21				37	16	21		
5	(CL) Gray brown CLAY with SAND, moist, firm	CL	MC 2-3-1	3-5-7 (12)	96	23	0	17	83					
	▼ (CL-ML) Gray brown Silty Lean CLAY, very moist, firm	CL-ML	MC 2-4-1	3-5-7 (12)	90	31								
	(ML) Brown and orange mottled Sandy SILT, very moist, firm	ML	MC 2-5-1	3-5-6 (11)	95	30	0	32	68					
	(CH) Gray lean to fat CLAY with SILT and decayed organic roots, wet, firm, slight odor	CH	MC 2-6-1	3-4-7 (11)	78	45	0	0	100					
	Same		MC 2-7-1	3-4-5 (9)										

Depth scale (ft): 0, 5, 10, 15, 20, 25

(Continued Next Page)

Haro, Kasunich and Associates, Inc.
114 East Lake Avenue
Watsonville, CA 95076
Telephone: 831-722-4175

BORING NUMBER 2

Figure No.: 4

CLIENT 180 Supporitive Housing, LLC

PROJECT NAME 119C Coral Street

PROJECT NUMBER SC11174.1

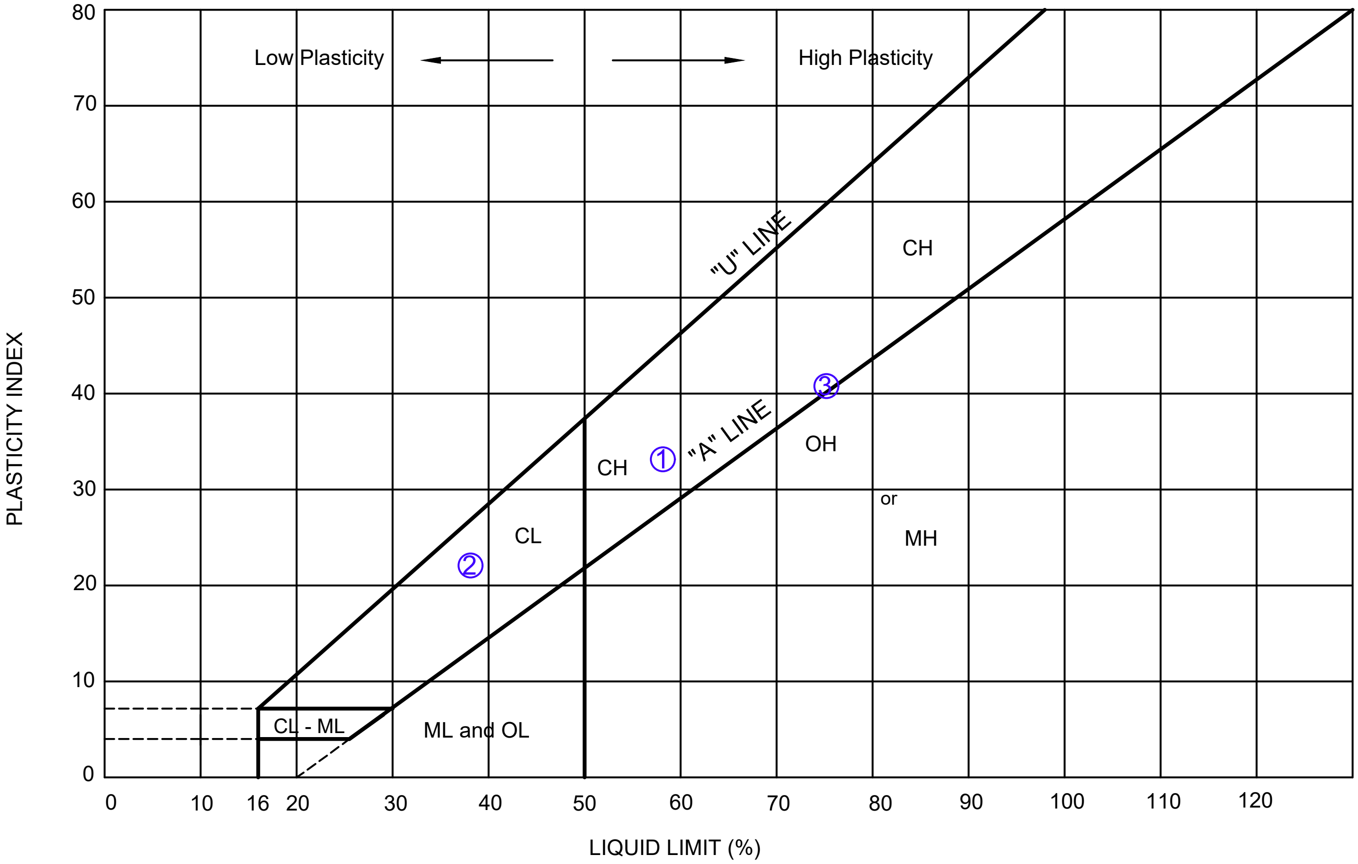
PROJECT LOCATION Santa Cruz, CA

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	USCS	SAMPLE TYPE NUMBER	BLOW COUNTS	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	SIEVE ANALYSIS GRAVEL %	SIEVE ANALYSIS SAND %	SIEVE ANALYSIS FINES %	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTIC LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	Phi (deg)	COHESION (psf)
25		Same *(continued)*													
		No odor or organics		MC 2-8-2	5-4-7 (11)										
30															
		Unconfined Compression Test (2-9-2) Uc = 1208 psf		MC 2-9-2	5-6-5 (11)	62	62								604
35															
		Slight odor, trace organics		MC 2-10-2	6-7-7 (14)										
40															
		(SC) Black Clayey SAND, wet, firm, gray coarse SAND in shoe	SC	MC 2-11-1	5-6-9 (15)	112	20								
45															
		(CH) Black/gray Fat CLAY, wet, firm	CH	MC 2-12-1	5-6-7 (13)	63	62								
50															

Bottom of borehole at 50.0 feet.

GEOTECH BH COLUMNS - GINT STD US.GDT - 6/23/21 11:35 - H:\PROJECTS\11000S\11174 FOLDER, 115 C CORAL ST. ENVISION HOUSE\11174.1 NEW HOMELESS SHELTER\APPENDIX\11174.1 BORING LOGS.GPJ

PLASTICITY CHART



PLASTICITY DATA

Key Symbol	Sample Number	Depth (feet)	Natural Water Content W(%)	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index	Liquidity Index W - PL / LL -PL	Unified Soil Classification Symbol
①	1-2	2.5	49	25	58	33	0.73	CH
②	2-2	2.5	33	16	37	22	0.81	CL
③	1-5-1	15.0	153	37	76	40	3.0	CH

ATTERBURG LIMITS TEST RESULTS
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE:	NA
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
GEOTECHNICAL AND COASTAL ENGINEERS
116 E. LAKE AVENUE, WATSONVILLE, CA 95076
(831) 722-4175

FIGURE NO. 9

SHEET NO.

Gravel Content:	**14.1%**
Sand Content:	**31.9%**
Fines Content	**54.0%**
Cumulative Sum	**100.0%**

Sample Description: Dk Brown Sandy CLAY
Group Symbol: CL-CH

D60	
D30	
D10	
Cu	#DIV/0!
Cc	#DIV/0!

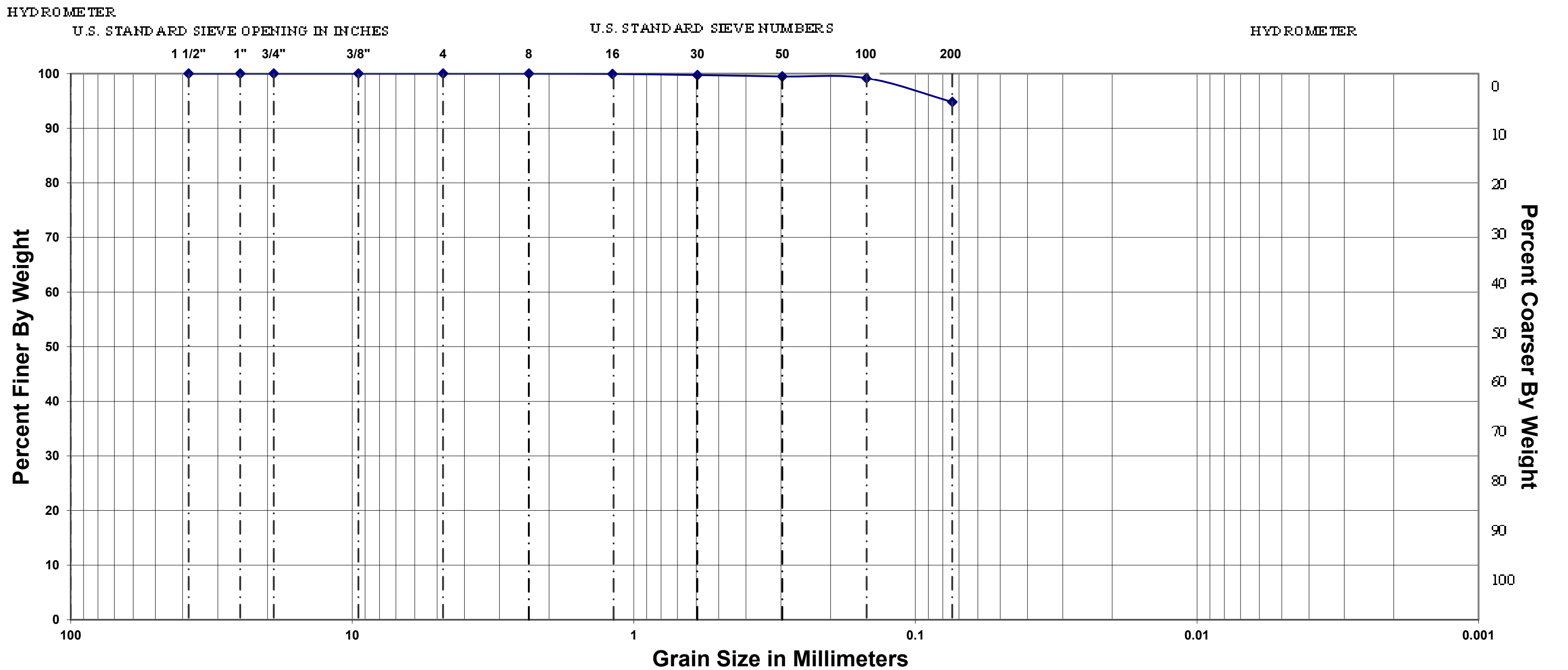
HKA Project No: 11174.1
Sample No: 1-1-1
Date: 3/24/21

GRAIN SIZE ANALYSIS

115 Coral St.

Figure No. 10

116 East Lake Avenue, Watsonville, California
(831) 722-4175 ~ Fax (831) 722-3202



Gravel Content:	**0.0%**
Sand Content:	**5.2%**
Fines Content	**94.8%**
Cumulative Sum	**100.0%**

Sample Description: Mottled Gray/Brown SILT
Group Symbol: ML-MH

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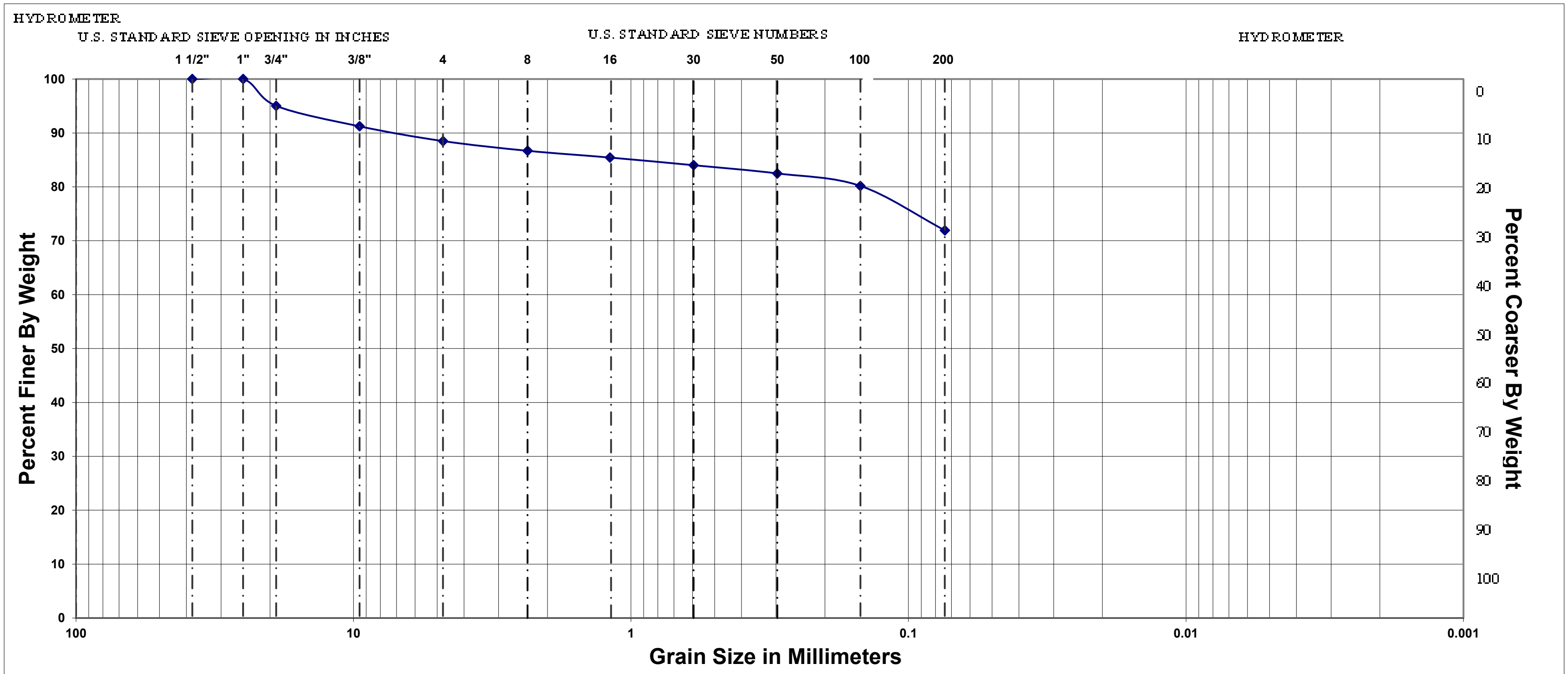
D60	
D30	
D10	
Cu	#DIV/0!
Cc	#DIV/0!

HKA Project No: 11174.1
Sample No: 1-3-1
Date: 3/24/21

GRAIN SIZE ANALYSIS

119C Coral Street

Figure No. 11



Gravel Content:	**11.5%**
Sand Content:	**16.6%**
Fines Content	**71.9%**
Cumulative Sum	**100.0%**

Sample Description: Dk Grayish Brown Sandy CLAY

Group Symbol: CL

D60	
D30	
D10	
Cu	#DIV/0!
Cc	#DIV/0!

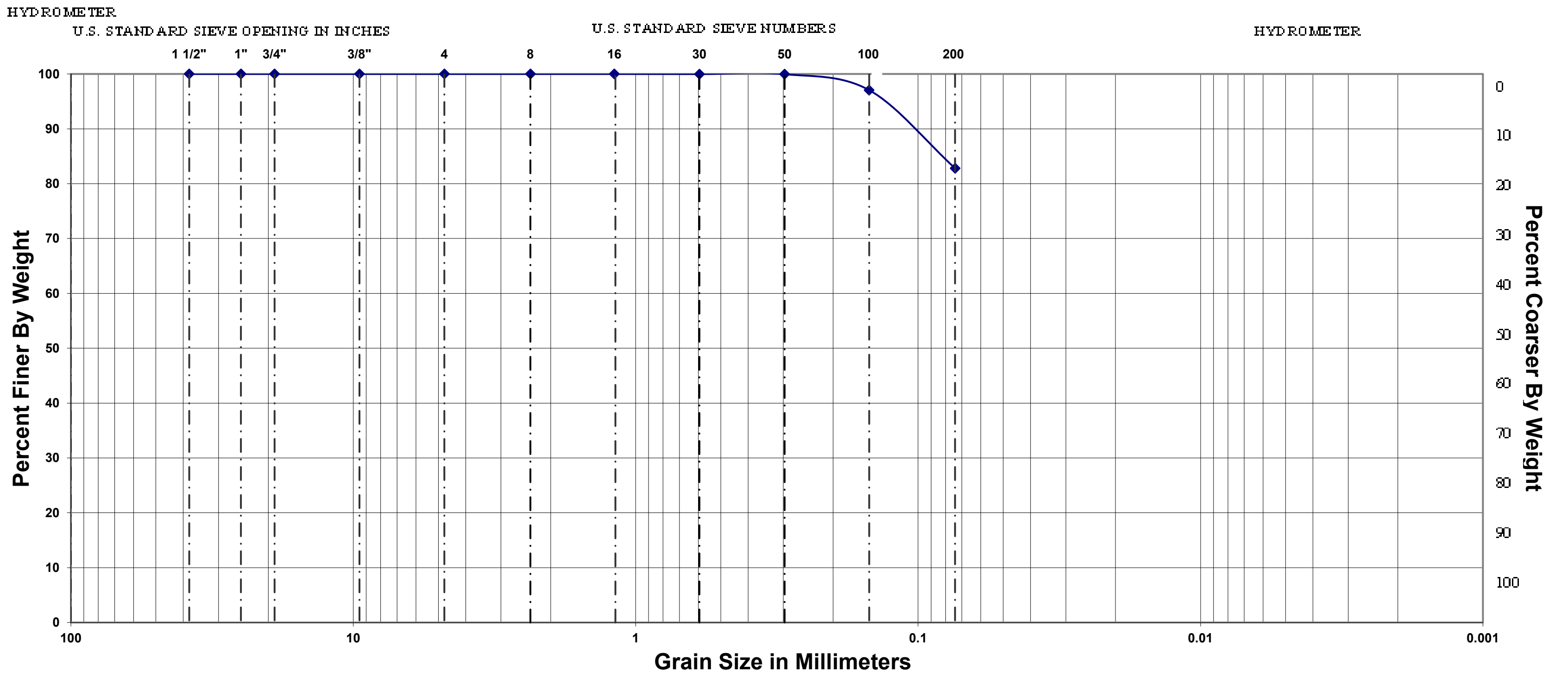
HKA Project No: 11174.1
Sample No: 2-1-1
Date: 3/30/21

GRAIN SIZE ANALYSIS

119C Coral Street

Figure No. 12

HARO, KASUNICH AND ASSOCIATES, INC.
CONSULTING GEOTECHNICAL & COASTAL ENGINEERS
116 East Lake Avenue, Watsonville, California
(831) 722-4175 ~ Fax (831) 722-3202



Gravel Content:	**0.0%**
Sand Content:	**17.2%**
Fines Content	**82.8%**
Cumulative Sum	**100.0%**

Sample Description: Grayish Brown CLAY w/ sand
Group Symbol: CL-CH

D60	
D30	
D10	
Cu	#DIV/0!
Cc	#DIV/0!

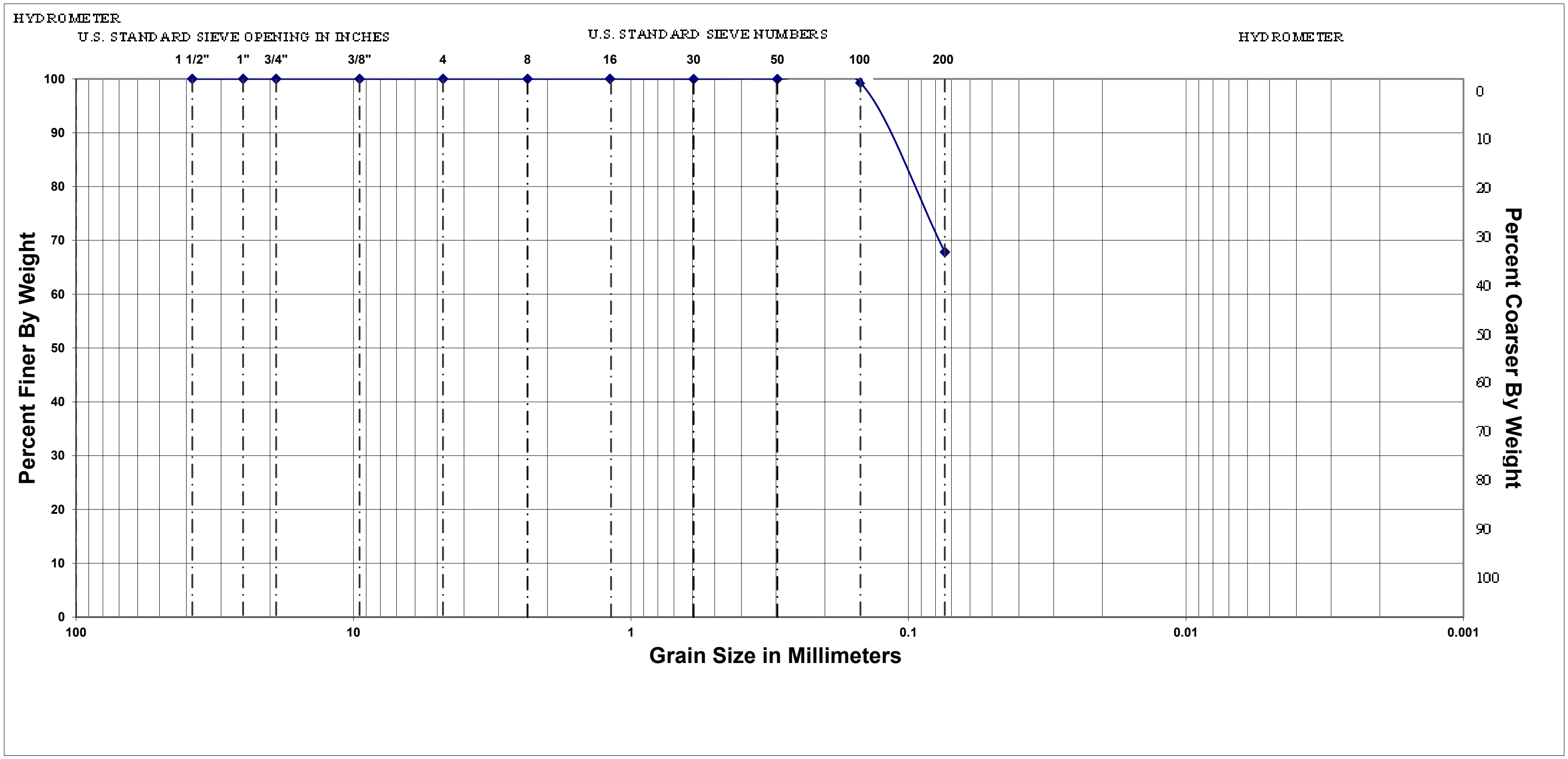
HKA Project No: 11174.1
Sample No: 2-3-1
Date: 3/30/21

GRAIN SIZE ANALYSIS

119C Coral Street

Figure No. 13

HARO, KASUNICH AND ASSOCIATES, INC.
CONSULTING GEOTECHNICAL & COASTAL ENGINEERS
116 East Lake Avenue, Watsonville, California
(831) 722-4175 ~ Fax (831) 722-3202



Gravel Content:	**0.0%**
Sand Content:	**32.2%**
Fines Content	**67.8%**
Cumulative Sum	**100.0%**

Sample Description: Grayish Olive Brown Sandy SILT
Group Symbol: ML-MH

D60	
D30	
D10	
Cu	#DIV/0!
Cc	#DIV/0!

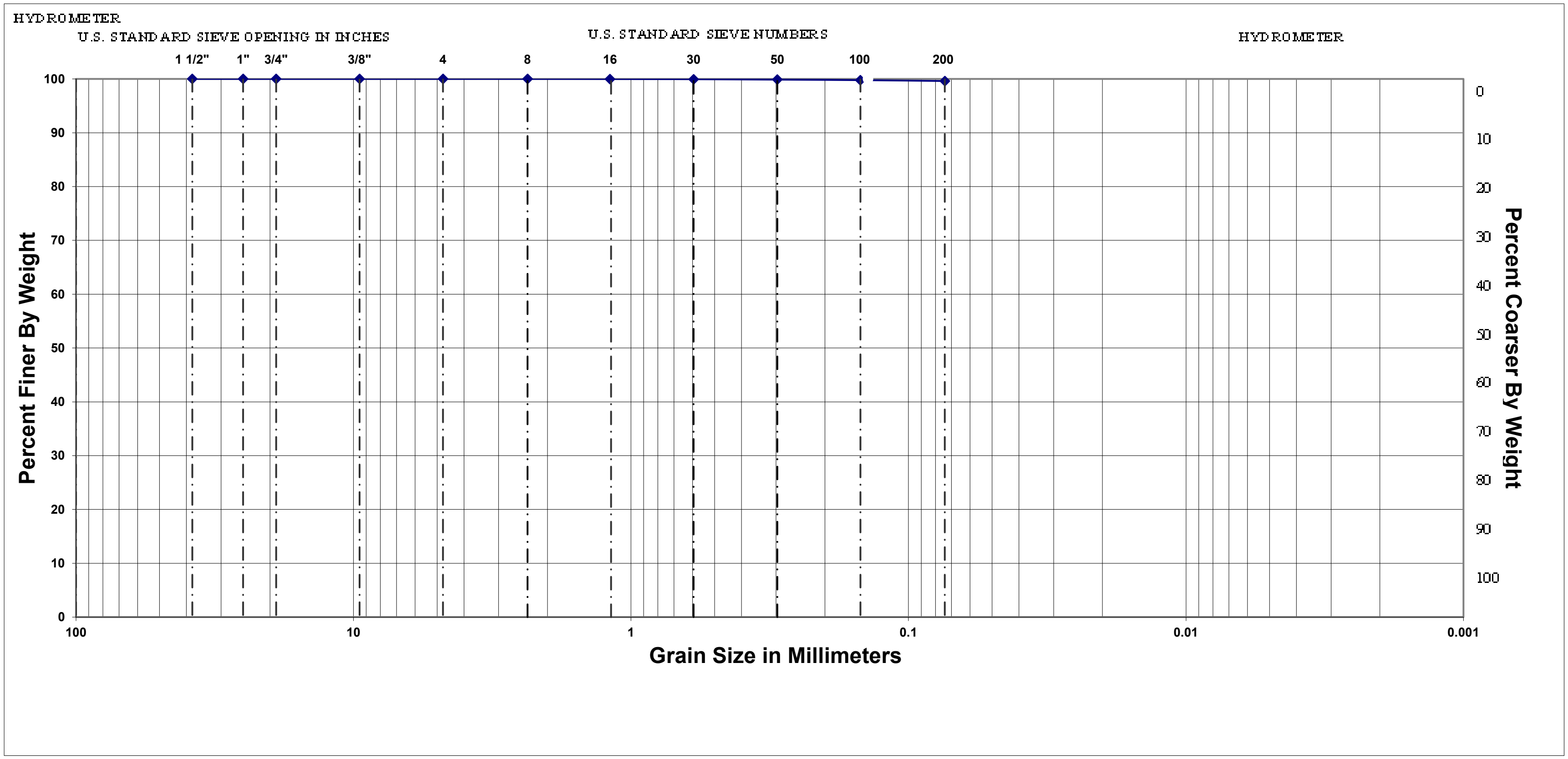
HKA Project No: 11174.1
Sample No: 2-5-1
Date: 3/30/21

GRAIN SIZE ANALYSIS

119C Coral Street

Figure No. 14

Haro, Kasunich and Associates, Inc.
Consulting Geotechnical & Coastal Engineers
116 East Lake Avenue, Watsonville, California
(831) 722-4175 ~ Fax (831) 722-3202



Gravel Content:	**0.0%**
Sand Content:	**0.4%**
Fines Content	**99.6%**
Cumulative Sum	**100.0%**

Sample Description: **Gray Lean to Fat CLAY**
Group Symbol: **CL-CH**

D60	
D30	
D10	
Cu	#DIV/0!
Cc	#DIV/0!

HKA Project No: 11174.1
Sample No: 2-6-1
Date: 3/30/21

GRAIN SIZE ANALYSIS

119C Coral Steet

Figure No. 15

HARO, KASUNICH AND ASSOCIATES, INC.
CONSULTING GEOTECHNICAL & COASTAL ENGINEERS
116 East Lake Avenue, Watsonville, California
(831) 722-4175 ~ Fax (831) 722-3202

Saturated Direct Shear

Project Name:	119C Coral St.				
Project #:	11174.1				
Sample #:	1-3-1				
Description:	Mottled Gray/Brown SILT				
Tested By:	KJ/MA				
Date Tested:	3/25/2021				

Test Number	1	2	3	4
Normal Pressure (PSF)	1000	2000	4000	8000
Max Shear Stress	20.2	37.3	88.3	130.1
Shear Stress (PSF)	630.1	1165.7		4062.6
* Indicates Points used for graph	*	*	2757.6	*

Equation of Trendline	
Intercept	Slope
164.44	0.4877

*Manually Enter from Trendline Equation

C (PSF)	PHI
164	26

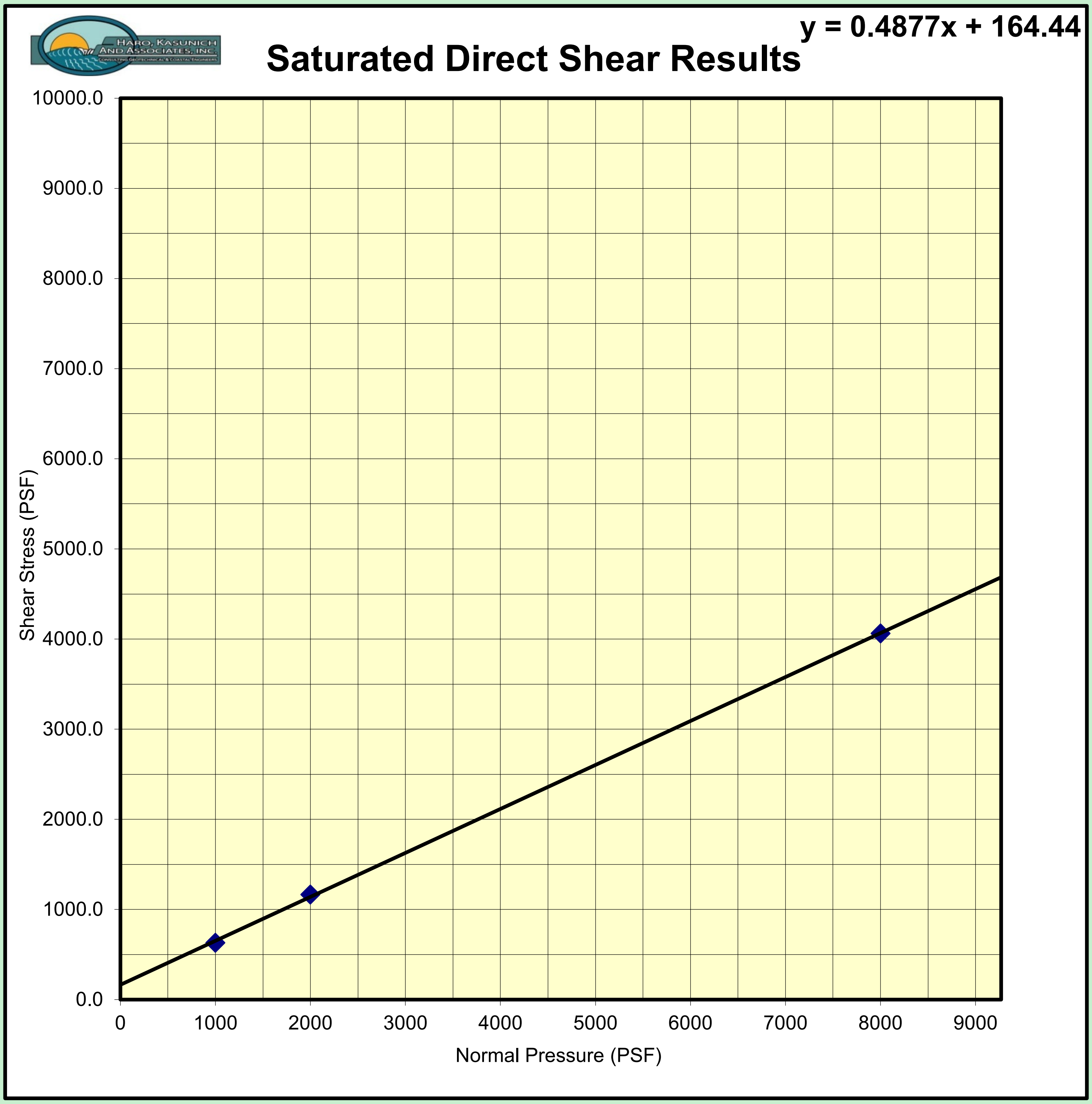


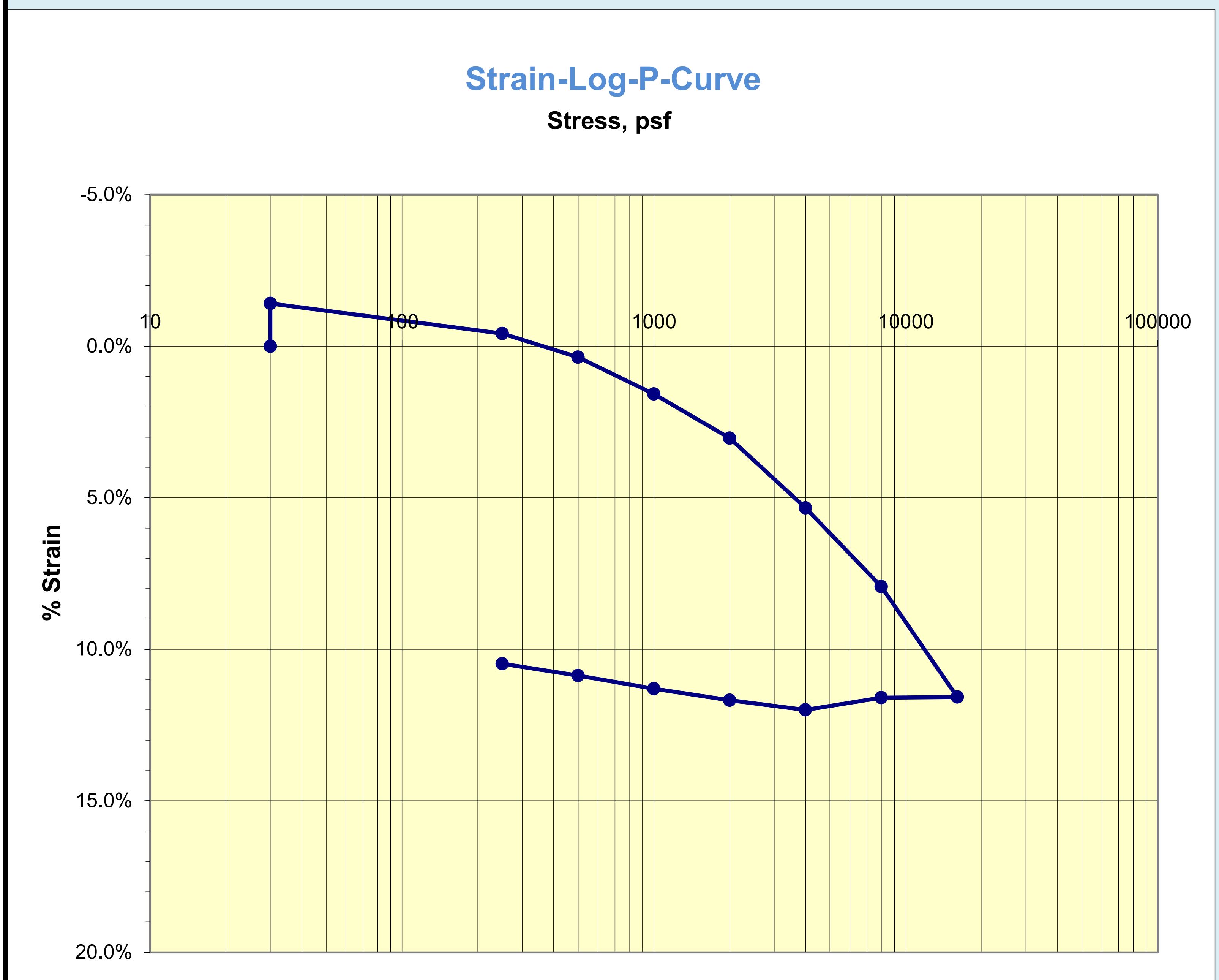
Figure No. 16

Job #:	SC 11174.1									
Date:	4/12/2021									
Project:	119C Coral Street									
Soil Decription:	Black Brown CLAY									
Tested By:	MA									
Sample #:	1-4-1									
					0					
				Initial Dial Reading, In		1				
Stress, psf:	30	30	250	500	1000	2000	4000	8000	16000	8000
Final Dial Reading	1	1.0141	1.0042	0.9964	0.9842	0.9697	0.9466	0.9207	0.8842	0.884
Strain,%	0.0%	-1.4%	-0.4%	0.4%	1.6%	3.0%	5.3%	7.9%	11.6%	11.6%

Stress, psf:	4000	2000	1000	500	250		**Initial Sample Height, in.**	1
Final Dial Reading	0.88	0.8832	0.887	0.8913	0.8952		**Final Sample Height, in.**	0.90
Strain,%	12.0%	11.7%	11.3%	10.9%	10.5%	100.00%		

	Initial	**Final**		
Moisture Content %	60.6%	48.8%	**% Swell**	
Dry Density, pcf	62	71	**1.4%**	
Void Ratio	1.698	1.373	**Stress For 0% Swell**	
Saturation %	96.4%	96.0%	**350psf**	
Specific Gravity -	**Assumed:** 2.7		**Measured:**	0

Remarks



Job #:	SC 11174.1
Date:	4/26/2021
Project:	119C Coral Street
Soil Decription:	Black Brown CLAY
Tested By:	MA
Sample #:	1-9-1

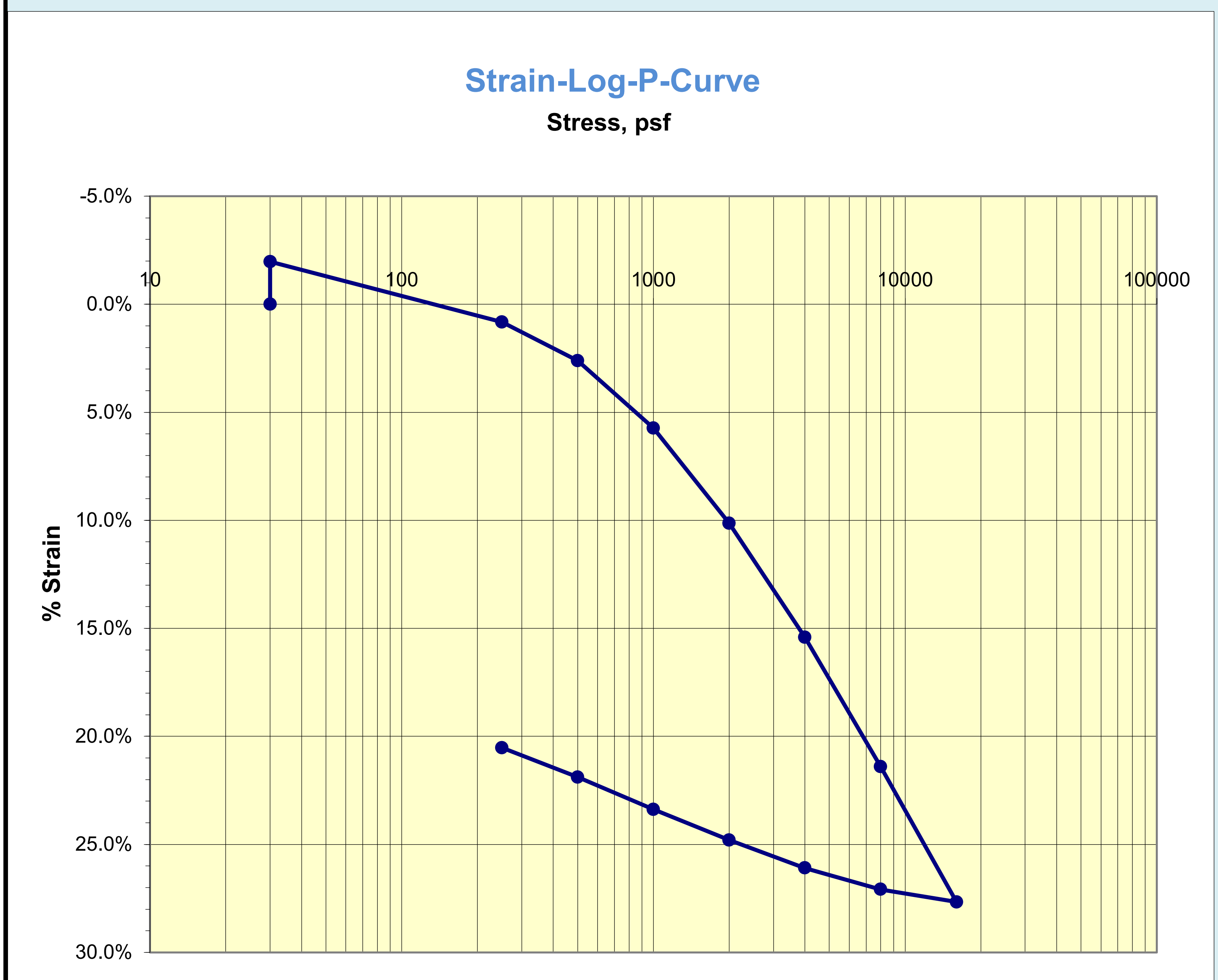
0

				Initial Dial Reading, In		1				
Stress, psf:	30	30	250	500	1000	2000	4000	8000	16000	8000
Final Dial Reading	1	1.0197	0.9918	0.9739	0.9427	0.8986	0.8459	0.786	0.7234	0.7292
Strain,%	0.0%	-2.0%	0.8%	2.6%	5.7%	10.1%	15.4%	21.4%	27.7%	27.1%

Stress, psf:	4000	2000	1000	500	250		**Initial Sample Height, in.**	1
Final Dial Reading	0.7391	0.752	0.7662	0.7811	0.7948		**Final Sample Height, in.**	0.79
Strain,%	26.1%	24.8%	23.4%	21.9%	20.5%	100.00%		

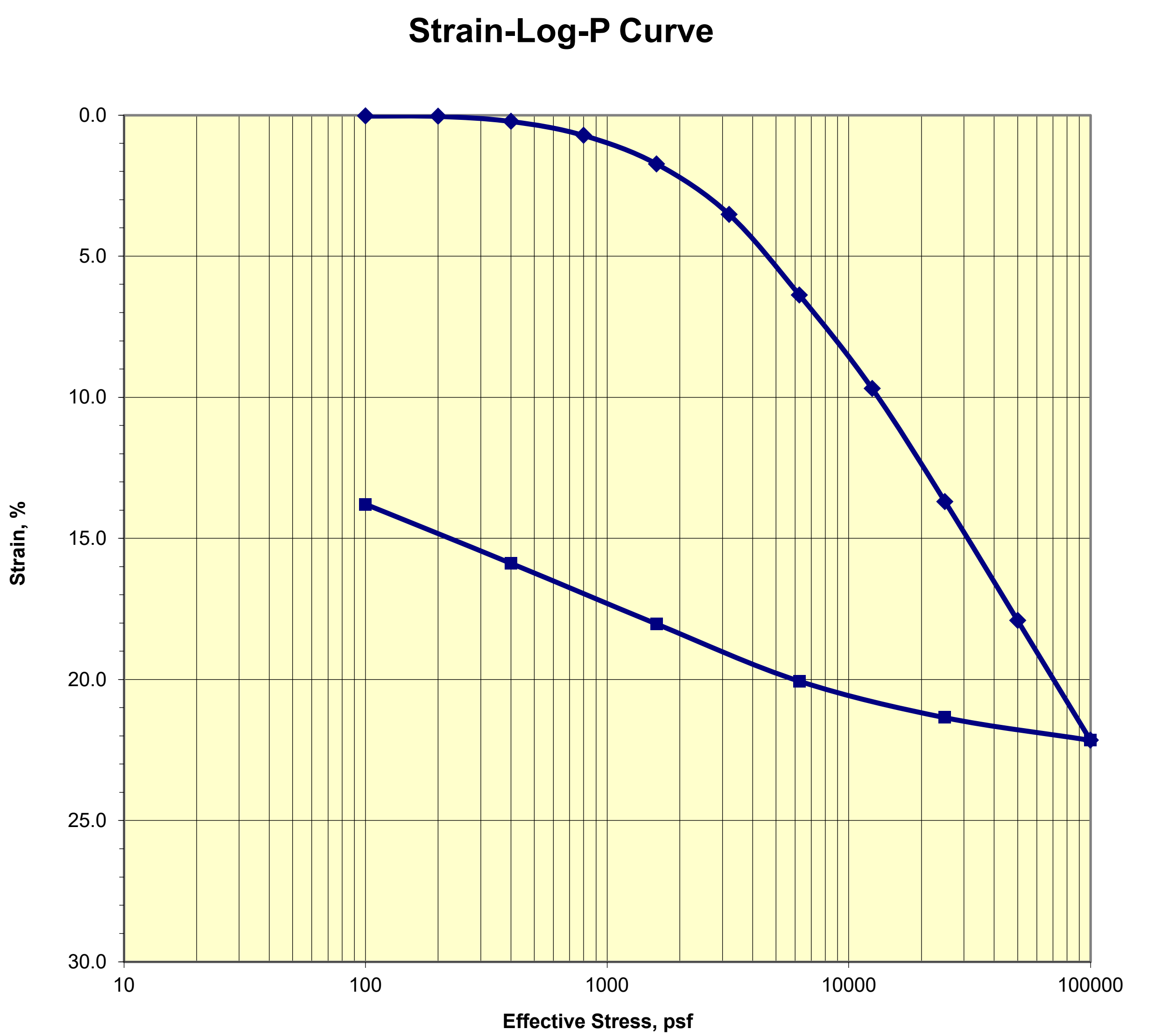
	Initial	**Final**		
Moisture Content %	71.2%	50.4%	**% Swell**	
Dry Density, pcf	56	86	**2.0%**	
Void Ratio	2.018	0.952	**Stress For 0% Swell**	
Saturation %	95.3%	100.0%	**150psf**	
Specific Gravity -	**Assumed:**	2.7	**Measured:**	0

Remarks



Consolidation Test
ASTM D2435

Job No.:	032-495	**Boring:**		**Run By:**	MD
Client:	Haro, Kasunich & Associates	**Sample:**	2-4-1	**Reduced:**	PJ
Project:	SC 11174.1	**Depth, ft.:**		**Checked:**	PJ/DC
Soil Type:	Gray CLAY			**Date:**	4/19/2021

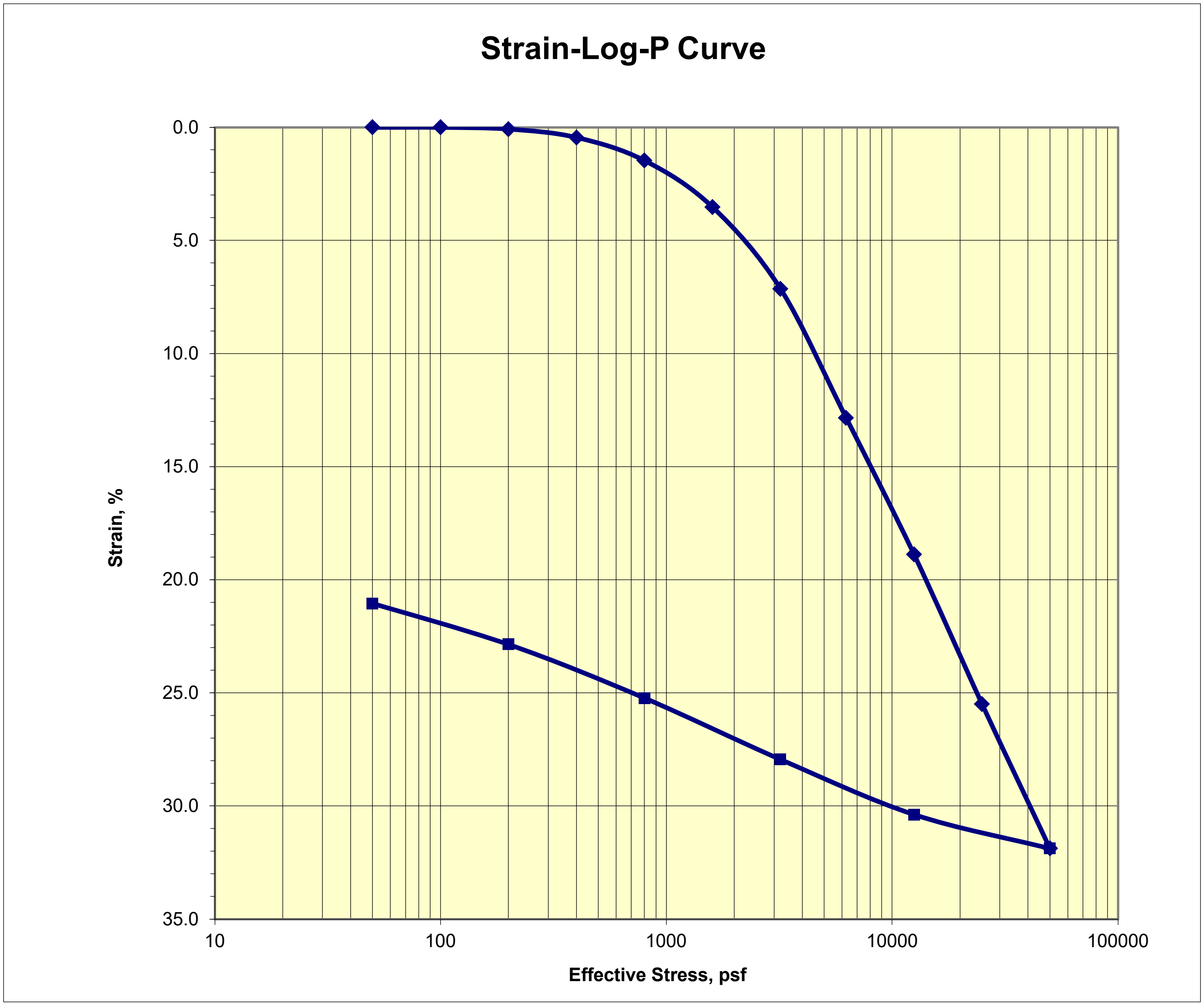


Assumed Gs 2.75	**Initial**	**Final**
Moisture %:	30.5	23.9
Dry Density, pcf:	89.5	103.6
Void Ratio:	0.917	0.657
% Saturation:	91.4	100.0

Remarks:

Consolidation Test
ASTM D2435

Job No.:	032-495	**Boring:**		**Run By:**	MD
Client:	Haro, Kasunich & Associates	**Sample:**	2-9-1	**Reduced:**	PJ
Project:	SC 11174.1	**Depth, ft.:**		**Checked:**	PJ/DC
Soil Type:	Greenish Gray CLAY			**Date:**	4/19/2021

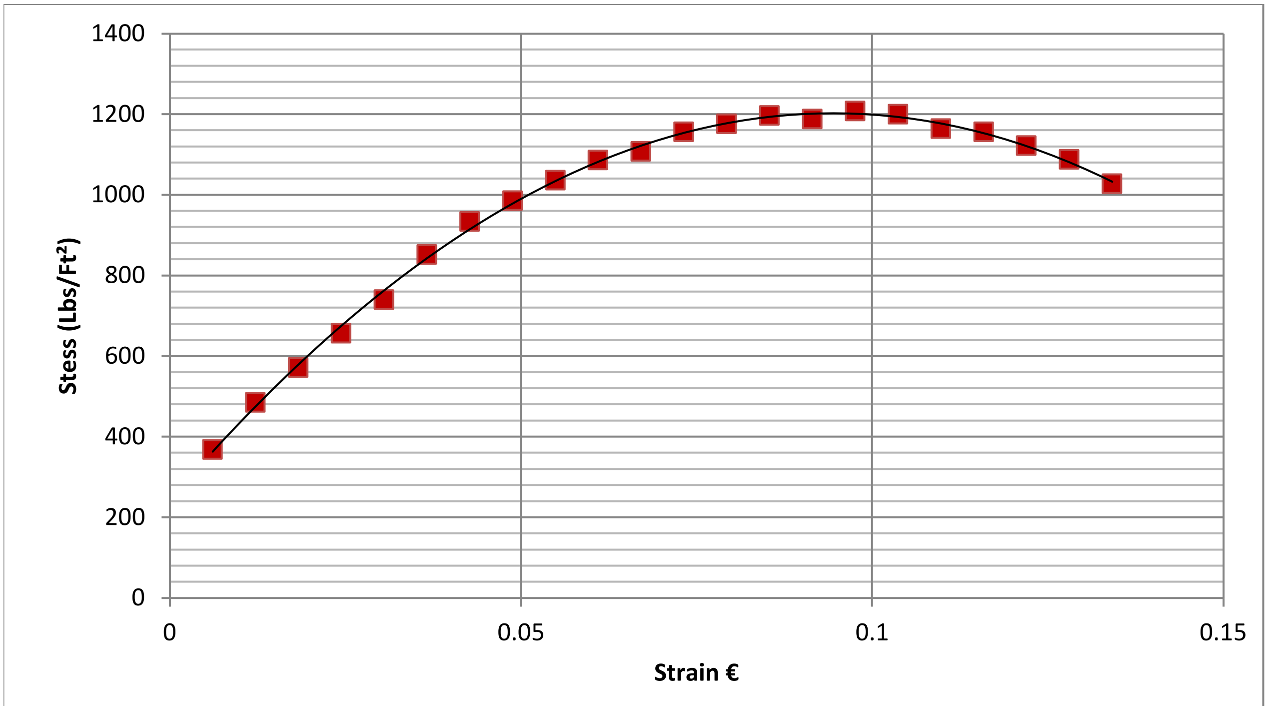


Assumed Gs 2.7	Initial	Final
Moisture %:	60.9	41.7
Dry Density, pcf:	62.2	79.3
Void Ratio:	1.711	1.127
% Saturation:	96.1	100.0

Remarks:

Figure No.: 20

Triaxial and Unconfined Compression Test



Sample 2-9-2
SC11174.1

APPENDIX B

Liquefaction Analysis (Figure 1-2) and Supporting Material

LIQUEFACTION ANALYSIS

SC11174.1 119C Coral Street

Hole No.=CPT-1   Water Depth=10 ft   Surface Elev.=30

Magnitude=7
Acceleration=0.766g

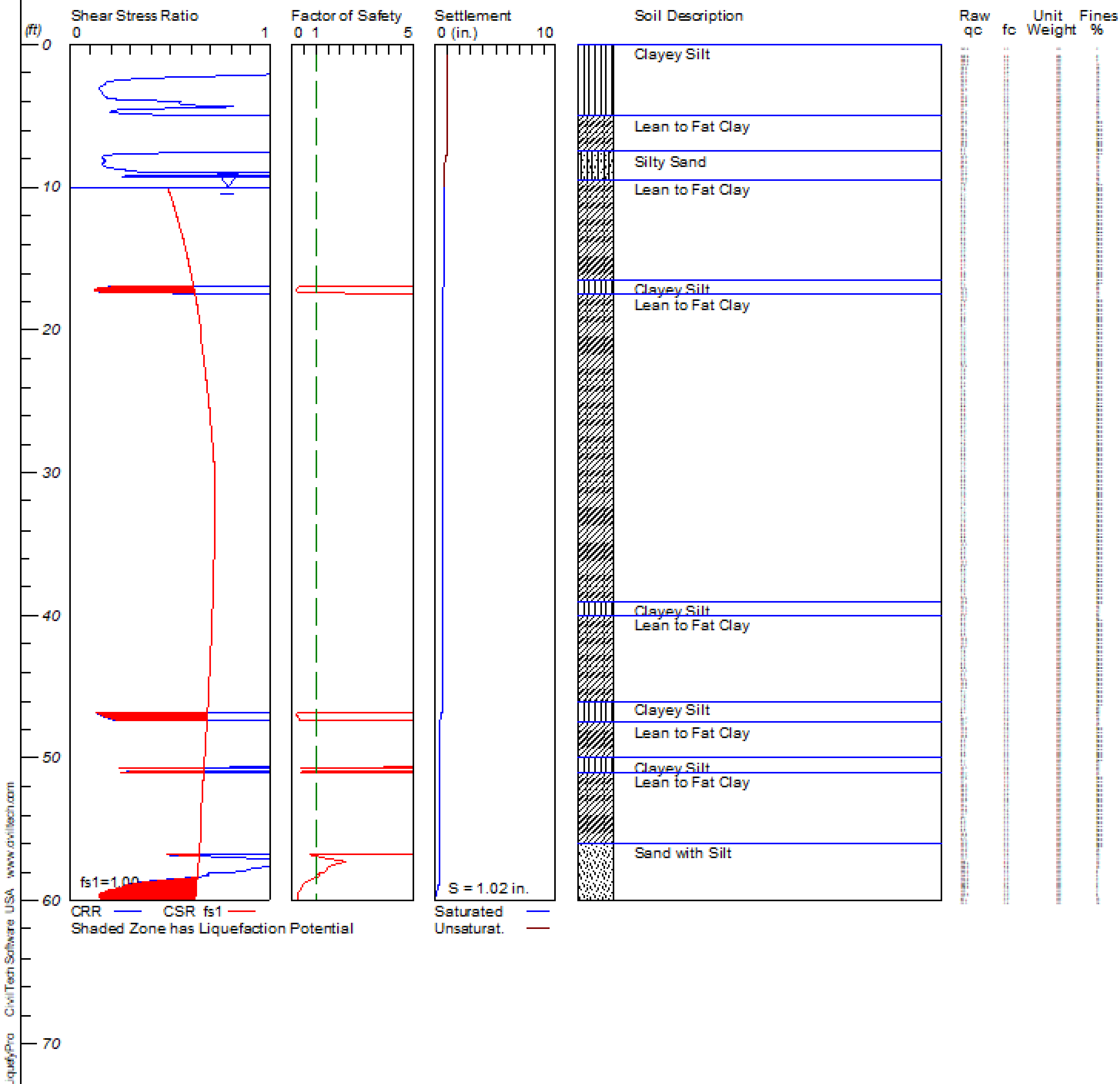


FIGURE NO. 1

LIQUEFACTION ANALYSIS

SC11174.1 119C Coral Street

Hole No.=CPT-2 Water Depth=10 ft Surface Elev.=28

Magnitude=7
Acceleration=0.77g

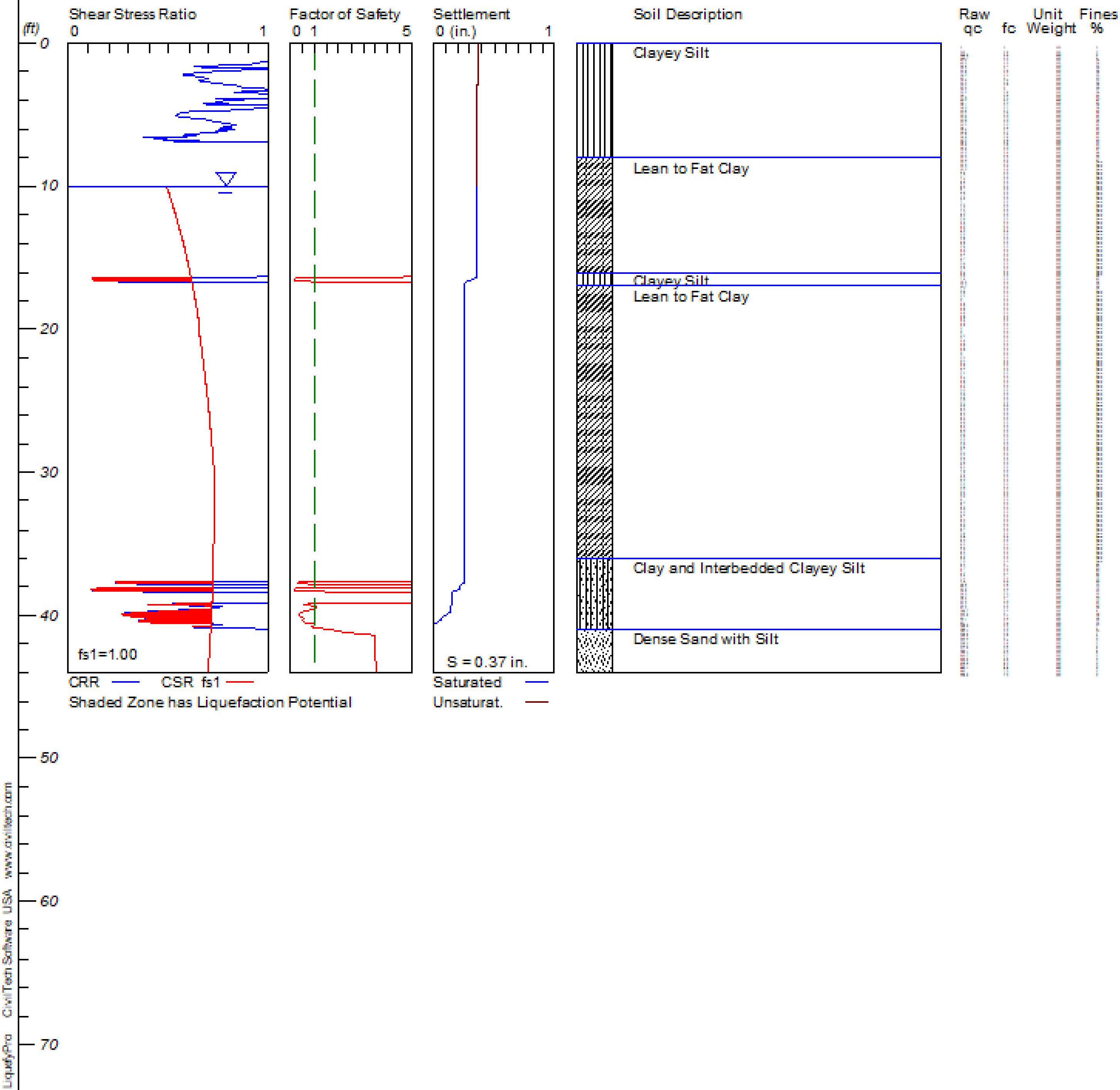


FIGURE NO. 2

****
****

LIQUEFACTION ANALYSIS SUMMARY

****
****

Font: Courier New, Regular, Size 8 is recommended for this report.
Licensed to ,   4/8/2021   3:06:21 PM

Input File Name: H:\PROJECTS\11000s\11174 folder, 115 C Coral St. Envision House\11174.1 New Homeless Shelter\Liquifaction\CPT-1.liq
Title: SC11174.1 119C Coral Street
Subtitle: Emergency Housing Shelter and Homeless Service Cen

Surface Elev.=30
Hole No.=CPT-1
Depth of Hole= 60.00 ft
Water Table during Earthquake= 10.00 ft
Water Table during In-Situ Testing= 10.00 ft
Max. Acceleration= 0.77 g
Earthquake Magnitude= 7.00

Input Data:
Surface Elev.=30
Hole No.=CPT-1
Depth of Hole=60.00 ft
Water Table during Earthquake= 10.00 ft
Water Table during In-Situ Testing= 10.00 ft
Max. Acceleration=0.77 g
Earthquake Magnitude=7.00
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
2. Settlement Analysis Method: Ishihara / Yoshimine
3. Fines Correction for Liquefaction: Stark/Olson et al.*
4. Fine Correction for Settlement: During Liquefaction*
5. Settlement Calculation in: All zones*
9. User request factor of safety (apply to CSR) ,   User= 1

10. Use Curve Smoothing: Yes*
* Recommended Options

In-Situ Test Data:

Depth	qc	fs	Rf	gamma	Fines	D50
ft	atm	atm	pcf	%	mm	

0.00	380.80	1.00	0.26	130.00	0.00	1.00
0.49	277.10	1.10	0.40	130.00	0.00	1.00
0.66	218.90	1.10	0.50	130.00	0.00	1.00
0.82	186.10	1.40	0.75	125.00	0.00	0.35
0.98	144.80	2.10	1.45	125.00	0.00	0.35
1.15	104.90	1.90	1.81	125.00	0.00	0.35
1.31	76.50	1.80	2.35	120.00	0.00	0.20
1.48	58.90	1.70	2.89	120.00	0.00	0.20
1.64	72.10	1.60	2.22	120.00	0.00	0.20
1.80	62.30	1.70	2.73	120.00	0.00	0.20
1.97	48.10	1.70	3.53	115.00	0.00	0.07
2.13	35.40	1.40	3.95	115.00	0.00	0.07
2.30	29.40	0.90	3.06	115.00	0.00	0.07
2.46	25.10	0.50	1.99	120.00	0.00	0.20
2.62	22.00	0.30	1.36	120.00	0.00	0.20
2.79	17.40	0.30	1.72	120.00	0.00	0.20
2.95	16.30	0.20	1.23	120.00	0.00	0.20
3.12	14.00	0.20	1.43	120.00	0.00	0.20
3.28	12.50	0.20	1.60	115.00	0.00	0.07
3.45	12.40	0.20	1.61	115.00	0.00	0.07
3.61	11.90	0.20	1.68	115.00	0.00	0.07
3.77	11.50	0.20	1.74	115.00	0.00	0.07
3.94	11.40	0.30	2.63	115.00	0.00	0.07
4.10	11.50	0.50	4.35	115.00	0.00	0.00
4.27	12.00	0.50	4.17	115.00	0.00	0.00
4.43	14.70	0.50	3.40	115.00	0.00	0.07
4.59	17.80	0.40	2.25	115.00	0.00	0.07
4.76	20.30	0.40	1.97	120.00	0.00	0.20
4.92	20.20	0.60	2.97	115.00	0.00	0.07
5.09	18.60	0.70	3.76	115.00	NoLiq	0.07
5.25	17.60	0.70	3.98	115.00	NoLiq	0.00
5.41	18.70	0.70	3.74	115.00	NoLiq	0.07
5.58	18.00	0.70	3.89	115.00	NoLiq	0.07
5.74	20.60	0.80	3.88	115.00	NoLiq	0.07
5.91	19.80	0.90	4.55	115.00	NoLiq	0.00
6.07	18.90	0.90	4.76	115.00	NoLiq	0.00
6.23	18.50	0.90	4.86	115.00	NoLiq	0.00
6.40	18.40	0.90	4.89	115.00	NoLiq	0.00
6.56	17.20	0.80	4.65	115.00	NoLiq	0.00
6.73	15.30	0.70	4.58	115.00	NoLiq	0.00
6.89	12.60	0.60	4.76	115.00	NoLiq	0.00
7.05	9.70	0.60	6.19	115.00	NoLiq	0.00
7.22	8.30	0.60	7.23	115.00	NoLiq	0.00
7.38	9.90	0.60	6.06	115.00	NoLiq	0.00
7.55	15.20	0.50	3.29	115.00	0.00	0.07
7.71	23.70	0.50	2.11	120.00	0.00	0.20
7.87	34.10	0.40	1.17	120.00	0.00	0.20
8.04	43.80	0.40	0.91	120.00	0.00	0.20
8.20	46.00	0.40	0.87	125.00	0.00	0.35

57.58	263.10	2.30	0.87	125.00	0.00	0.35
57.75	251.40	2.30	0.91	125.00	0.00	0.35
57.91	248.30	2.20	0.89	125.00	0.00	0.35
58.07	231.10	1.50	0.65	125.00	0.00	0.35
58.24	234.60	1.20	0.51	125.00	0.00	0.35
58.40	215.80	0.90	0.42	125.00	0.00	0.35
58.57	190.00	1.00	0.53	125.00	0.00	0.35
58.73	166.80	0.80	0.48	125.00	0.00	0.35
58.89	158.40	0.60	0.38	125.00	0.00	0.35
59.06	150.00	0.50	0.33	125.00	0.00	0.35
59.22	133.40	0.50	0.37	125.00	0.00	0.35
59.39	110.20	0.50	0.45	125.00	0.00	0.35
59.55	85.00	0.50	0.59	125.00	0.00	0.35
59.71	64.40	0.70	1.09	120.00	0.00	0.20
59.88	51.20	0.80	1.56	120.00	0.00	0.20

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=0.71 in.
Settlement of Unsaturated Sands=0.31 in.
Total Settlement of Saturated and Unsaturated Sands=1.02 in.
Differential Settlement=0.508 to 0.671 in.

Depth ft	CRRm	CSRfs	F.S.	S_sat. in.	S_dry in.	S_all in.
0.00	2.00	0.50	5.00	0.71	0.31	1.02
0.05	2.48	0.50	5.00	0.71	0.31	1.02
0.10	2.48	0.50	5.00	0.71	0.31	1.02
0.15	2.48	0.50	5.00	0.71	0.31	1.02
0.20	2.48	0.50	5.00	0.71	0.31	1.02
0.25	2.48	0.50	5.00	0.71	0.31	1.02
0.30	2.48	0.50	5.00	0.71	0.31	1.02
0.35	2.48	0.50	5.00	0.71	0.31	1.02
0.40	2.48	0.50	5.00	0.71	0.31	1.02
0.45	2.48	0.50	5.00	0.71	0.31	1.02
0.50	2.48	0.50	5.00	0.71	0.31	1.02
0.55	2.48	0.50	5.00	0.71	0.31	1.02
0.60	2.48	0.50	5.00	0.71	0.31	1.02
0.65	2.48	0.50	5.00	0.71	0.31	1.02
0.70	2.48	0.50	5.00	0.71	0.31	1.02
0.75	2.48	0.50	5.00	0.71	0.31	1.02
0.80	2.48	0.50	5.00	0.71	0.31	1.02
0.85	2.48	0.50	5.00	0.71	0.31	1.02
0.90	2.48	0.50	5.00	0.71	0.31	1.02
0.95	2.48	0.50	5.00	0.71	0.31	1.02
1.00	2.48	0.50	5.00	0.71	0.31	1.02
1.05	2.48	0.50	5.00	0.71	0.31	1.02

1.10	2.48	0.50	5.00	0.71	0.31	1.02
1.15	2.48	0.50	5.00	0.71	0.31	1.02
1.20	2.48	0.50	5.00	0.71	0.31	1.02
1.25	2.48	0.50	5.00	0.71	0.31	1.02
1.30	2.48	0.50	5.00	0.71	0.31	1.02
1.35	2.48	0.50	5.00	0.71	0.31	1.02
1.40	2.48	0.50	5.00	0.71	0.31	1.01
1.45	2.33	0.50	5.00	0.71	0.31	1.01
1.50	2.15	0.50	5.00	0.71	0.31	1.01
1.55	2.21	0.50	5.00	0.71	0.31	1.01
1.60	2.29	0.50	5.00	0.71	0.31	1.01
1.65	2.32	0.50	5.00	0.71	0.31	1.01
1.70	2.14	0.50	5.00	0.71	0.31	1.01
1.75	1.99	0.50	5.00	0.71	0.31	1.01
1.80	1.86	0.50	5.00	0.71	0.31	1.01
1.85	1.68	0.50	5.00	0.71	0.31	1.01
1.90	1.54	0.50	5.00	0.71	0.31	1.01
1.95	1.44	0.50	5.00	0.71	0.31	1.01
2.00	1.31	0.50	5.00	0.71	0.31	1.01
2.05	1.17	0.50	5.00	0.71	0.31	1.01
2.10	1.06	0.50	5.00	0.71	0.31	1.01
2.15	0.95	0.50	5.00	0.71	0.31	1.01
2.20	0.79	0.50	5.00	0.71	0.31	1.01
2.25	0.64	0.50	5.00	0.71	0.31	1.01
2.30	0.51	0.50	5.00	0.71	0.31	1.01
2.35	0.42	0.50	5.00	0.71	0.31	1.01
2.40	0.34	0.50	5.00	0.71	0.31	1.01
2.45	0.27	0.50	5.00	0.71	0.31	1.01
2.50	0.23	0.49	5.00	0.71	0.31	1.01
2.55	0.21	0.49	5.00	0.71	0.31	1.01
2.60	0.18	0.49	5.00	0.71	0.31	1.01
2.65	0.17	0.49	5.00	0.71	0.30	1.01
2.70	0.17	0.49	5.00	0.71	0.30	1.01
2.75	0.17	0.49	5.00	0.71	0.30	1.01
2.80	0.17	0.49	5.00	0.71	0.30	1.01
2.85	0.16	0.49	5.00	0.71	0.30	1.01
2.90	0.15	0.49	5.00	0.71	0.30	1.01
2.95	0.14	0.49	5.00	0.71	0.30	1.00
3.00	0.14	0.49	5.00	0.71	0.29	1.00
3.05	0.14	0.49	5.00	0.71	0.29	1.00
3.10	0.14	0.49	5.00	0.71	0.29	0.99
3.15	0.14	0.49	5.00	0.71	0.28	0.99
3.20	0.15	0.49	5.00	0.71	0.28	0.99
3.25	0.15	0.49	5.00	0.71	0.28	0.99
3.30	0.16	0.49	5.00	0.71	0.28	0.98
3.35	0.16	0.49	5.00	0.71	0.27	0.98
3.40	0.16	0.49	5.00	0.71	0.27	0.98
3.45	0.16	0.49	5.00	0.71	0.27	0.98
3.50	0.16	0.49	5.00	0.71	0.27	0.97
3.55	0.17	0.49	5.00	0.71	0.26	0.97

58.60	0.39	0.63	0.62*	0.38	0.00	0.38
58.65	0.36	0.63	0.57*	0.37	0.00	0.37
58.70	0.33	0.63	0.52*	0.36	0.00	0.36
58.75	0.31	0.63	0.49*	0.34	0.00	0.34
58.80	0.29	0.63	0.47*	0.33	0.00	0.33
58.85	0.28	0.63	0.45*	0.32	0.00	0.32
58.90	0.27	0.63	0.44*	0.31	0.00	0.31
58.95	0.27	0.63	0.42*	0.30	0.00	0.30
59.00	0.26	0.63	0.41*	0.28	0.00	0.28
59.05	0.25	0.63	0.40*	0.27	0.00	0.27
59.10	0.24	0.63	0.38*	0.26	0.00	0.26
59.15	0.22	0.62	0.36*	0.24	0.00	0.24
59.20	0.21	0.62	0.34*	0.23	0.00	0.23
59.25	0.20	0.62	0.32*	0.22	0.00	0.22
59.30	0.19	0.62	0.30*	0.20	0.00	0.20
59.35	0.18	0.62	0.29*	0.19	0.00	0.19
59.40	0.17	0.62	0.27*	0.18	0.00	0.18
59.45	0.16	0.62	0.26*	0.16	0.00	0.16
59.50	0.15	0.62	0.24*	0.14	0.00	0.14
59.55	0.14	0.62	0.23*	0.13	0.00	0.13
59.60	0.14	0.62	0.23*	0.11	0.00	0.11
59.65	0.14	0.62	0.23*	0.10	0.00	0.10
59.70	0.14	0.62	0.23*	0.08	0.00	0.08
59.75	0.14	0.62	0.23*	0.07	0.00	0.07
59.80	0.15	0.62	0.24*	0.05	0.00	0.05
59.85	0.15	0.62	0.25*	0.04	0.00	0.04
59.90	0.16	0.62	0.25*	0.03	0.00	0.03
59.95	0.16	0.62	0.25*	0.01	0.00	0.01
60.00	0.16	0.62	0.25*	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

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1 atm (atmosphere) = 1 tsf (ton/ft2)

CRRm	Cyclic resistance ratio from soils
CSRsf	Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
F.S.	Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
S_sat	Settlement from saturated sands
S_dry	Settlement from Unsaturated Sands
S_all	Total Settlement from Saturated and Unsaturated Sands
NoLiq	No-Liquefy Soils

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LIQUEFACTION ANALYSIS SUMMARY

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Font: Courier New, Regular, Size 8 is recommended for this report.
Licensed to , 4/8/2021 3:28:21 PM

Input File Name: H:\PROJECTS\11000s\11174 folder, 115 C Coral St. Envision House\11174.1 New Homeless Shelter\Liquifaction\CPT-2.liq
Title: SC11174.1 119C Coral Street
Subtitle: Emergency Housing Shelter and Homeless Center

Surface Elev.=28
Hole No.=CPT-2
Depth of Hole= 44.00 ft
Water Table during Earthquake= 10.00 ft
Water Table during In-Situ Testing= 10.00 ft
Max. Acceleration= 0.77 g
Earthquake Magnitude= 7.00

Input Data:
Surface Elev.=28
Hole No.=CPT-2
Depth of Hole=44.00 ft
Water Table during Earthquake= 10.00 ft
Water Table during In-Situ Testing= 10.00 ft
Max. Acceleration=0.77 g
Earthquake Magnitude=7.00
No-Liquefiable Soils: CL, OL are Non-Liq. Soil

1. CPT Calculation Method: Modify Robertson*
2. Settlement Analysis Method: Ishihara / Yoshimine
3. Fines Correction for Liquefaction: Stark/Olson et al.*
4. Fine Correction for Settlement: During Liquefaction*
5. Settlement Calculation in: All zones*
9. User request factor of safety (apply to CSR) , User= 1

10. Use Curve Smoothing: Yes*
* Recommended Options

In-Situ Test Data:

Depth	qc	fs	Rf	gamma	Fines	D50
ft	atm	atm	pcf	%	mm	

0.00	0.00	0.00	100.00	130.00	0.00	0.00
0.33	312.00	0.60	0.19	130.00	0.00	1.00
0.49	198.40	2.30	1.16	125.00	0.00	0.35
0.66	212.50	2.40	1.13	125.00	0.00	0.35
0.82	168.70	2.30	1.36	125.00	0.00	0.35
0.98	81.40	2.10	2.58	120.00	0.00	0.20
1.15	45.20	1.30	2.88	120.00	0.00	0.20
1.31	28.90	1.10	3.81	115.00	0.00	0.07
1.48	24.20	1.00	4.13	115.00	0.00	0.07
1.64	22.90	0.80	3.49	115.00	0.00	0.07
1.80	23.90	1.10	4.60	115.00	0.00	0.07
1.97	29.50	1.10	3.73	115.00	0.00	0.07
2.13	35.00	1.00	2.86	115.00	0.00	0.07
2.30	24.80	0.90	3.63	115.00	0.00	0.07
2.46	23.20	0.90	3.88	115.00	0.00	0.07
2.62	24.10	0.90	3.73	115.00	0.00	0.07
2.79	25.30	1.00	3.95	115.00	0.00	0.07
2.95	24.30	1.00	4.12	115.00	0.00	0.07
3.12	22.20	0.90	4.05	115.00	0.00	0.07
3.28	19.00	0.80	4.21	115.00	0.00	0.07
3.45	17.40	0.70	4.02	115.00	0.00	0.00
3.61	15.70	0.70	4.46	115.00	0.00	0.00
3.77	15.70	0.70	4.46	115.00	0.00	0.00
3.94	19.00	0.70	3.68	115.00	0.00	0.07
4.10	19.70	0.70	3.55	115.00	0.00	0.07
4.27	19.50	0.70	3.59	115.00	0.00	0.07
4.43	15.80	0.70	4.43	115.00	0.00	0.00
4.59	15.10	0.60	3.97	115.00	0.00	0.07
4.76	15.10	0.50	3.31	115.00	0.00	0.07
4.92	15.60	0.50	3.21	115.00	0.00	0.07
5.09	15.80	0.50	3.16	115.00	0.00	0.07
5.25	15.50	0.50	3.23	115.00	0.00	0.07
5.41	15.20	0.50	3.29	115.00	0.00	0.07
5.58	16.00	0.60	3.75	115.00	0.00	0.07
5.74	16.90	0.70	4.14	115.00	0.00	0.07
5.91	16.60	0.70	4.22	115.00	0.00	0.00
6.07	17.90	0.60	3.35	115.00	0.00	0.07
6.23	16.80	0.60	3.57	115.00	0.00	0.07
6.40	15.70	0.60	3.82	115.00	0.00	0.07
6.56	18.30	0.50	2.73	115.00	0.00	0.07
6.73	19.20	0.60	3.13	115.00	0.00	0.07
6.89	14.80	0.60	4.05	115.00	0.00	0.00
7.05	14.10	0.50	3.55	115.00	0.00	0.07
7.22	12.90	0.50	3.88	115.00	0.00	0.00
7.38	12.20	0.40	3.28	115.00	0.00	0.07
7.55	11.20	0.40	3.57	115.00	0.00	0.00
7.71	10.20	0.30	2.94	115.00	0.00	0.00
7.87	11.40	0.30	2.63	115.00	0.00	0.07
8.04	10.70	0.40	3.74	115.00	NoLiq	0.00

41.01	236.40	2.60	1.10	125.00	0.00	0.35
41.18	266.90	2.90	1.09	125.00	0.00	0.35
41.34	311.10	3.00	0.96	125.00	0.00	0.35
41.50	337.70	2.90	0.86	125.00	0.00	0.35
41.67	359.10	3.40	0.95	125.00	0.00	0.35
41.83	374.20	3.90	1.04	125.00	0.00	0.35
42.00	377.90	5.20	1.38	125.00	0.00	0.35
42.16	384.00	5.80	1.51	125.00	0.00	0.35
42.32	399.20	6.10	1.53	125.00	0.00	0.35
42.49	411.70	5.70	1.38	125.00	0.00	0.35
42.65	434.10	5.80	1.34	125.00	0.00	0.35
42.82	444.80	6.40	1.44	125.00	0.00	0.35
42.98	456.90	6.50	1.42	125.00	0.00	0.35
43.15	470.70	6.10	1.30	125.00	0.00	0.35
43.31	482.00	6.60	1.37	125.00	0.00	0.35
43.47	493.10	6.90	1.40	125.00	0.00	0.35
43.64	480.00	7.30	1.52	125.00	0.00	0.35
43.80	488.20	7.50	1.54	125.00	0.00	0.35
43.97	506.60	7.20	1.42	125.00	0.00	0.35

Modify Robertson method generates Fines from qc/fs. Inputted Fines are not relevant.

Output Results:

Settlement of Saturated Sands=0.35 in.
Settlement of Unsaturated Sands=0.02 in.
Total Settlement of Saturated and Unsaturated Sands=0.37 in.
Differential Settlement=0.184 to 0.243 in.

Depth ft	CRRm	CSRfs	F.S.	S_sat. in.	S_dry in.	S_all in.
0.00	2.00	0.50	5.00	0.35	0.02	0.37
0.05	2.48	0.50	5.00	0.35	0.02	0.37
0.10	2.48	0.50	5.00	0.35	0.02	0.37
0.15	2.48	0.50	5.00	0.35	0.02	0.37
0.20	2.48	0.50	5.00	0.35	0.02	0.37
0.25	2.48	0.50	5.00	0.35	0.02	0.37
0.30	2.48	0.50	5.00	0.35	0.02	0.37
0.35	2.48	0.50	5.00	0.35	0.02	0.37
0.40	2.48	0.50	5.00	0.35	0.02	0.37
0.45	2.48	0.50	5.00	0.35	0.02	0.37
0.50	2.48	0.50	5.00	0.35	0.02	0.37
0.55	2.48	0.50	5.00	0.35	0.02	0.37
0.60	2.48	0.50	5.00	0.35	0.02	0.37
0.65	2.48	0.50	5.00	0.35	0.02	0.37
0.70	2.48	0.50	5.00	0.35	0.02	0.37
0.75	2.48	0.50	5.00	0.35	0.02	0.37
0.80	2.48	0.50	5.00	0.35	0.02	0.37
0.85	2.48	0.50	5.00	0.35	0.02	0.37

43.40	2.48	0.70	3.54	0.00	0.00	0.00
43.45	2.48	0.70	3.54	0.00	0.00	0.00
43.50	2.48	0.70	3.54	0.00	0.00	0.00
43.55	2.48	0.70	3.54	0.00	0.00	0.00
43.60	2.48	0.70	3.54	0.00	0.00	0.00
43.65	2.48	0.70	3.54	0.00	0.00	0.00
43.70	2.48	0.70	3.55	0.00	0.00	0.00
43.75	2.48	0.70	3.55	0.00	0.00	0.00
43.80	2.48	0.70	3.55	0.00	0.00	0.00
43.85	2.48	0.70	3.55	0.00	0.00	0.00
43.90	2.48	0.70	3.55	0.00	0.00	0.00
43.95	2.48	0.70	3.55	0.00	0.00	0.00
44.00	2.48	0.70	3.55	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

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1 atm (atmosphere) = 1 tsf (ton/ft2)

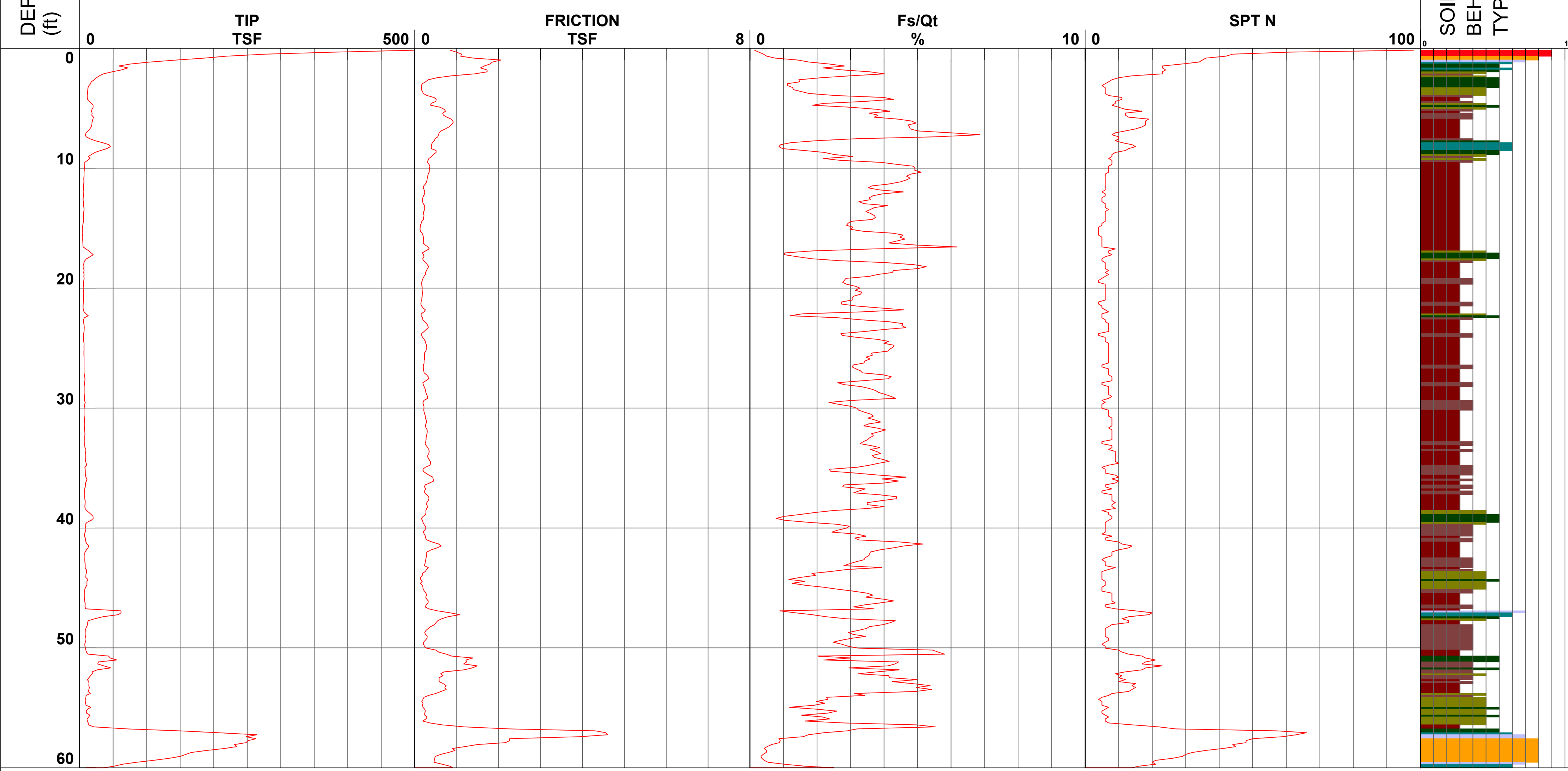
CRRm	Cyclic resistance ratio from soils
CSRsf	Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
F.S.	Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
S_sat	Settlement from saturated sands
S_dry	Settlement from Unsaturated Sands
S_all	Total Settlement from Saturated and Unsaturated Sands
NoLiq	No-Liquefy Soils

Haro Kasunich & Associates

Project	Santa Cruz Homeless Shelter	Operator	BH-ZG-OO	Filename	SDF(383).cpt
Job Number	SC11174.1	Cone Number	DPG1556	GPS	
Hole Number	CPT-01	Date and Time	3/18/2021 7:47:38 AM	Maximum Depth	60.53 ft
EST GW Depth During Test		14.00 ft			

Net Area Ratio .8

CPT DATA



- 1 - sensitive fine grained
- 2 - organic material
- 3 - clay
- 4 - silty clay to clay
- 5 - clayey silt to silty clay
- 6 - sandy silt to clayey silt
- 7 - silty sand to sandy silt
- 8 - sand to silty sand
- 9 - sand
- 10 - gravelly sand to sand
- 11 - very stiff fine grained (*)
- 12 - sand to clayey sand (*)

Cone Size 15cm squared

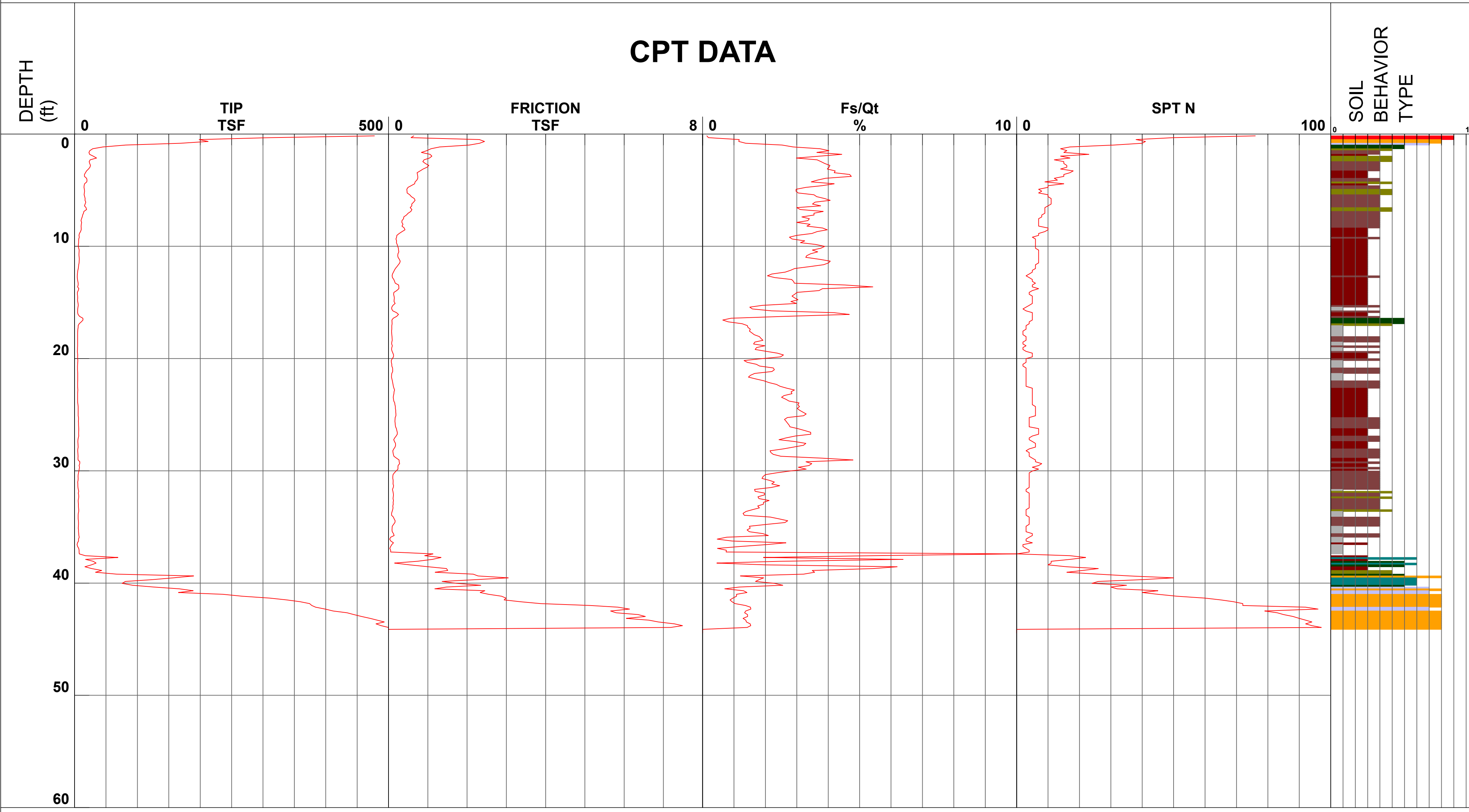
S*Soil behavior type and SPT based on data from UBC-1983

Haro Kasunich & Associates

Project	Santa Cruz Homeless Shelter	Operator	BH-ZG-OO	Filename	SDF(384).cpt
Job Number	SC11174.1	Cone Number	DPG1556	GPS	
Hole Number	CPT-02	Date and Time	3/18/2021 9:01:01 AM	Maximum Depth	44.45 ft
EST GW Depth During Test			12.00 ft		

Net Area Ratio .8

CPT DATA



1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

Cone Size 15cm squared

S*Soil behavior type and SPT based on data from UBC-1983

APPENDIX C

Consolidation Time Settlement Analysis (Figure 1-6)

SC11174.1 119C Coral Street, Santa Cruz, CA

Time Rate Consolidation Settlment Analysis

BORING B-1 Normally Consolidated

Layer	Layer Midpoint Depth	Height Layer (ft)	Initial Pressure σ'o(psf)	Final Pressure σ'f(psf)	Boussinesq I	Cc/1+eo	Settlement (ft)	Settlement (in)	Boussinesq Factor N	Boussinesq Factor M
1	1	2	108	1585.035	0.246	0.11	0.257	3.080	3.50	3.50
1	3	2	324	1481.958	0.193	0.11	0.145	1.743	1.17	1.17
1	5	2	540	1306.734	0.128	0.11	0.084	1.013	0.70	0.70
2	7	2	756	1260.417	0.084	0.11	0.049	0.586	0.50	0.50
2	9	2	972	1317.825	0.058	0.11	0.029	0.349	0.39	0.39
2	11	2	1047	1295.354	0.041	0.21	0.039	0.465	0.32	0.32
2	13	2	1122	1307.715	0.031	0.21	0.028	0.334	0.27	0.27
2	15	2	1198	1340.646	0.024	0.21	0.021	0.247	0.23	0.23
2	17	2	1273	1386.265	0.019	0.21	0.016	0.187	0.21	0.21
2	19	2	1348	1440.05	0.015	0.21	0.012	0.145	0.18	0.18
2	21	2	1423	1499.292	0.013	0.21	0.010	0.114	0.17	0.17
2	23	2	1498	1562.305	0.011	0.21	0.008	0.091	0.15	0.15
2	25	2	1574	1628	0.009	0.21	0.006	0.074	0.14	0.14
2	27	2	1649	1695.651	0.008	0.21	0.005	0.061	0.13	0.13
2	29	2	1724	1764.76	0.007	0.21	0.004	0.051	0.12	0.12
2	31	2	1799	1834.976	0.006	0.21	0.004	0.043	0.11	0.11
2	33	2	1874	1906.048	0.005	0.21	0.003	0.037	0.11	0.11
2	35	2	1950	1977.792	0.005	0.21	0.003	0.031	0.10	0.10
2	37	2	2025	2050.071	0.004	0.21	0.002	0.027	0.09	0.09
2	39	2	2100	2122.779	0.004	0.21	0.002	0.024	0.09	0.09
2	41	2	2175	2195.837	0.003	0.21	0.002	0.021	0.09	0.09
2	43	2	2250	2269.182	0.003	0.21	0.002	0.018	0.08	0.08
3	45	2	2356	2372.766	0.003	0.01	0.000	0.001	0.08	0.08
3	47	2	2461	2476.549	0.003	0.01	0.000	0.001	0.07	0.07
3	49	2	2566	2580.5	0.002	0.01	0.000	0.000	0.07	0.07
							Total	**8.744426034**		

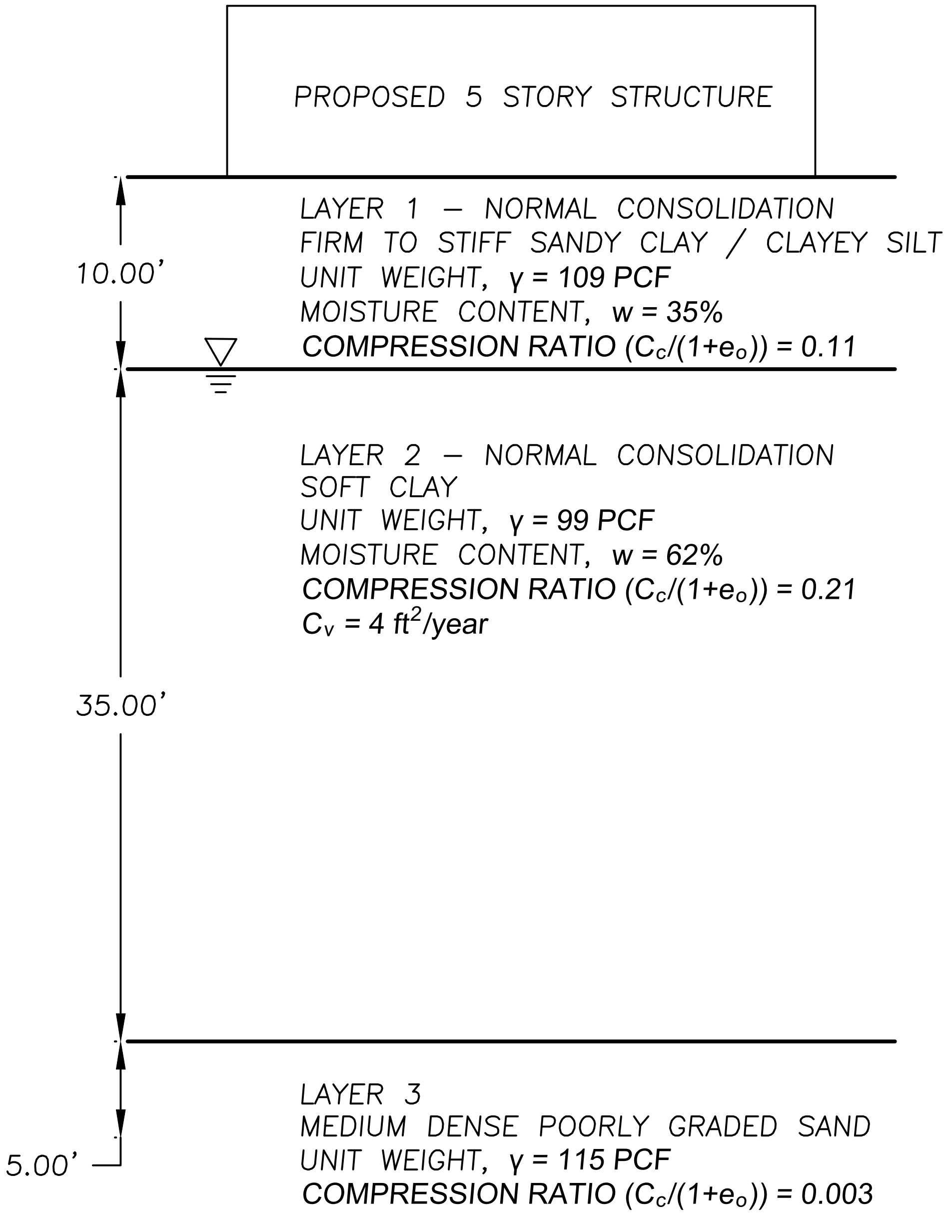
Square Footing Dimensions				
	Width (ft)	Length (ft)	Qallow (psf)	
	7	7	1500	1500

Thickness of Compressible Layer 1 (ft) =	10
$Cv_{avg}(ft^2/yr)$ =	43

U (%)	Time Factor, Tv	ΔH (in.)	Time, t (yr)
0%	0	0	0
10%	0.008	0.677	0.23
20%	0.031	1.354	0.47
30%	0.071	2.031	0.70
40%	0.126	2.709	0.93
50%	0.197	3.386	1.16
60%	0.286	4.063	1.40
70%	0.403	4.740	1.63
80%	0.567	5.417	1.86
90%	0.848	6.094	2.09
100%	3.00	6.771	2.33

Thickness of Compressible Layer 2 (ft) =	35
$Cv_{avg}(ft^2/yr)$ =	4.2

U (%)	Time Factor, Tv	ΔH (in.)	Time, t (yr)
0%	0	0	0
10%	0.008	0.197	29.17
20%	0.031	0.395	58.33
30%	0.071	0.592	87.50
40%	0.126	0.789	116.67
50%	0.197	0.987	145.83
60%	0.286	1.184	175.00
70%	0.403	1.381	204.17
80%	0.567	1.579	233.33
90%	0.848	1.776	262.50
100%	3.00	1.973	291.67



BORING B-1 SOIL PROFILE
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

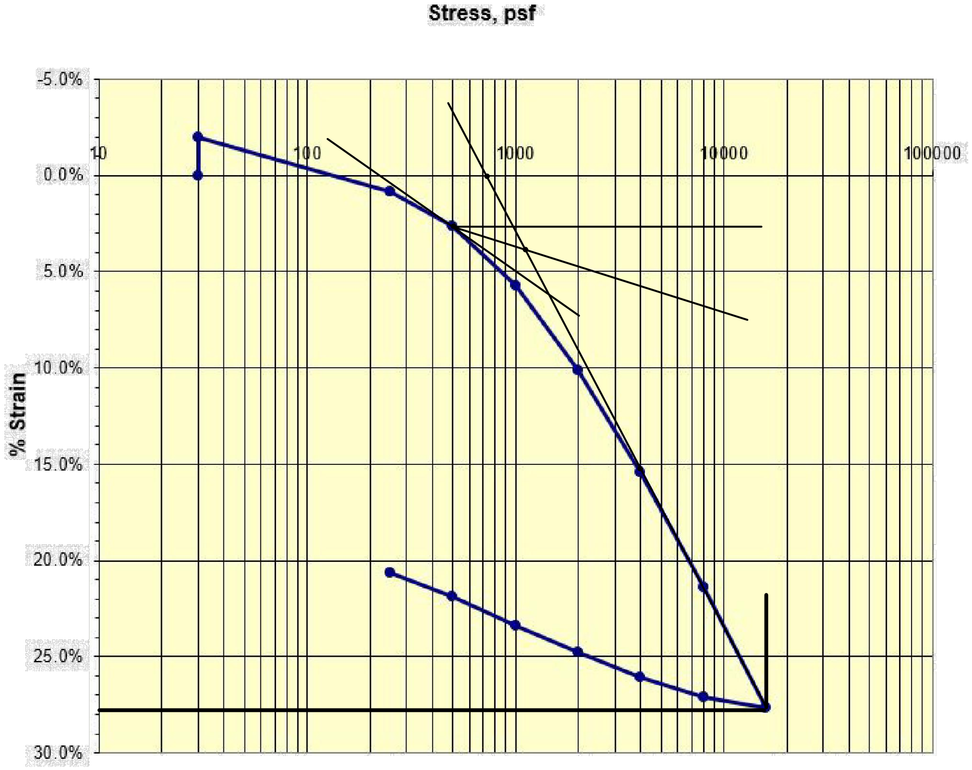
SCALE:	NTS
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
GEOTECHNICAL AND COASTAL ENGINEERS
116 E. LAKE AVENUE, WATSONVILLE, CA 95076
(831) 722-4175

FIGURE NO. 2

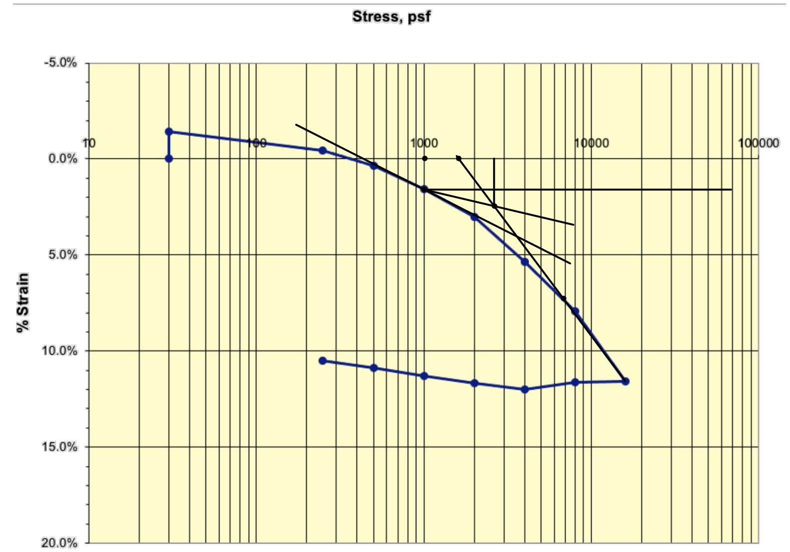
SHEET NO.

SAMPLE 1-9-1



Max Past Pressure: 4000psf
Est. Maximum Past Pressure: 1200psf
Min Past Pressure: 700psf
Sample Depth:35ft, Unit Weight: 100
Est effective stress: 1500-1900 psf, NORMAL CONSOL
Cc = 0.21

SAMPLE 1-4-1



Max Past Pressure: 7000psf
Est. Past Pressure: 2400psf
Min Past Pressure: 1500psf
B1 Sample Depth:10ft, Unit weight: 100 pcf
Est effective stress: 1000 psf, NORMAL CONSOL
Cc = 0.11

CASAGRANDE BORING B-1
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE:	NA
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

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116 E. LAKE AVENUE, WATSONVILLE, CA 95076
(831) 722-4175

FIGURE NO. 3

SHEET NO.

Time Rate Consolidation Settlment Analysis

BORING B-2 - NORMALLY CONSOLIDATED

Layer #	Layer midpoint depth	Height Layer (ft)	Initial Pressure σ'o(psf)	Final Pressure σ'f(psf)	Boussinesq I	Cc/1+eo	Settlement (ft)	Settlement (in)	Boussinesq Factor N	Boussinesq Factor M
1	1	2	128	1605	0.2462	0.1097	0.241	2.8915	3.50	3.50
1	3	2	384	1542	0.1930	0.1097	0.132	1.5895	1.17	1.17
1	5	2	640	1407	0.1278	0.1097	0.075	0.9005	0.70	0.70
1	7	2	876	1380	0.0841	0.1097	0.043	0.5200	0.50	0.50
1	9	2	1111.5	1457	0.0576	0.1097	0.026	0.3097	0.39	0.39
2	11	2	1220.7	1469	0.0414	0.2561	0.041	0.4940	0.32	0.32
2	13	2	1329.9	1515	0.0309	0.2561	0.029	0.3482	0.27	0.27
2	15	2	1448.85	1592	0.0238	0.2561	0.021	0.2513	0.23	0.23
2	17	2	1571.05	1685	0.0189	0.2561	0.016	0.1861	0.21	0.21
2	19	2	1687.85	1780	0.0153	0.2561	0.012	0.1417	0.18	0.18
2	21	2	1788.45	1865	0.0127	0.2561	0.009	0.1112	0.17	0.17
2	23	2	1889.05	1953	0.0107	0.2561	0.007	0.0888	0.15	0.15
2	25	2	1989.65	2044	0.0091	0.2561	0.006	0.0720	0.14	0.14
2	27	2	2090.25	2137	0.0078	0.2561	0.005	0.0592	0.13	0.13
2	29	2	2190.85	2232	0.0068	0.2561	0.004	0.0492	0.12	0.12
2	31	2	2291.45	2327	0.0060	0.2561	0.003	0.0414	0.11	0.11
2	33	2	2392.05	2424	0.0053	0.2561	0.003	0.0351	0.11	0.11
2	35	2	2473.6	2502	0.0047	0.2561	0.003	0.0303	0.10	0.10
2	37	2	2548.8	2574	0.0042	0.2561	0.002	0.0263	0.09	0.09
2	39	2	2624	2647	0.0038	0.2561	0.002	0.0231	0.09	0.09
2	41	2	2699.2	2720	0.0034	0.2561	0.002	0.0203	0.09	0.09
2	43	2	2774.4	2793	0.0031	0.2561	0.002	0.0180	0.08	0.08
3	45	2	2849.6	2867	0.0029	0.0100	0.000	0.0006	0.08	0.08
3	47	2	2924.8	2941	0.0026	0.0100	0.000	0.0006	0.07	0.07
3	49	2	3000	3015	0.0024	0.0100	0.000	0.0005	0.07	0.07
							Total	**8.209275597**		

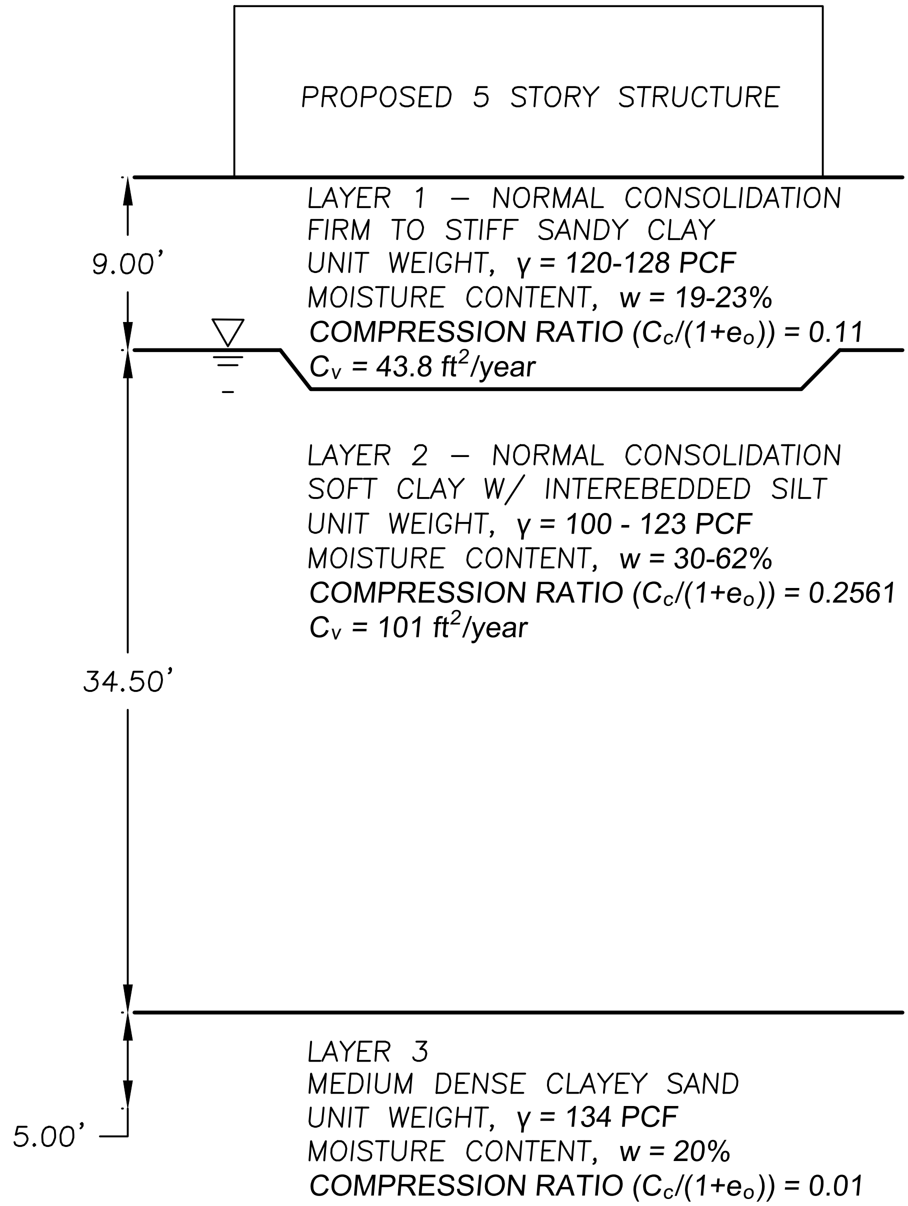
Square Footing Dimensions			
	Width (ft)	Length (ft)	Qallow (psf)
	7	7	1500

Thickness of Compressible Layer 1 (ft) =	10
$Cv_{avg}(ft^2/yr)$ =	43.8

U (%)	Time Factor, Tv	ΔH (in.)	Time, t (yr)
0%	0	0	0
10%	0.008	0.621	0.23
20%	0.031	1.242	0.46
30%	0.071	1.863	0.68
40%	0.126	2.485	0.91
50%	0.197	3.106	1.14
60%	0.286	3.727	1.37
70%	0.403	4.348	1.60
80%	0.567	4.969	1.83
90%	0.848	5.590	2.05
100%	3.00	6.211	2.28

Thickness of Compressible Layer 2 (ft) =	40
$Cv_{avg}(ft^2/yr)$ =	101

U (%)	Time Factor, Tv	ΔH (in.)	Time, t (yr)
0%	0	0	0
10%	0.008	0.200	1.58
20%	0.031	0.400	3.17
30%	0.071	0.599	4.75
40%	0.126	0.799	6.34
50%	0.197	0.999	7.92
60%	0.286	1.199	9.50
70%	0.403	1.399	11.09
80%	0.567	1.598	12.67
90%	0.848	1.798	14.26
100%	3.00	1.998	15.84



SOIL PROFILE B-2

SCALE: NTS

BORING B-2 SOIL PROFILE
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE:	NTS
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
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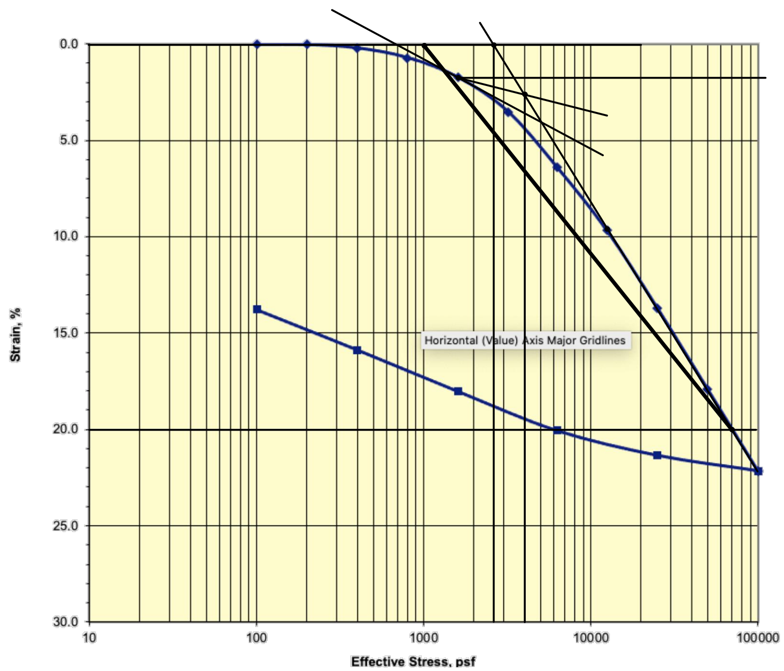
(831) 722-4175

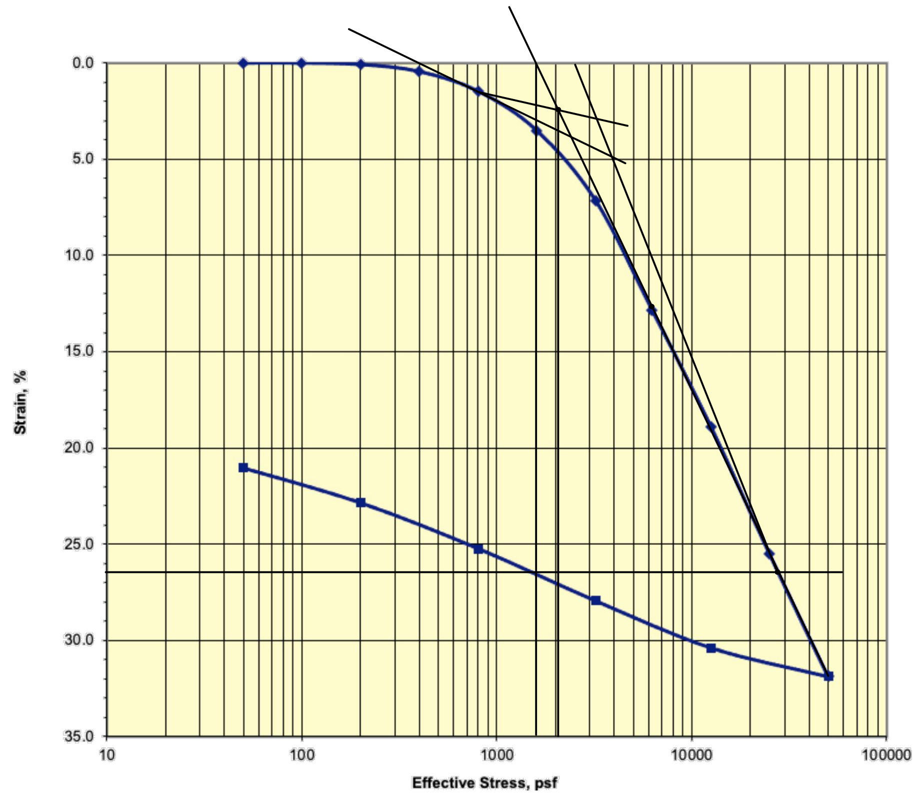
FIGURE NO. 5

SHEET NO.



Max Past Pressure: 11,000psf
Est. Maximum Past Pressure: 4000psf
Min Past Pressure: 2500psf
Sample Depth: 8.5ft, Unit Weight:117
Est effective stress: 1050 psf, Slightly Overconsolidated
Cc = 0.1097

2-4-1



Max Past Pressure: 6000psf
Est. Maximum Past Pressure: 2000psf
Min Past Pressure: 1500psf
Sample Depth:33.5ft, Unit Weight: 100
Est effective stress: 2400 psf, Normally Consol
Cc = 0.2561

2-9-1

CASAGRANDE BORING B-1
119C CORAL STREET
SANTA CRUZ, CALIFORNIA
APN: 008-171-31

SCALE:	NA
DRAWN BY:	AJB
DATE:	MAR 2021
REVISED:	
JOB NO.	SC11174.1

HARO, KASUNICH & ASSOCIATES, INC.
GEOTECHNICAL AND COASTAL ENGINEERS
116 E. LAKE AVENUE, WATSONVILLE, CA 95076
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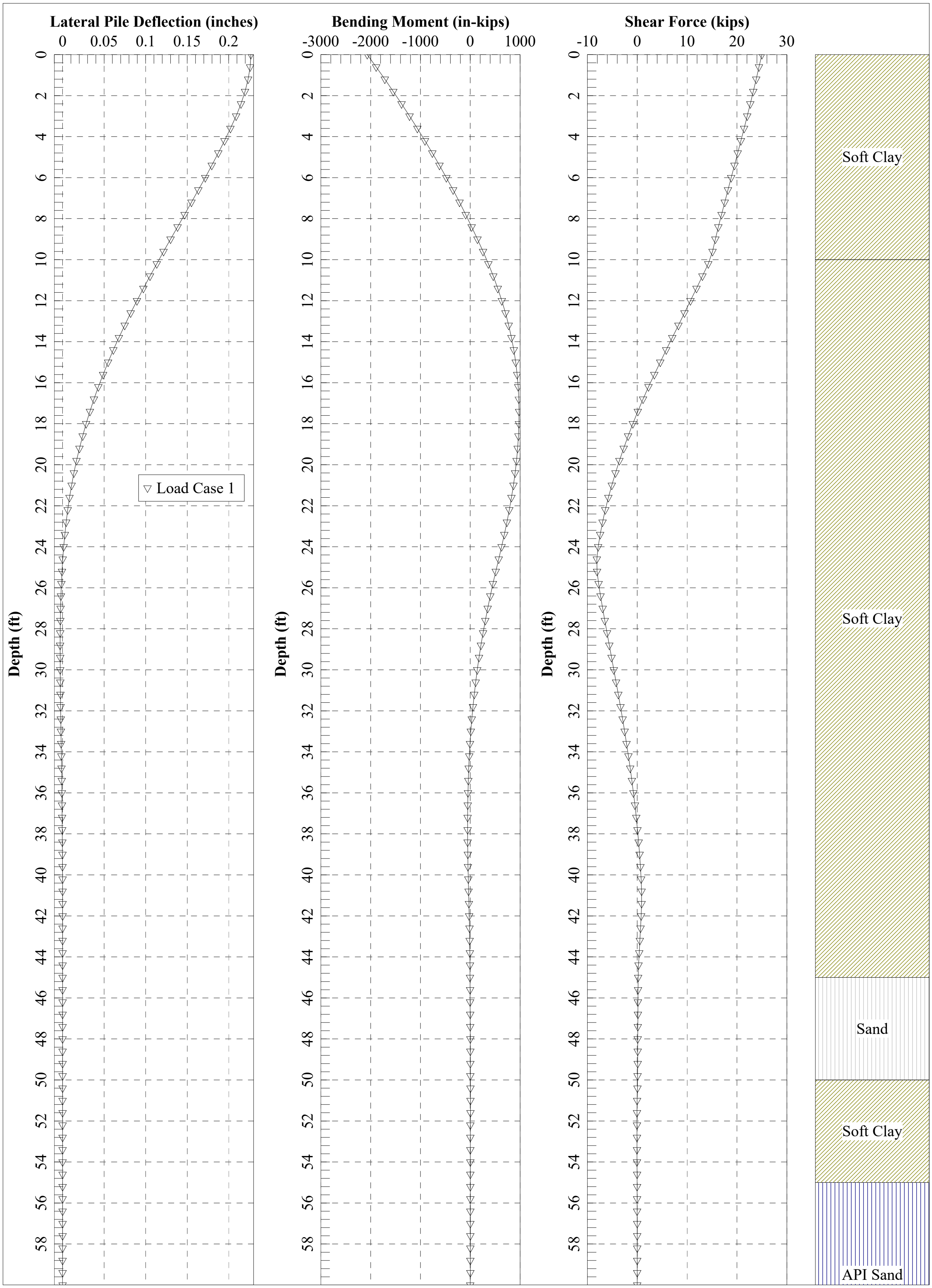
FIGURE NO. 6

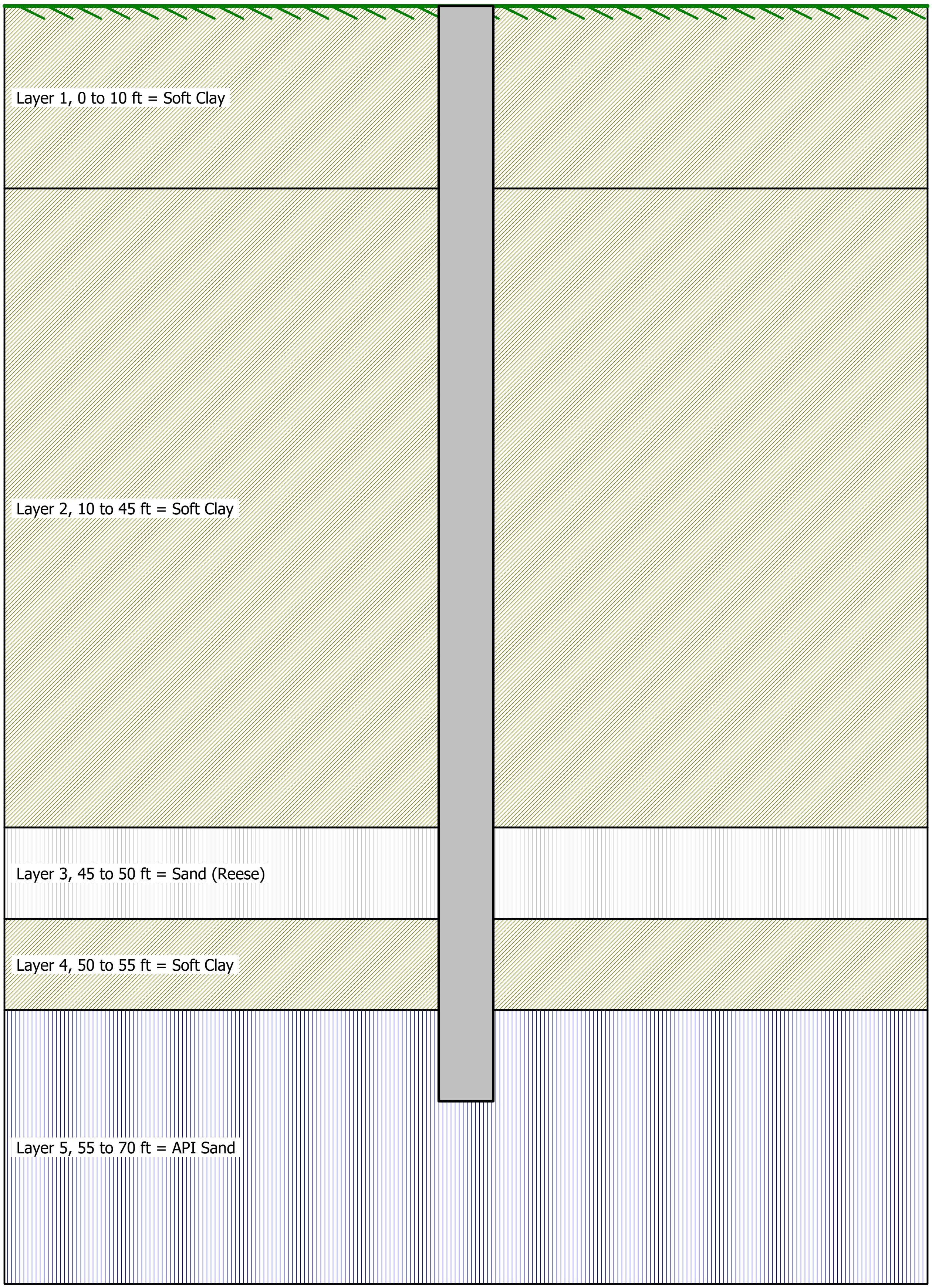
SHEET NO.

APPENDIX D

LPile Analysis Results, Soil Profile, and Output File



Lateral Pile Deflection (inches)
0
0.05
0.1
0.15
0.2
Bending Moment (in-kips)
-3000
-2000
-1000
0
1000
Shear Force (kips)
-10
0
10
20
30
Depth (ft)
Load Case 1
Soft Clay
Soft Clay
Sand
Soft Clay
API Sand



Layer 1, 0 to 10 ft = Soft Clay
Layer 2, 10 to 45 ft = Soft Clay
Layer 3, 45 to 50 ft = Sand (Reese)
Layer 4, 50 to 55 ft = Soft Clay
Layer 5, 55 to 70 ft = API Sand

==

LPile for Windows, Version 2019-11.008

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

This copy of LPile is being used by:

Ashton Buckner
HaroKasunich and Associates, Inc.

Serial Number of Security Device: 161222630

This copy of LPile is licensed for exclusive use by:

Haro, Kasunich & Associates, Wat

Files Used for Analysis

Path to file locations:
\PROJECTS\11000s\11174 folder, 115 C Coral St. Envision House\11174.1 New Homeless Shelter\Pile Design\

Name of input data file:
Boring B-1 Model.lp11d

Name of output report file:
Boring B-1 Model.lp11o

Name of plot output file:
Boring B-1 Model.lp11p

Name of runtime message file:
Boring B-1 Model.lp11r

Date and Time of Analysis

Date: July 7, 2021   Time: 10:39:42

Problem Title

119C Coral Street

SC11174.1

180 Supportive Houseing, LLC

Ashton Buckner

Deep Pile Foundation

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed = 500
 - Deflection tolerance for convergence = 1.0000E-05 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

```
Number of pile sections defined                          =            1
Total length of pile                                     =       60.000 ft
Depth of ground surface below top of pile                =       0.0000 ft
```

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	24.0000
2	60.000	24.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a rectangular concrete pile
   Length of section                                     =    60.000000 ft
```

```
   Shear capacity of section                                 =      0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                           =       0.000 degrees
                                                             =       0.000 radians

Pile Batter Angle                                            =       0.000 degrees
                                                             =       0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

Layer 1 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer                 =      0.0000 ft
   Distance from top of pile to bottom of layer              =   10.000000 ft
   Effective unit weight at top of layer                     =  108.000000 pcf
   Effective unit weight at bottom of layer                  =  102.000000 pcf
   Undrained cohesion at top of layer                        =  500.000000 psf
   Undrained cohesion at bottom of layer                     =  200.000000 psf
   Epsilon-50 at top of layer                                =      0.0000
   Epsilon-50 at bottom of layer                             =      0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 2 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer                 =   10.000000 ft
   Distance from top of pile to bottom of layer              =   45.000000 ft
   Effective unit weight at top of layer                     =  100.000000 pcf
   Effective unit weight at bottom of layer                  =  100.000000 pcf
   Undrained cohesion at top of layer                        =  500.000000 psf
   Undrained cohesion at bottom of layer                     =  500.000000 psf
   Epsilon-50 at top of layer                                =      0.0000
   Epsilon-50 at bottom of layer                             =      0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.
```

Layer 3 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    50.000000 ft
   Effective unit weight at top of layer              =   125.000000 pcf
   Effective unit weight at bottom of layer           =   125.000000 pcf
   Friction angle at top of layer                     =    32.000000 deg.
   Friction angle at bottom of layer                  =    32.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

NOTE: Default values for subgrade k will be computed for this layer.

Layer 4 is soft clay, p-y criteria by Matlock, 1970

```
   Distance from top of pile to top of layer          =    50.000000 ft
   Distance from top of pile to bottom of layer       =    55.000000 ft
   Effective unit weight at top of layer              =   100.000000 pcf
   Effective unit weight at bottom of layer           =   100.000000 pcf
   Undrained cohesion at top of layer                 =   500.000000 psf
   Undrained cohesion at bottom of layer              =   500.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000
```

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 5 is sand, p-y criteria by API RP-2A, 1987

```
   Distance from top of pile to top of layer          =    55.000000 ft
   Distance from top of pile to bottom of layer       =    70.000000 ft
   Effective unit weight at top of layer              =   130.000000 pcf
   Effective unit weight at bottom of layer           =   130.000000 pcf
   Friction angle at top of layer                     =    42.000000 deg.
   Friction angle at bottom of layer                  =    42.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

NOTE: Default values for subgrade k will be computed for this layer.

(Depth of the lowest soil layer extends 10.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Soil Type Layer Effective Undrained Angle of E50

```
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
  or           kpy
 Num.     (p-y Curve Type)        ft           pcf          psf          deg.
  krm          pci
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------
  1            Soft                  0.00     108.0000     500.0000       --
default        --
               Clay               10.0000     102.0000     200.0000       --
default        --
  2            Soft               10.0000     100.0000     500.0000       --
default        --
               Clay               45.0000     100.0000     500.0000       --
default        --
  3            Sand               45.0000     125.0000       --         32.0000
  --         default
          (Reese, et al.)         50.0000     125.0000       --         32.0000
  --         default
  4            Soft               50.0000     100.0000     500.0000       --
default        --
               Clay               55.0000     100.0000     500.0000       --
default        --
  5            API                55.0000     130.0000       --         42.0000
  --         default
               Sand               70.0000     130.0000       --         42.0000
  --         default
```

```
--------------------------------------------------------------------------------
                              Static Loading Type
--------------------------------------------------------------------------------
```

Static loading criteria were used when computing p-y curves for all analyses.

```
--------------------------------------------------------------------------------
               Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------
```

Number of loads specified = 1

```
Load    Load         Condition                Condition            Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------   ------------
   1     2     V =       25000. lbs   S =       0.0000 in/in            75000.
     No                Yes
```

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Rectangular Concrete Pile:

Length of Section	=	60.000000 ft
Depth of Section	=	24.000000 in
Width of Section	=	24.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.000000 in
Number of Reinforcing Bars	=	16 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Compressive Strength of Concrete	=	4000. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Gross Area of Pile	=	576.000000 sq. in.
Total Area of Reinforcing Steel	=	20.320000 sq. in.
Area Ratio of Steel Reinforcement	=	3.527778 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	3108.512 kips
Tensile Load for Cracking of Concrete	=	-299.098 kips
Nominal Axial Tensile Capacity	=	-1219.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar	Bar Diam.	Bar Area	X	Y

Number	inches	sq. in.	inches	inches
1	1.270000	1.270000	-8.365000	-8.365000
2	1.270000	1.270000	-4.182500	-8.365000
3	1.270000	1.270000	0.00000	-8.365000
4	1.270000	1.270000	4.182500	-8.365000
5	1.270000	1.270000	8.365000	-8.365000
6	1.270000	1.270000	-8.365000	-4.182500
7	1.270000	1.270000	8.365000	-4.182500
8	1.270000	1.270000	-8.365000	0.00000
9	1.270000	1.270000	8.365000	0.00000
10	1.270000	1.270000	-8.365000	4.182500
11	1.270000	1.270000	8.365000	4.182500
12	1.270000	1.270000	-8.365000	8.365000
13	1.270000	1.270000	-4.182500	8.365000
14	1.270000	1.270000	0.00000	8.365000
15	1.270000	1.270000	4.182500	8.365000
16	1.270000	1.270000	8.365000	8.365000

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 2.913 inches
between bars 1 and 2.

Ratio of bar spacing to maximum aggregate size = 3.88

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	75.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 75.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	174.9497356	139959789.	32.4906478	0.00004061	0.00001061	0.1697712	1.0690360	
0.00000250	349.8959340	139958374.	22.2646032	0.00005566	-0.00000434	0.2313521	1.3966837	
0.00000375	524.4802737	139861406.	18.8615068	0.00007073	-0.00001927	0.2925194	1.7249389	
0.00000500	698.3241681	139664834.	17.1613781	0.00008581	-0.00003419	0.3532150	2.0533998	
0.00000625	871.3520238	139416324.	16.1418036	0.0001009	-0.00004911	0.4134223	2.3819519	
0.00000750	1044.	139139364.	15.4623332	0.0001160	-0.00006403	0.4731358	2.7105575	
0.00000875	1215.	138845449.	14.9771473	0.0001311	-0.00007895	0.5323532	3.0392012	
0.00001000	1215.	121489768.	12.3403994	0.0001234	-0.0001166	0.5014993	2.7087159	C
0.00001125	1215.	107990905.	11.8717622	0.0001336	-0.0001364	0.5410640	-2.9780876	C
0.00001250	1215.	97191814.	11.4886166	0.0001436	-0.0001564	0.5800001	-3.4478765	C
0.00001375	1215.	88356195.	11.1700325	0.0001536	-0.0001764	0.6184422	-3.9196998	C
0.00001500	1215.	80993179.	10.8999461	0.0001635	-0.0001965	0.6563996	-4.3935234	C
0.00001625	1215.	74762934.	10.6684316	0.0001734	-0.0002166	0.6939559	-4.8687516	C

0.00001750	1270.	72560753.	10.4675770	0.0001832	-0.0002368	0.7311383	-5.3452046	C
0.00001875	1337.	71305067.	10.2916671	0.0001930	-0.0002570	0.7679791	-5.8226559	C
0.00002000	1404.	70197314.	10.1368048	0.0002027	-0.0002773	0.8045398	-6.3006532	C
0.00002125	1471.	69211565.	9.9992766	0.0002125	-0.0002975	0.8408217	-6.7791957	C
0.00002250	1537.	68327559.	9.8760682	0.0002222	-0.0003178	0.8768153	-7.2583654	C
0.00002375	1604.	67531568.	9.7656238	0.0002319	-0.0003381	0.9125846	-7.7376766	C
0.00002500	1670.	66809602.	9.6656850	0.0002416	-0.0003584	0.9480979	-8.2173783	C
0.00002625	1736.	66151573.	9.5749133	0.0002513	-0.0003787	0.9833719	-8.6973472	C
0.00002750	1803.	65550649.	9.4927143	0.0002610	-0.0003990	1.0184732	-9.1770603	C
0.00002875	1869.	64996746.	9.4169169	0.0002707	-0.0004193	1.0532909	-9.6573955	C
0.00003000	1935.	64486034.	9.3475351	0.0002804	-0.0004396	1.0879149	-10.1376444	C
0.00003125	2000.	64013795.	9.2839899	0.0002901	-0.0004599	1.1223665	-10.6176340	C
0.00003250	2066.	63575055.	9.2253593	0.0002998	-0.0004802	1.1566161	-11.0975988	C
0.00003375	2132.	63165123.	9.1706343	0.0003095	-0.0005005	1.1906083	-11.5779916	C
0.00003500	2197.	62782346.	9.1200779	0.0003192	-0.0005208	1.2244281	-12.0581208	C
0.00003625	2263.	62423907.	9.0732598	0.0003289	-0.0005411	1.2580751	-12.5379855	C
0.00003750	2328.	62087366.	9.0298072	0.0003386	-0.0005614	1.2915490	-13.0175846	C
0.00003875	2394.	61770273.	8.9892068	0.0003483	-0.0005817	1.3248238	-13.4971288	C
0.00004000	2459.	61470278.	8.9508805	0.0003580	-0.0006020	1.3578566	-13.9769785	C
0.00004125	2524.	61186646.	8.9151034	0.0003677	-0.0006223	1.3907162	-14.4565574	C
0.00004250	2589.	60917926.	8.8816516	0.0003775	-0.0006425	1.4234021	-14.9358643	C
0.00004375	2654.	60662833.	8.8503266	0.0003872	-0.0006628	1.4559139	-15.4148980	C
0.00004500	2719.	60420226.	8.8209521	0.0003969	-0.0006831	1.4882510	-15.8936575	C
0.00004625	2784.	60189085.	8.7933708	0.0004067	-0.0007033	1.5204131	-16.3721414	C
0.00004750	2849.	59968499.	8.7674420	0.0004165	-0.0007235	1.5523995	-16.8503487	C

0.00004875	2913.	59757254.	8.7427288	0.0004262	-0.0007438	1.5841600	-17.3287170	C
0.00005125	3042.	59360872.	8.6972368	0.0004457	-0.0007843	1.6471116	-18.2849817	C
0.00005375	3171.	58995630.	8.6567065	0.0004653	-0.0008247	1.7093581	-19.2401086	C
0.00005625	3299.	58657331.	8.6204826	0.0004849	-0.0008651	1.7708955	-20.1940877	C
0.00005875	3428.	58342493.	8.5880213	0.0005045	-0.0009055	1.8317197	-21.1469086	C
0.00006125	3555.	58048202.	8.5588680	0.0005242	-0.0009458	1.8918267	-22.0985607	C
0.00006375	3683.	57772001.	8.5326391	0.0005440	-0.0009860	1.9512122	-23.0490335	C
0.00006625	3810.	57511637.	8.5088012	0.0005637	-0.0010263	2.0098309	-23.9987154	C
0.00006875	3937.	57265348.	8.4870869	0.0005835	-0.0010665	2.0676778	-24.9476203	C
0.00007125	4064.	57031788.	8.4674915	0.0006033	-0.0011067	2.1247947	-25.8952955	C
0.00007375	4190.	56809625.	8.4498052	0.0006232	-0.0011468	2.1811771	-26.8417290	C
0.00007625	4316.	56597702.	8.4338455	0.0006431	-0.0011869	2.2368207	-27.7869090	C
0.00007875	4441.	56395006.	8.4194534	0.0006630	-0.0012270	2.2917208	-28.7308232	C
0.00008125	4566.	56200650.	8.4064895	0.0006830	-0.0012670	2.3458728	-29.6734590	C
0.00008375	4691.	56013851.	8.3948311	0.0007031	-0.0013069	2.3992721	-30.6148039	C
0.00008625	4816.	55833918.	8.3843698	0.0007232	-0.0013468	2.4519139	-31.5548449	C
0.00008875	4940.	55660235.	8.3750096	0.0007433	-0.0013867	2.5037934	-32.4935688	C
0.00009125	5064.	55492255.	8.3666651	0.0007635	-0.0014265	2.5549057	-33.4309623	C
0.00009375	5187.	55329488.	8.3592600	0.0007837	-0.0014663	2.6052458	-34.3670118	C
0.00009625	5310.	55171494.	8.3527261	0.0008039	-0.0015061	2.6548086	-35.3017033	C
0.00009875	5433.	55017877.	8.3470021	0.0008243	-0.0015457	2.7035890	-36.2350227	C
0.0001013	5555.	54868280.	8.3420330	0.0008446	-0.0015854	2.7515819	-37.1669557	C
0.0001038	5677.	54722380.	8.3377691	0.0008650	-0.0016250	2.7987819	-38.0974874	C
0.0001063	5799.	54579883.	8.3341654	0.0008855	-0.0016645	2.8451836	-39.0266030	C
0.0001088	5920.	54440523.	8.3311813	0.0009060	-0.0017040	2.8907817	-39.9542866	C

0.0001113	6041.	54304054.	8.3287799	0.0009266	-0.0017434	2.9355704	-40.8805237	C
0.0001138	6162.	54170256.	8.3269274	0.0009472	-0.0017828	2.9795442	-41.8052980	C
0.0001163	6282.	54038922.	8.3255933	0.0009679	-0.0018221	3.0226974	-42.7285932	C
0.0001188	6402.	53909867.	8.3247497	0.0009886	-0.0018614	3.0650240	-43.6503930	C
0.0001213	6521.	53782917.	8.3243709	0.0010093	-0.0019007	3.1065182	-44.5706805	C
0.0001238	6640.	53657912.	8.3244336	0.0010301	-0.0019399	3.1471739	-45.4894384	C
0.0001263	6759.	53534706.	8.3249164	0.0010510	-0.0019790	3.1869850	-46.4066494	C
0.0001288	6877.	53413162.	8.3257996	0.0010719	-0.0020181	3.2259452	-47.3222955	C
0.0001313	6995.	53293153.	8.3270650	0.0010929	-0.0020571	3.2640482	-48.2363585	C
0.0001338	7112.	53174562.	8.3286961	0.0011140	-0.0020960	3.3012874	-49.1488197	C
0.0001363	7229.	53057278.	8.3306775	0.0011351	-0.0021349	3.3376563	-50.0596602	C
0.0001388	7346.	52941200.	8.3329951	0.0011562	-0.0021738	3.3731482	-50.9688604	C
0.0001413	7462.	52826231.	8.3356360	0.0011774	-0.0022126	3.4077562	-51.8764006	C
0.0001438	7577.	52712282.	8.3385881	0.0011987	-0.0022513	3.4414734	-52.7822605	C
0.0001463	7693.	52599268.	8.3418403	0.0012200	-0.0022900	3.4742927	-53.6864193	C
0.0001488	7807.	52487109.	8.3453825	0.0012414	-0.0023286	3.5062068	-54.5888560	C
0.0001588	8262.	52045600.	8.3622720	0.0013275	-0.0024825	3.6246622	-58.1809400	C
0.0001688	8694.	51522182.	8.3763717	0.0014135	-0.0026365	3.7267501	-60.0000000	CY
0.0001788	8967.	50162299.	8.3270618	0.0014885	-0.0028015	3.8023869	-60.0000000	CY
0.0001888	9112.	48276041.	8.2321321	0.0015538	-0.0029762	3.8582354	-60.0000000	CY
0.0001988	9251.	46544879.	8.1467145	0.0016192	-0.0031508	3.9048251	-60.0000000	CY
0.0002088	9387.	44967804.	8.0722903	0.0016851	-0.0033249	3.9424622	-60.0000000	CY
0.0002188	9520.	43522271.	8.0065720	0.0017514	-0.0034986	3.9708289	-60.0000000	CY
0.0002288	9651.	42190855.	7.9486016	0.0018182	-0.0036718	3.9897515	-60.0000000	CY
0.0002388	9776.	40946586.	7.8966008	0.0018853	-0.0038447	3.9990145	-60.0000000	CY

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0.0002488       9878.     39708796.     7.8410526     0.0019505    -0.0040195
3.9992770   -60.0000000 CY
0.0002588       9949.     38449794.     7.7771909     0.0020123    -0.0041977
3.9990432   -60.0000000 CY
0.0002688      10000.     37210341.     7.7091967     0.0020718    -0.0043782
3.9981855   -60.0000000 CY
0.0002788      10048.     36046467.     7.6465985     0.0021315    -0.0045585
3.9965298   -60.0000000 CY
0.0002888      10094.     34958842.     7.5899785     0.0021916    -0.0047384
3.9999523   -60.0000000 CY
0.0002988      10139.     33939323.     7.5379335     0.0022520    -0.0049180
3.9990764   -60.0000000 CY
0.0003088      10183.     32981928.     7.4895344     0.0023124    -0.0050976
3.9965337   -60.0000000 CY
0.0003188      10226.     32081905.     7.4453483     0.0023732    -0.0052768
3.9998804   -60.0000000 CY
0.0003288      10268.     31234016.     7.4050117     0.0024344    -0.0054556
3.9978606   -60.0000000 CY
0.0003388      10310.     30434446.     7.3679022     0.0024959    -0.0056341
4.0000000   -60.0000000 CY
0.0003488      10350.     29678411.     7.3339891     0.0025577    -0.0058123
3.9982019   -60.0000000 CY
0.0003588      10390.     28962856.     7.3019070     0.0026196    -0.0059904
3.9995491   -60.0000000 CY
0.0003688      10430.     28283951.     7.2719543     0.0026815    -0.0061685
3.9976738   -60.0000000 CY
0.0003788      10469.     27640010.     7.2441075     0.0027437    -0.0063463
3.9999580   -60.0000000 CY
0.0003888      10506.     27025797.     7.2178969     0.0028060    -0.0065240
3.9959577   -60.0000000 CY
0.0003988      10542.     26438261.     7.1925092     0.0028680    -0.0067020
3.9993997   -60.0000000 CY
0.0004088      10573.     25866897.     7.1653242     0.0029288    -0.0068812
3.9960792   -60.0000000 CY
0.0004188      10601.     25315932.     7.1380318     0.0029891    -0.0070609
3.9968456   -60.0000000 CY
0.0004288      10624.     24779353.     7.1088001     0.0030479    -0.0072421
3.9994695   -60.0000000 CYT
0.0004388      10643.     24257879.     7.0781661     0.0031055    -0.0074245
3.9973901   -60.0000000 CYT
0.0004488      10659.     23752646.     7.0458602     0.0031618    -0.0076082
3.9943820   -60.0000000 CYT
0.0004588      10670.     23259074.     7.0113825     0.0032165    -0.0077935
3.9976161   -60.0000000 CYT
0.0004688      10680.     22784820.     6.9779221     0.0032709    -0.0079791
3.9994745   -60.0000000 CYT
0.0004788      10689.     22326695.     6.9446562     0.0033248    -0.0081652
3.9992998   -60.0000000 CYT
0.0004888      10697.     21887079.     6.9130529     0.0033788    -0.0083512
3.9917751   -60.0000000 CYT
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    0.0004988        10706.     21465051.     6.8828278     0.0034328    -0.0085372
    3.9945837   -60.0000000 CYT
    0.0005088        10714.     21059571.     6.8539000     0.0034869    -0.0087231
    3.9974422   -60.0000000 CYT
    0.0005188        10722.     20669173.     6.8253616     0.0035407    -0.0089093
    3.9992186   -60.0000000 CYT
    0.0005288        10730.     20293011.     6.7971943     0.0035940    -0.0090960
    3.9999672   -60.0000000 CYT
    0.0005388        10738.     19930691.     6.7702636     0.0036475    -0.0092825
    3.9950907   -60.0000000 CYT
    0.0005488        10745.     19581526.     6.7444223     0.0037010    -0.0094690
    3.9898712   -60.0000000 CYT
    0.0006088        10745.     17651519.     6.8861685     0.0041920    -0.0104180
    3.9876135    60.0000000 CYT
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   Summary of Results for Nominal Moment Capacity for Section 1
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Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	75.000	10605.345	0.00300000

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

```
Axial     Resist.       Nominal        Nominal     Ult. (Fac)    Ult. (Fac)   Bend.
Stiff.
Load      Factor       Ax. Thrust    Moment Cap    Ax. Thrust    Moment Cap    at
Ult Mom
 No.                      kips         in-kips       kips          in-kips
kip-in^2
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1	0.65	75.000000	10605.	48.750000	6893.
53396320.					
1	0.75	75.000000	10605.	56.250000	7954.
52344835.					
1	0.90	75.000000	10605.	67.500000	9545.
43274520.					

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	38715.
2	10.0000	7.9992	Yes	No	38715.	308863.
3	45.0000	15.7774	No	No	347578.	394250.
4	50.0000	86.8017	No	No	741828.	45000.
5	55.0000	15.6196	No	No	786828.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 25000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 75000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth   Deflect.   Bending   Shear   Slope   Total   Bending   Soil

X feet	y inches	Moment in-lbs	Force lbs	S radians	Stress psi*	Stiffness lb-in^2	p lb/inch	Res. Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.2267	-2067317.	25000.	0.00	0.00	6.36E+10	-90.3652	1435.	0.00
0.6000	0.2258	-1889596.	24403.	-2.24E-04	0.00	6.36E+10	-75.5973	2410.	0.00
1.2000	0.2234	-1715679.	23846.	-4.24E-04	0.00	6.64E+10	-79.0124	2546.	0.00
1.8000	0.2197	-1545756.	23266.	-5.99E-04	0.00	6.82E+10	-81.9668	2686.	0.00
2.4000	0.2148	-1379995.	22667.	-7.51E-04	0.00	7.06E+10	-84.4597	2831.	0.00
3.0000	0.2089	-1218537.	22052.	-8.80E-04	0.00	7.46E+10	-86.4942	2981.	0.00
3.6000	0.2021	-1061498.	21423.	-9.66E-04	0.00	1.39E+11	-88.0784	3137.	0.00
4.2000	0.1950	-908997.	20785.	-0.00102	0.00	1.39E+11	-89.2685	3296.	0.00
4.8000	0.1875	-761097.	20139.	-0.00106	0.00	1.40E+11	-90.0708	3459.	0.00
5.4000	0.1797	-617845.	19489.	-0.00110	0.00	1.40E+11	-90.4926	3625.	0.00
6.0000	0.1717	-479268.	18838.	-0.00112	0.00	1.40E+11	-90.5431	3796.	0.00
6.6000	0.1635	-345370.	18187.	-0.00115	0.00	1.40E+11	-90.2322	3973.	0.00
7.2000	0.1552	-216141.	17539.	-0.00116	0.00	1.40E+11	-89.5714	4155.	0.00
7.8000	0.1468	-91550.	16898.	-0.00117	0.00	1.40E+11	-88.5730	4343.	0.00
8.4000	0.1384	28453.	16265.	-0.00117	0.00	1.40E+11	-87.2507	4539.	0.00
9.0000	0.1300	143932.	15655.	-0.00116	0.00	1.40E+11	-82.2346	4555.	0.00
9.6000	0.1216	255144.	15092.	-0.00115	0.00	1.40E+11	-74.1378	4388.	0.00
10.2000	0.1134	362505.	14242.	-0.00114	0.00	1.40E+11	-161.8741	10280.	0.00
10.8000	0.1052	461465.	13068.	-0.00112	0.00	1.40E+11	-164.2307	11236.	0.00
11.4000	0.09728	551898.	11879.	-0.00109	0.00	1.40E+11	-166.1378	12296.	0.00
12.0000	0.08953	633704.	10678.	-0.00106	0.00	1.40E+11	-167.5863	13478.	0.00
12.6000	0.08200	706803.	9468.	-0.00103	0.00	1.40E+11			

-168.5678	14800.	0.00				
13.2000	0.07475	771145.	8252.	-9.88E-04	0.00	1.40E+11
-169.0739	16286.	0.00				
13.8000	0.06777	826701.	7035.	-9.47E-04	0.00	1.39E+11
-169.0964	17964.	0.00				
14.4000	0.06111	873467.	5819.	-9.03E-04	0.00	1.39E+11
-168.6271	19868.	0.00				
15.0000	0.05477	911468.	4608.	-8.57E-04	0.00	1.39E+11
-167.6576	22040.	0.00				
15.6000	0.04877	940751.	3420.	-8.09E-04	0.00	1.39E+11
-162.4462	23983.	0.00				
16.2000	0.04312	961588.	2274.	-7.60E-04	0.00	1.39E+11
-155.9131	26035.	0.00				
16.8000	0.03783	974315.	1175.	-7.10E-04	0.00	1.39E+11
-149.2535	28410.	0.00				
17.4000	0.03290	979277.	124.9856	-6.59E-04	0.00	1.39E+11
-142.4653	31182.	0.00				
18.0000	0.02833	976826.	-875.8486	-6.09E-04	0.00	1.39E+11
-135.5442	34447.	0.00				
18.6000	0.02413	967322.	-1826.	-5.59E-04	0.00	1.39E+11
-128.4820	38338.	0.00				
19.2000	0.02029	951130.	-2725.	-5.09E-04	0.00	1.39E+11
-121.2660	43037.	0.00				
19.8000	0.01680	928626.	-3572.	-4.60E-04	0.00	1.39E+11
-113.8762	48804.	0.00				
20.4000	0.01366	900192.	-4365.	-4.13E-04	0.00	1.39E+11
-106.2821	56027.	0.00				
21.0000	0.01085	866223.	-5102.	-3.68E-04	0.00	1.39E+11
-98.4360	65315.	0.00				
21.6000	0.00837	827127.	-5781.	-3.24E-04	0.00	1.39E+11
-90.2618	77680.	0.00				
22.2000	0.00619	783329.	-6400.	-2.82E-04	0.00	1.40E+11
-81.6317	94973.	0.00				
22.8000	0.00430	735277.	-6954.	-2.43E-04	0.00	1.40E+11
-72.3135	121025.	0.00				
23.4000	0.00269	683456.	-7437.	-2.06E-04	0.00	1.40E+11
-61.8252	165568.	0.00				
24.0000	0.00133	628411.	-7835.	-1.73E-04	0.00	1.40E+11
-48.8800	264865.	0.00				
24.6000	2.02E-04	570815.	-8105.	-1.42E-04	0.00	1.40E+11
-26.0847	929517.	0.00				
25.2000	-7.13E-04	511850.	-8056.	-1.14E-04	0.00	1.40E+11
39.7240	401160.	0.00				
25.8000	-0.00144	454931.	-7732.	-8.90E-05	0.00	1.40E+11
50.1914	251259.	0.00				
26.4000	-0.00199	400600.	-7350.	-6.70E-05	0.00	1.40E+11
55.9748	202016.	0.00				
27.0000	-0.00240	349161.	-6934.	-4.77E-05	0.00	1.40E+11
59.5589	178433.	0.00				
27.6000	-0.00268	300799.	-6497.	-3.10E-05	0.00	1.40E+11

```
61.7795    165835.       0.00
   28.2000   -0.00285    255632.      -6048.  -1.67E-05       0.00   1.40E+11
63.0401    159270.       0.00
   28.8000   -0.00292    213725.      -5592.  -4.62E-06       0.00   1.40E+11
63.5730    156611.       0.00
   29.4000   -0.00292    175108.      -5135.   5.38E-06       0.00   1.40E+11
63.5274    156837.       0.00
   30.0000   -0.00285    139780.      -4679.   1.35E-05       0.00   1.40E+11
63.0066    159441.       0.00
   30.6000   -0.00272    107714.      -4229.   1.98E-05       0.00   1.40E+11
62.0860    164205.       0.00
   31.2000   -0.00256     78863.      -3786.   2.46E-05       0.00   1.40E+11
60.8228    171098.       0.00
   31.8000   -0.00237     53163.      -3354.   2.80E-05       0.00   1.40E+11
59.2622    180229.       0.00
   32.4000   -0.00216     30534.      -2934.   3.02E-05       0.00   1.40E+11
57.4403    191845.       0.00
   33.0000   -0.00193     10882.      -2528.   3.13E-05       0.00   1.40E+11
55.3870    206334.       0.00
   33.6000   -0.00171     -5899.      -2137.   3.14E-05       0.00   1.40E+11
53.1272    224263.       0.00
   34.2000   -0.00148    -19926.      -1763.   3.07E-05       0.00   1.40E+11
50.6817    246429.       0.00
   34.8000   -0.00126    -31325.      -1408.   2.94E-05       0.00   1.40E+11
48.0680    273959.       0.00
   35.4000   -0.00106    -40231.      -1072.   2.76E-05       0.00   1.40E+11
45.3004    308459.       0.00
   36.0000  -8.66E-04    -46788.  -756.0757   2.53E-05       0.00   1.40E+11
42.3901    352270.       0.00
   36.6000  -6.93E-04    -51146.  -461.8320   2.28E-05       0.00   1.40E+11
39.3443    408924.       0.00
   37.2000  -5.38E-04    -53463.  -189.9971   2.01E-05       0.00   1.40E+11
36.1654    483975.       0.00
   37.8000  -4.03E-04    -53904.    58.4487   1.74E-05       0.00   1.40E+11
32.8474    586691.       0.00
   38.4000  -2.88E-04    -52640.   282.4314   1.46E-05       0.00   1.40E+11
29.3700    733842.       0.00
   39.0000  -1.93E-04    -49853.   480.6258   1.20E-05       0.00   1.40E+11
25.6839    959605.       0.00
   39.6000  -1.16E-04    -45732.   651.0965   9.52E-06       0.00   1.40E+11
21.6690   1348205.       0.00
   40.2000  -5.57E-05    -40487.   790.2342   7.30E-06       0.00   1.40E+11
16.9804   2195973.       0.00
   40.8000  -1.06E-05    -34361.   886.5819   5.37E-06       0.00   1.40E+11
9.7829   6631193.       0.00
   41.4000   2.17E-05    -27726.   877.1815   3.78E-06       0.00   1.40E+11
-12.3941   4111764.       0.00
   42.0000   4.38E-05    -21733.   776.1864   2.50E-06       0.00   1.40E+11
-15.6601   2576707.       0.00
   42.6000   5.78E-05    -16552.   657.9710   1.52E-06       0.00   1.40E+11
```

```
-17.1775   2141093.       0.00
   43.2000   6.56E-05    -12260.   531.6115   7.78E-07       0.00   1.40E+11
-17.9223   1965918.       0.00
   43.8000   6.90E-05     -8897.   401.5107   2.34E-07       0.00   1.40E+11
-18.2168   1901626.       0.00
   44.4000   6.90E-05     -6479.   270.3571  -1.61E-07       0.00   1.40E+11
-18.2148   1900366.       0.00
   45.0000   6.66E-05     -5004.   194.0133  -4.57E-07       0.00   1.40E+11
-2.9918    323195.      0.00
   45.6000   6.24E-05     -3684.   173.0189  -6.80E-07       0.00   1.40E+11
-2.8400    327505.      0.00
   46.2000   5.69E-05     -2512.   153.3623  -8.40E-07       0.00   1.40E+11
-2.6202    331814.      0.00
   46.8000   5.03E-05     -1475.   135.4683  -9.42E-07       0.00   1.40E+11
-2.3503    336123.      0.00
   47.4000   4.33E-05  -560.1131   119.6385  -9.94E-07       0.00   1.40E+11
-2.0468    340433.      0.00
   48.0000   3.60E-05   248.7748   106.0600  -1.00E-06       0.00   1.40E+11
-1.7250    344742.      0.00
   48.6000   2.89E-05   968.2341    94.8144  -9.71E-07       0.00   1.40E+11
-1.3988    349051.      0.00
   49.2000   2.20E-05      1615.    85.8842  -9.05E-07       0.00   1.40E+11
-1.0818    353360.      0.00
   49.8000   1.58E-05      2206.    79.1595  -8.06E-07       0.00   1.40E+11
-0.7862    357670.      0.00
   50.4000   1.04E-05      2756.    42.1537  -6.79E-07       0.00   1.40E+11
-9.4932   6553680.      0.00
   51.0000   6.05E-06      2814.   -20.1482  -5.36E-07       0.00   1.40E+11
-7.8129   9294075.      0.00
   51.6000   2.72E-06      2466.   -52.6663  -4.00E-07       0.00   1.40E+11
-1.2199   3231652.      0.00
   52.2000   2.97E-07      2056.   -57.5375  -2.83E-07       0.00   1.40E+11
-0.1332   3231652.      0.00
   52.8000  -1.36E-06      1638.   -55.8148  -1.88E-07       0.00   1.40E+11
0.6117   3231652.      0.00
   53.4000  -2.42E-06      1252.   -49.7090  -1.14E-07       0.00   1.40E+11
1.0843   3231652.      0.00
   54.0000  -3.01E-06   922.4426   -40.9498  -5.81E-08       0.00   1.40E+11
1.3488   3231652.      0.00
   54.6000  -3.25E-06   662.5829   -30.8388  -1.73E-08       0.00   1.40E+11
1.4598   3231652.      0.00
   55.2000  -3.25E-06   478.3833   -23.1750   1.20E-08       0.00   1.40E+11
0.6690   1479929.      0.00
   55.8000  -3.08E-06   328.8493   -18.4633   3.28E-08       0.00   1.40E+11
0.6398   1496015.      0.00
   56.4000  -2.78E-06   212.4757   -14.0562   4.67E-08       0.00   1.40E+11
0.5844   1512101.      0.00
   57.0000  -2.41E-06   126.3897   -10.1134   5.54E-08       0.00   1.40E+11
0.5109   1528187.      0.00
   57.6000  -1.98E-06    66.7829    -6.7421   6.04E-08       0.00   1.40E+11
```

```
0.4256   1544273.       0.00
   58.2000  -1.54E-06    29.2387    -4.0105   6.29E-08       0.00   1.40E+11
0.3331   1560359.       0.00
   58.8000  -1.08E-06     8.9643    -1.9604   6.38E-08       0.00   1.40E+11
0.2363   1576446.       0.00
   59.4000  -6.18E-07     0.9395    -0.6177   6.41E-08       0.00   1.40E+11
0.1367   1592532.       0.00
   60.0000  -1.56E-07       0.00       0.00   6.41E-08       0.00   1.40E+11
0.03491    804309.       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 1:

Pile-head deflection                =     0.22666909 inches
Computed slope at pile head         =       0.000000 radians
Maximum bending moment              =      -2067317. inch-lbs
Maximum shear force                 =         25000. lbs
Depth of maximum bending moment     =       0.000000 feet below pile head
Depth of maximum shear force        =       0.000000 feet below pile head
Number of iterations                =             66
Number of zero deflection points    =              4


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches      radians
lbs      in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
```

```
---------- ----------
  1  V, lb     25000.   S, rad         0.00     75000.     0.2267       0.00
25000.  -2067317.


Maximum pile-head deflection = 0.2266690942 inches
Maximum pile-head rotation   = -0.0000000000 radians = -0.000000 deg.

--------------------------------------------------------------------------------
                           Summary of Warning Messages
--------------------------------------------------------------------------------

The following warning was reported 594 times

**** Warning ****

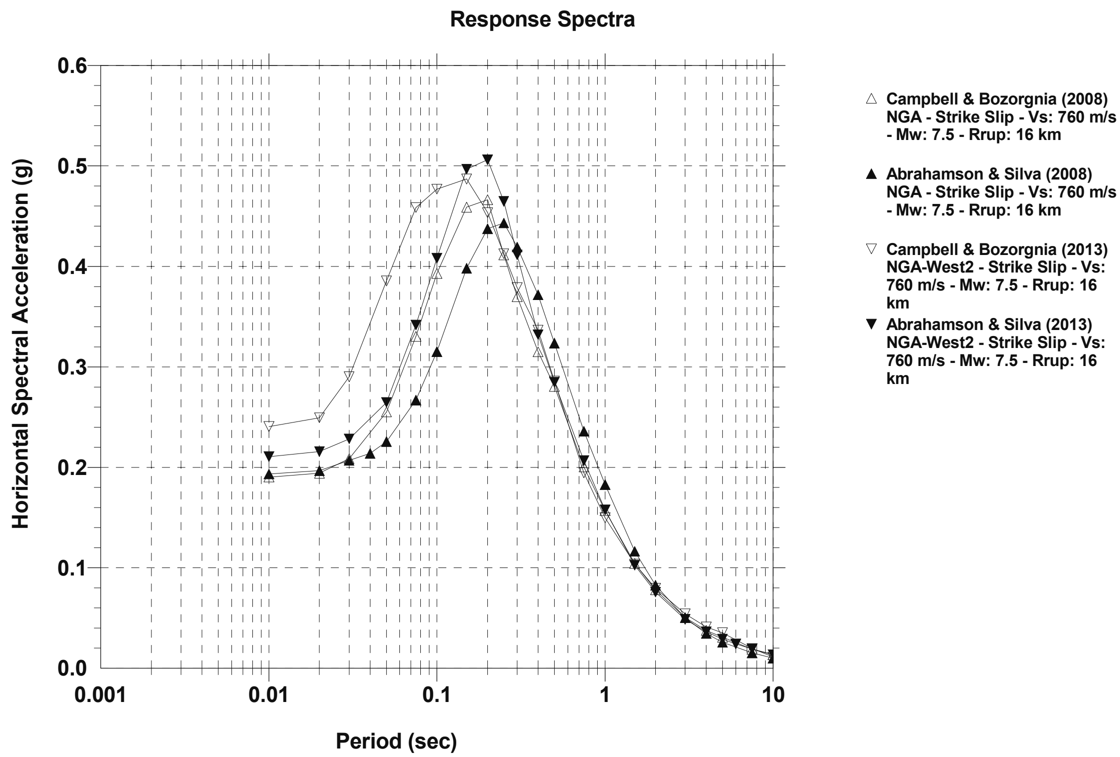
The input value for friction angle is either smaller than 29 degrees or
higher than 41 degrees and no value of k has been specified for a soil layer
defined using the API sand criteria. Program will assume an internal default value,

for k, but the friction angle is outside the range of data available.
Please check your input data for correctness.


The analysis ended normally.
```

APPENDIX E

Shake Analysis (Figure 1-9)



Response Spectra
Horizontal Spectral Acceleration (g)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.001
0.01
0.1
1
10
Period (sec)
Campbell & Bozorgnia (2008) NGA - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km
Abrahamson & Silva (2008) NGA - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km
Campbell & Bozorgnia (2013) NGA-West2 - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km
Abrahamson & Silva (2013) NGA-West2 - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km

Figure No. 1

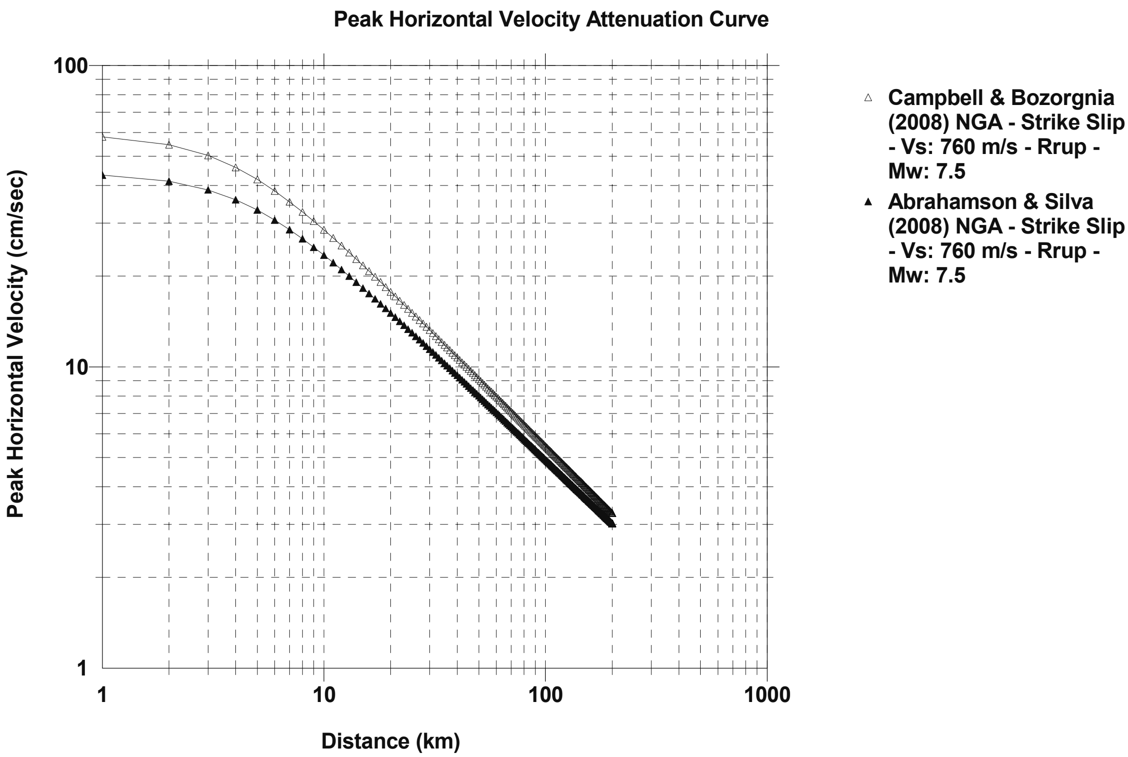

Peak Horizontal Velocity Attenuation Curve
Peak Horizontal Velocity (cm/sec)
100
10
1
1
10
100
1000
Distance (km)
Campbell & Bozorgnia (2008) NGA - Strike Slip - Vs: 760 m/s - Rrup - Mw: 7.5
Abrahamson & Silva (2008) NGA - Strike Slip - Vs: 760 m/s - Rrup - Mw: 7.5

Figure No. 2

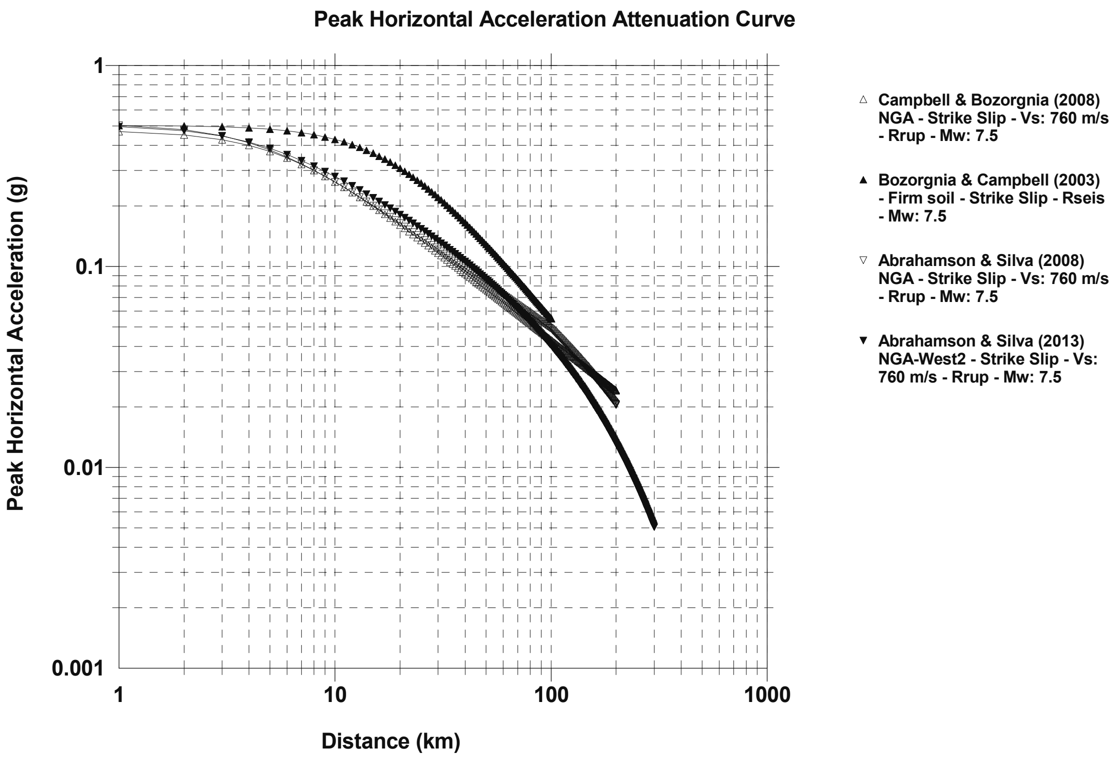

Peak Horizontal Acceleration Attenuation Curve
Peak Horizontal Acceleration (g)
1
0.1
0.01
0.001
1
10
100
1000
Distance (km)
Campbell & Bozorgnia (2008) NGA - Strike Slip - Vs: 760 m/s - Rrup - Mw: 7.5
Bozorgnia & Campbell (2003) - Firm soil - Strike Slip - Rseis - Mw: 7.5
Abrahamson & Silva (2008) NGA - Strike Slip - Vs: 760 m/s - Rrup - Mw: 7.5
Abrahamson & Silva (2013) NGA-West2 - Strike Slip - Vs: 760 m/s - Rrup - Mw: 7.5

Figure No. 3

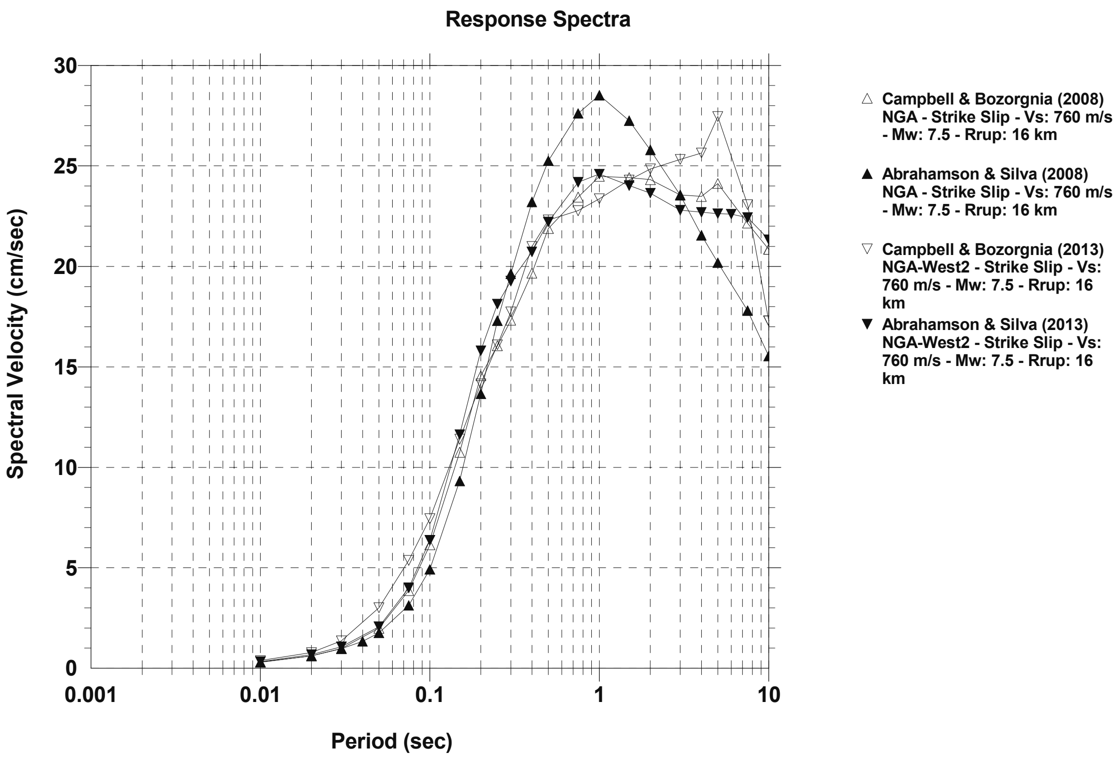

Response Spectra
Spectral Velocity (cm/sec)
Period (sec)
30
25
20
15
10
5
0
0.001
0.01
0.1
1
10
Campbell & Bozorgnia (2008) NGA - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km
Abrahamson & Silva (2008) NGA - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km
Campbell & Bozorgnia (2013) NGA-West2 - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km
Abrahamson & Silva (2013) NGA-West2 - Strike Slip - Vs: 760 m/s - Mw: 7.5 - Rrup: 16 km

Figure No. 4

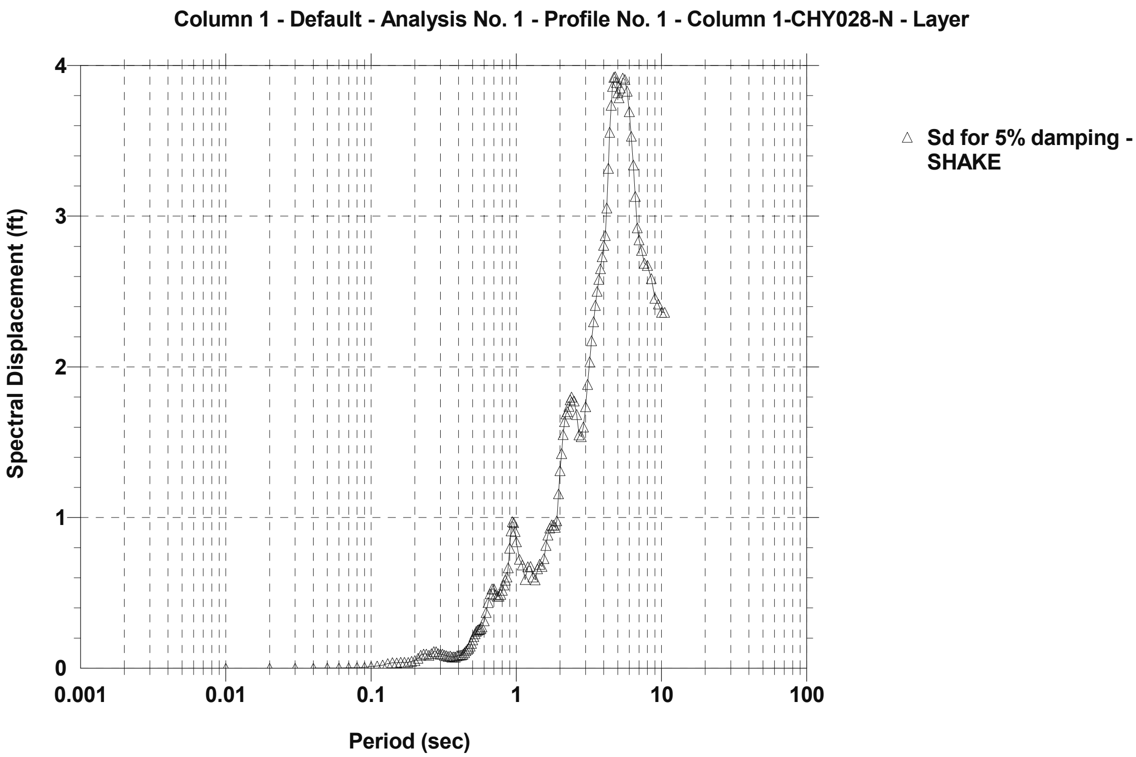
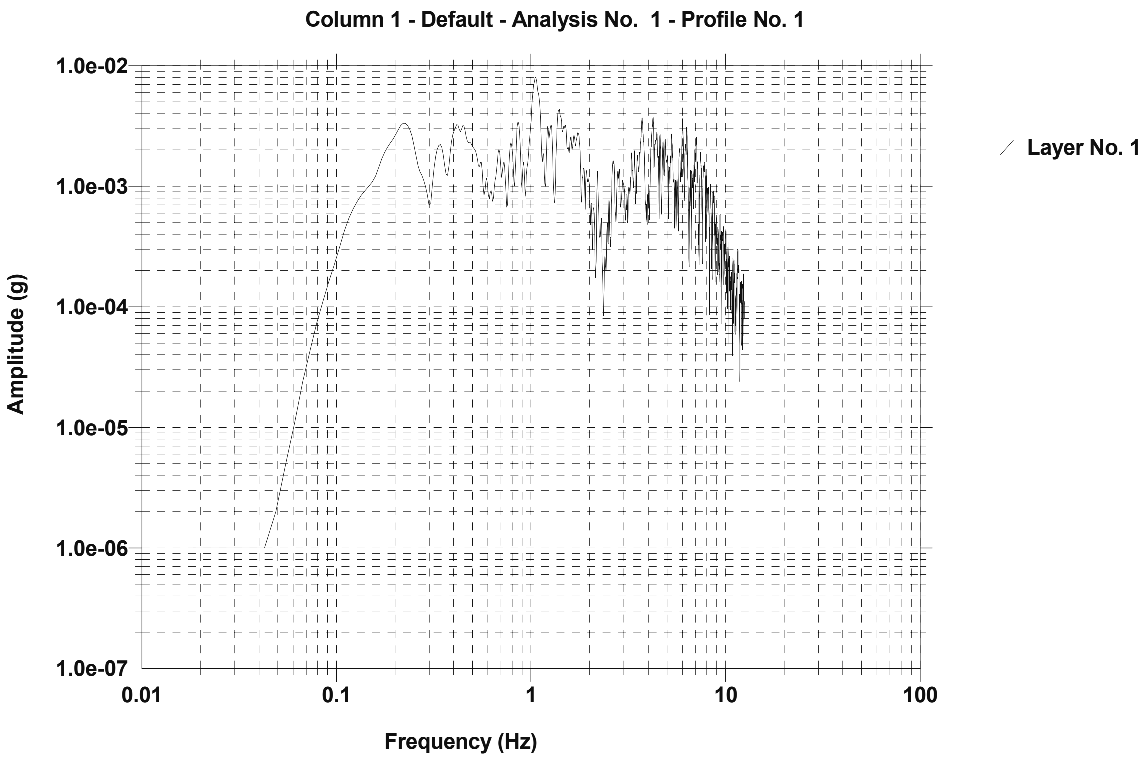

Column 1 - Default - Analysis No. 1 - Profile No. 1 - Column 1-CHY028-N - Layer
Spectral Displacement (ft)
4
3
2
1
0
0.001
0.01
0.1
1
10
100
Period (sec)
Sd for 5% damping - SHAKE

Figure No. 5



Column 1 - Default - Analysis No. 1 - Profile No. 1
Layer No. 1
Amplitude (g)
Frequency (Hz)
1.0e-02
1.0e-03
1.0e-04
1.0e-05
1.0e-06
1.0e-07
0.01
0.1
1
10
100

Figure No. 6

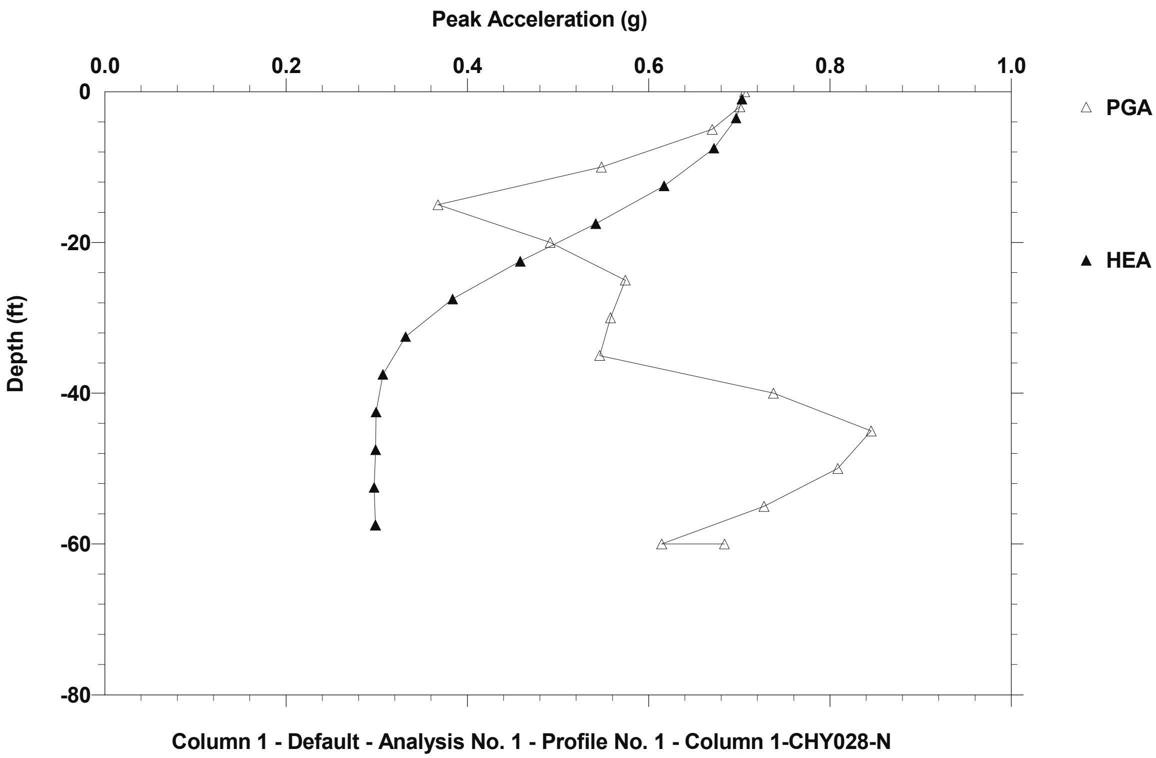

Peak Acceleration (g)
0.0
0.2
0.4
0.6
0.8
1.0
0
-20
-40
-60
-80
Depth (ft)
PGA
HEA
Column 1 - Default - Analysis No. 1 - Profile No. 1 - Column 1-CHY028-N

Figure No. 7

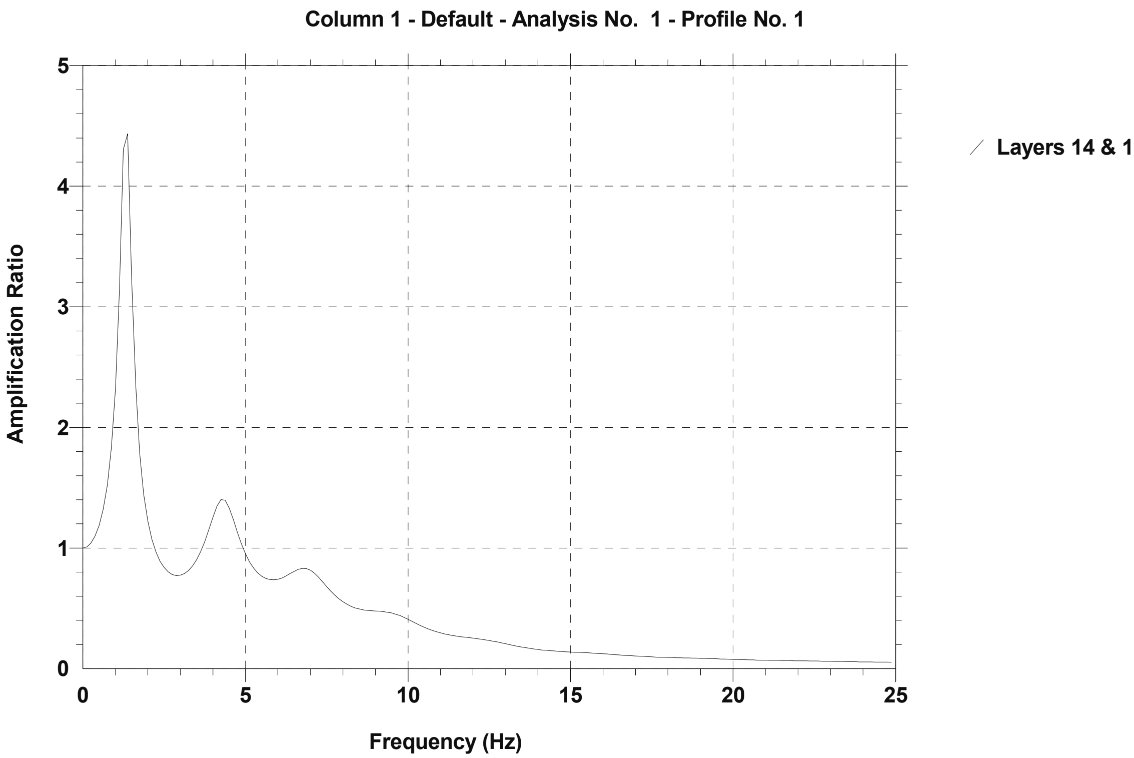

Column 1 - Default - Analysis No. 1 - Profile No. 1
Amplification Ratio
0
1
2
3
4
5
0
5
10
15
20
25
Frequency (Hz)
Layers 14 & 1

Figure No. 8

Column 1 - Default
Analysis No. 1 - Profile No. 1 - Column 1-CHY028-N
C:\PROGRAM FILES (X86)\GEOMOTIONS\QUAKES\SHAKE\CRUSTAL\CHY028-N.EQK

Layer	Depth to Middle of Layer (ft)	Total Unit Weight (kcf)	Damping Used (%)	Shear Modulus (ksf)	Maximum Shear Strain (%)	Maximum Shear Stress (psf)	Shear Wave Velocity (fps)	Depth to Top of Layer (ft)	Peak Acceleration (g)	G/Gmax Curve	Damping Curve	Type of Motion
1	1	.125	4.3	861.4	.0102	87.86	471.0591	0	.70581	Clay PI=40	Clay	Outcrop
2	3.5	.125	6.2	759	.04015	304.72	442.1746	2	.70054	Clay PI=40	Clay	Within
3	7.5	.118	8.299999	594.2	.10405	618.27	402.6737	5	.67009	Clay PI=40	Clay	Within
4	12.5	.118	10	504.6	.18465	931.78	371.074	10	.54785	Clay PI=40	Clay	Within
5	17.5	.124	11.1	461.7	.2481	1145.44	346.2558	15	.36764	Clay PI=40	Clay	Within
6	22.5	.113	12.2	384	.3232	1241.24	330.7915	20	.49138	Clay PI=40	Clay	Within
7	27.5	.113	12.8	325.8	.38561	1256.13	304.6942	25	.57424	Clay PI=40	Clay	Within
8	32.5	.1	13	312.4	.40424	1262.97	317.1637	30	.5578	Clay PI=40	Clay	Within
9	37.5	.1	13.3	303.2	.43564	1320.92	312.4586	35	.54607	Clay PI=40	Clay	Within
10	42.5	.1	13.1	351.1	.40947	1437.81	336.2354	40	.73761	Clay PI=40	Clay	Within
11	47.5	.1	13.7	328.3	.48277	1584.86	325.1347	45	.84553	Clay PI=40	Clay	Within
12	52.5	.13	9.8	995.1	.17558	1747.24	496.4661	50	.80861	Clay PI=40	Clay	Within
13	57.5	.108	15.2	302.3	.63954	1933.46	300.2169	55	.7272	Clay PI=40	Clay	Within
14	Base							60	.6143			Within
14	Outcrop							60	.6836			Outcrop

Notes:
Period for Soil Column: .67 sec
Average Shear Wave Velocity for Soil Column: 358 ft/sec

Figure No. 9

APPENDIX F

Scale of Acceptable Risk

APPENDIX F
SCALE OF ACCEPTABLE RISKS FROM NON-SEISMIC GEOLOGIC HAZARDS*

RISK LEVEL	STRUCTURE TYPE	RISK CHARACTERISTICS
EXTREMELY LOW RISKS	Structures whose continued functioning is critical, or whose failure might be catastrophic: nuclear reactors, large dams, power intently systems, plants manufacturing or storing explosive or toxic materials.	Failure affects substantial populations risk equals nearly zero.
VERY LOW RISKS	Structures whose use is critically needed after a disaster: important utility centers: hospitals: fire, police, and emergency communication facilities; fire stations; and critical transportation elements such as bridges and overpasses; also smaller dams.	Failure affects substantial populations.
LOW RISKS	Structures of high occupancy, or whose use after a disaster: important utility centers; hospitals; fire, police, and emergency communication facilities; fire stations; and critical transportation elements such as bridges and overpasses; also smaller dams.	Failure of a single structure would affect primary only the occupants.
"ORDINARY RISKS"	The vast majority of structures: most commercial and industrial buildings; small hotels and apartment buildings, and single-family residences.	Failure only affects owners/occupants of a structure rather than a substantial population. No significant potential for loss of life of serious physical injury. Risk level is similar or comparable to other ordinary risks (including seismic risks) to citizens of coastal California. No collapse of structures; structural damage limited to repairable damage in most cases. This degree of damage is unlikely as a result of storms with a repeat time of 50 years or less.
MODERATE RISKS	fences, driveways, non-habitable structures, detached retaining walls, sanitary landfills, recreation areas and open space.	Structure is not occupied or occupied infrequently. Low probability of physical injury. Moderate probability of collapse.

***Non-seismic geologic hazards include flooding, landslides, erosion, wave run-up and sinkhole collapse.**

APPENDIX F SCALES OF ACCEPTABLE RISKS FROM SEISMIC GEOLOGIC HAZARDS		
LEVEL OF ACCEPTABLE RISK	KINDS OF STRUCTURES	EXTRA PROJECT COST PROBABLY REQUIRED TO REDUCE RISK TO AN ACCEPTABLE LEVEL
Extremely Low	Structures whose continued functioning is critical, or whose failure might be catastrophic nuclear reactors, large dams, power intently systems, plants manufacturing or storing explosives to toxic materials.	No set percentage (whatever is required for maximum attainable safety).
Slightly higher than under level 1[1]	Structures whose use is critically needed after a disaster; important utility centers; hospitals; fire, police, and emergency communication facilities; fire station; and critical transportation elements such as bridges and overpasses; also smaller dams.	5 to 25 percent of project cost.
Lowest possible risk to occupants of the structure [3]	Structures of high occupancy or whose use after a disaster would be particularly convenient; schools, churches, theaters, large hotels, and other high-rise buildings housing large numbers of people, other places normally attracting large concentrations of people civic buildings such as fire stations, secondary utility structures, extremely large commercial enterprises, most roads,alternative or non-critical bridges and overpasses.	5 to 15 percent of project cost.
An "ordinary" level or risk to occupants of the structure [3,5]	The vast majority of structures; most commercial and industrial buildings, small hotels and apartment buildings and single-family residences.	1 to 2 percent of project cost in most cases (2 to 10 percent of project cost in a minority of cases)[4]

1. Failure of a single structure may affect substantial populations.

2. These additional percentages are based on the assumption that the base cost is the total cost of the building or other facility when ready for occupancy. In addition, it is assumed that the structure would have been designed and built in accordance with current California practice. Moreover, the estimated additional cost presumes that structures in this acceptable-risk category are to embody sufficient safety to remain functional following an earthquake.

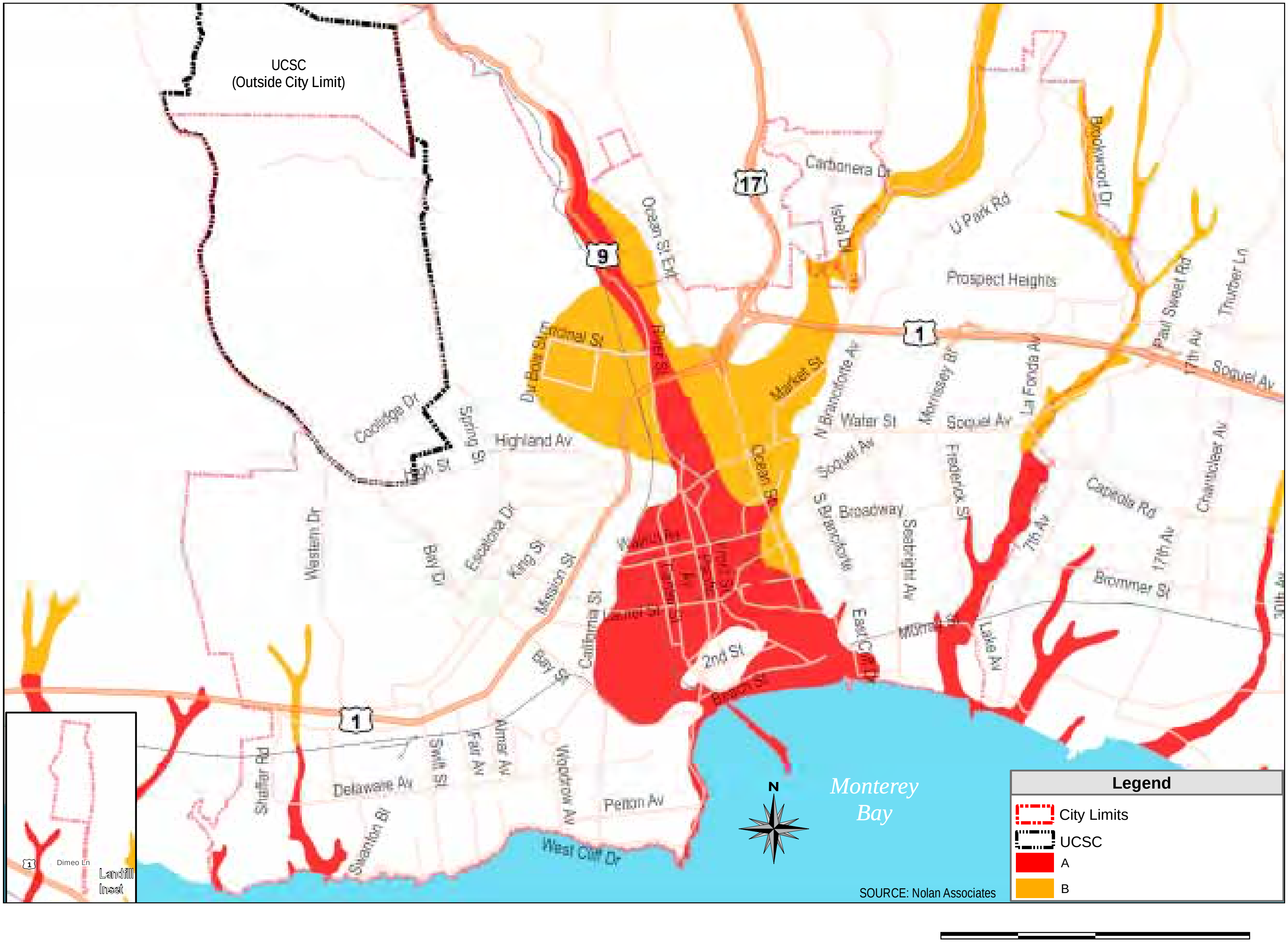
3. Failure of single structure would affect primarily only the occupants.

4. These additional percentages are based on the assumption that the base cost is the total cost of the building or facility when ready for occupancy. In addition, it is assumed that the structures would have been designed and built in accordance with current California Practice. Moreover, the estimated additional cost presumes that structures in this acceptable-risk category are to be sufficiently safe to give reasonable assurance of preventing injury or loss of life during and following an earthquake, but otherwise not necessarily to remain functional.

5. "Ordinary Risk": Resist minor earthquakes without damage; resist moderate earthquakes without structural damage but with some non-structural damage; resist major earthquakes of the intensity or severity of the strongest experienced in California, without collapse, but with some structural, as well as non-structural damage. In most structures, it is expected that structural damage, even in a major earthquake, could be limited to repairable damage. (Structural Engineers Association of California).

Source:Meeting The Earthquake Challenge, Joint Committee on Seismic Safety of the California Legislature, January 1974, p.9.

Liquefaction



HZ4.3 Ensure that resources are available for quick and proper response to hazardous-waste emergencies. Cf. CC7.1.6 and HZ1.2.

HZ4.3.1 Train personnel and ensure that resources are available to quickly respond to hazardous-waste emergencies.

HZ4.4 Reduce the risk of exposure to hazardous materials from sites being developed or redeveloped.

HZ4.4.1 Regulate the siting and permitting of businesses that handle hazardous materials, and assure that safe handling and use information from those businesses is provided to fire protection and other safety agencies.

HZ4.4.2 Periodically review and update procedures for land uses that handle, store, or transport lead, mercury, vinyl chloride, benzene, asbestos, beryllium, or other hazardous materials.

HZ4.5 Maintain Santa Cruz as a nuclear free zone.

GOAL HZ5 Minimal light pollution

HZ5.1 Reduce light pollution. Cf. CD3.6, M1.6.1, M3.2.10, NRC7.1.2.

HZ5.1.1 Investigate the merits of a “dark sky ordinance” and the standards and enforcement efforts required.

HZ5.1.2 Develop lighting design guidelines that reduce light spillage both upward and onto adjoining properties.

HZ5.1.3 Consider appropriateness of lighting when reviewing proposed development or renovation of parks and recreation facilities.

GOAL HZ6 Protection from natural hazards

HZ6.1 Reduce erosion hazards.

HZ6.1.1 Minimize hazards posed by coastal cliff retreat.

HZ6.1.2 For development adjacent to cliffs, require setbacks for buildings equal to 50 years of anticipated cliff retreat.

HZ6.2 Discourage development on unstable slopes.

HZ6.2.1 Require engineering geology reports when, in the opinion of the City’s planning director, excavation and grading have the potential for exposure to slope instability or the potential to create unstable slope or soil conditions.

HZ6.3 Reduce the potential for life loss, injury, and property and economic damage from earthquakes, liquefaction, and other seismic hazards.

HZ6.3.1 Adopt new State-approved California Building Codes (CBC) and require that all new construction conform with the latest edition of the CBC.

HZ6.3.2 Complete seismic retrofit of unreinforced masonry buildings within the city in accordance with the Uniform Code for the Abatement of Dangerous Buildings.

HZ6.3.3 Require earthquake retrofit in connection with repair or alterations, and use the City’s Rehabilitation Program, where appropriate, to manage the work.

HZ6.3.4 When feasible, upgrade sewer, water, and other piping to withstand seismic shaking and differential settlement.

HZ6.3.5 Consider an automatic gas shutoff ordinance for buildings within the city to reduce fire hazards related to seismic shaking.

HZ6.3.6 Require site specific geologic investigation(s) by qualified professionals for proposed development in potential liquefaction areas shown on the Liquefaction Hazard Map to assess potential liquefaction hazards, and require developments to incorporate the design and other mitigation measures recommended by the investigation(s).

HZ6.4 Avoid or reduce the potential for life loss, injury, and property and economic damage from flooding.

HZ6.4.1 Address the effects of global warming through changes in land use and building codes for low-lying areas that may be flooded by increases in sea levels and storm violence.

HZ6.4.2 Increase public awareness of flood hazards.

HZ6.4.3 Ensure that flood information is made available to property owners, potential buyers, and residents living in floodplains and coastal inundation areas, and

NUMBER	ACTION	RESPONSIBLE DEPARTMENT	TIME FRAME
HZ6.1.2	For development adjacent to cliffs, require setbacks for buildings equal to 50 years of anticipated cliff retreat.	PL	Ongoing
HZ6.2.1	Require engineering geology reports when, in the opinion of the City's planning director, excavation and grading have the potential for exposure to slope instability or the potential to create unstable slope or soil conditions.	PL, PW, PR, W	Ongoing
HZ6.3.1	Adopt new State-approved California Building Codes (CBC) and require that all new construction conform with the latest edition of the CBC.	PL	Ongoing
HZ6.3.2	Complete seismic retrofit of unreinforced masonry buildings within the city in accordance with the Uniform Code for the Abatement of Dangerous Buildings	PL	Ongoing
HZ6.3.3	Require earthquake retrofit in connection with repair or alterations, and use the City's Rehabilitation Program, where appropriate to manage the work.	PW, PL	Ongoing
HZ6.3.4	When feasible, upgrade sewer, water, and other piping to withstand seismic shaking and differential settlement.	PW, W	Ongoing
HZ6.3.5	Consider an automatic gas shutoff ordinance for buildings within the city to reduce fire hazards related to seismic shaking.	PL, F	Ongoing
HZ6.3.6	Require site specific geologic investigation(s) by qualified professionals for proposed development in potential liquefaction areas shown on the Liquefaction Hazard Map to assess potential liquefaction hazards, and require developments to incorporate the design and other mitigation measures recommended by the investigation(s).	PL	Ongoing
HZ6.4.1	Address the effects of global warming through changes in land use and building codes for low-lying areas that may be flooded by increases in sea levels and storm violence.	PL, PW	Ongoing
HZ6.4.2	Increase public awareness of flood hazards.	PL, PW, F	Ongoing
HZ6.4.3	Ensure that flood information is made available to property owners, potential buyers, and residents living in floodplains and coastal inundation areas, and encourage them to participate in the Federal Flood Insurance Program.	PL	Ongoing
HZ6.4.4	Work with creekside property owners to reduce and mitigate flood hazards.	PL, PW, W	Ongoing
HZ6.4.5	Continue to reduce flooding hazards in areas with flood potential.	PW, PL	Ongoing
HZ6.4.6	Regulate and provide guidelines for construction and development in floodplains.	PL	Ongoing
HZ6.4.7	Restrict or prohibit uses in undeveloped flood areas, and maintain floodplain and floodway regulations in developed flood areas.	PL	Ongoing