Local Hazard Mitigation Plan
City of Newport Beach, California

2016 Update

EXECUTIVE SUMMARY

Plan Authority and Adoption

The Federal Disaster Mitigation Act of 2000 (DMA 2000), Section 322 (a-d), as a condition of receiving Federal disaster mitigation funds, requires local governments, including counties, cities, and tribes in the United States, to complete a Local Hazards Mitigation Plan. These Plans are to identify the hazards that have occurred or may occur in the study area, and provide mitigation strategies, or action items, designed to save lives and reduce the destruction of property. The City of Newport Beach has addressed this requirement by completing a Local Natural Hazards Mitigation Plan ("the Plan") that describes and analyzes several issues of concern to the City, including earthquakes, floods, tsunamis, wildfires, unstable slopes, and strong winds. The Plan provides resources and information, in addition to action items and programs, that are meant to assist Newport Beach in reducing risk and preventing loss from future natural hazard events. Per Federal requirements, this Plan is to be reviewed and updated every five years. This is the first five-year update to the original plan completed in 2008 and adopted in 2009.

Adoption of the Local Hazard Mitigation Plan by the local jurisdiction's governing body is one of the prime requirements for approval of the Plan. Once the Plan is completed, City Council is responsible for adopting the Local Hazards Mitigation Plan. The local agency governing body has the responsibility and authority to promote sound public policy regarding natural hazards. The City Council will periodically need to re-adopt the Plan as it is revised to meet changes in the natural hazard risks and exposures in the community. The approved Local Natural Hazard Mitigation Plan will be significant in the future growth and development and redevelopment of the community. The City of Newport Beach will use a resolution to adopt the Local Hazard Mitigation Plan Update. The adoption process is scheduled for January 2015.

Summary of Findings

Analysis of the natural hazards that could impact the City of Newport Beach indicates that there are five main hazards (earthquakes, flooding, wildfires, landslides and strong winds) that could impact Newport Beach causing sufficient damage that a Federal emergency could be declared. The hazard most devastating to Newport Beach would be an earthquake on any of three faults that extend through or are located near the City. An earthquake under or near the City has the potential to cause extensive damage due to ground shaking, fault rupture, liquefaction, earthquake-induced slope instability, and inundation due to catastrophic failure of the City's water storage reservoirs. Other potential secondary effects of such an earthquake include urban fires ignited by fallen appliances, rupture of gas mains, or fallen electrical lines, and the release of hazardous materials as a result of broken containers.

Flooding due to intense rainfall, often combined with high tides, can cause damage in some sections of Newport Beach. Flooding of the coastal areas could also occur due to tsunamis, storm surge, and as a result of a rise in sea level due to global warming. During wet winters, when the ground becomes saturated, the hilly areas of the City can slide, with the potential for loss of property and damage to the City's infrastructure. Another hazard with the potential to cause significant losses in the City is wildland fire, especially at the interface with urban development. Wildland fires fanned by strong Santa Ana winds have the potential to increase the burn area and therefore losses. Thunderstorms, tropical hurricanes, and winter storms descending from the north have in the past caused sporadic, but widespread flooding and damage in Southern California. Tornadoes and water spouts have occasionally landed in the Southern California area. These unusual, but potentially damaging meteorological conditions are discussed, with emphasis on their historical incidence in Newport Beach and potential future impacts in the region.

Plan Mission

The mission of the Newport Beach Local Natural Hazards Mitigation Plan is to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards. This can be achieved by increasing public awareness, documenting resources available for risk reduction and loss prevention, and identifying activities to guide the City towards building a safer, more sustainable community.

Plan's Goals

The goals of the Mitigation Plan describe the overall direction that the City of Newport Beach, through its departments, agencies, organizations, and citizens, can take toward reducing its risk to natural hazards. The goals of the Plan are stepping-stones between the broad direction of the mission statement and the specific recommendations outlined in the action items. The main goals of Newport Beach's Mitigation Plan are:

1. Protect life and property,
2. Increase public awareness of natural hazards,
3. Preserve and enhance the natural systems to provide natural hazard mitigation functions,
4. Develop partnerships among stakeholders with an interest in hazard reduction to facilitate the implementation of mitigation measures, and
5. Strengthen emergency services.

Action Items

The action items are a list of activities that Newport Beach's agencies and citizens can implement to reduce risk in the community. Some action items have community-wide application, whereas others can be implemented on an individual basis by residents and business owners. Each action item includes an estimate of the time line for implementation. This Plan identifies action items by timing of implementation (already being implemented, short-term, and long-term), and by hazard (multi-hazard, and hazard-specific).

Chapter 4 includes all of the action items developed for the Plan, including both multi-hazard action items, and hazard-specific action items. Each action item is followed by the following information:

Coordinating Organization

The coordinating organization is the public agency with regulatory responsibility to address natural hazards, or that is willing and able to organize resources, find appropriate funding, or oversee activity implementation, monitoring, and evaluation.

Timeline

Action items include both short- and long-term activities. Each action item includes an estimate of the time line for implementation. Short-term action items are activities which Newport Beach's agencies are capable of implementing with existing resources and authorities in the next five years. Long-term action items may require new or additional resources or authorities, and may take between five and ten years (or more) to implement. Section 4 also lists the action items that are already being implemented on an on-going basis.

Ideas for Implementation

Each action item includes ideas for implementation and potential resources, which may include grant programs or human resources.

Plan Goals Addressed

The Mitigation Plan needs to be regularly monitored and evaluated to measure its success in achieving its goals once implementation begins. To that end, the plan goals addressed by each action item are identified – they provide the means by which the success of each action can be measured.

Partner Organizations

Partner organizations are agencies or public/private sector organizations that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization. The partner organizations listed in the Resource Directory (Appendix A) of the City of Newport Beach's Local Natural Hazards Mitigation Plan are potential partners recommended by the Hazard Mitigation Advisory Board. These organizations, however, were not involved during the development of the Mitigation Plan, and should therefore be contacted by the coordinating organization to establish their commitment of time and resources to action items.

Constraints

Constraints may apply to some of the action items. These constraints may be a lack of City staff, lack of funds, or vested property rights, which might expose the City of Newport Beach to legal action as a result of adverse impacts on private property.

How Will the Plan be Implemented, Monitored, and Evaluated?

The Plan Maintenance Section (Section 5) of this document details the formal process that will ensure that the Newport Beach Local Natural Hazards Mitigation Plan remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the Plan annually and producing a Plan revision every five years. This section describes how the City will integrate public participation throughout the plan maintenance process. Finally, this section includes an explanation of how the City's government intends to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms such as the City's General Plan, Building and Safety Codes, and community development plans.

Coordinating Body

The City of Newport Beach Hazard Mitigation Strategic Committee has been and will continue to be responsible for coordinating implementation of Plan action items and undertaking the formal review process. The City's Manager, or his or her designee, can and will assign representatives from City agencies and other organizations to serve in this committee, as appropriate, including, but not limited to, the current Hazard Mitigation Advisory Committee members.

Convener

City Council is responsible for adopting the City of Newport Beach Local Natural Hazard Mitigation Plan and Plan Updates, and the Hazard Mitigation Advisory Committee has responsibility for Plan implementation. The City Manager, or designee, serves as a convener to facilitate the Hazard Mitigation Advisory Committee meetings, and can assign tasks such as updating and presenting the Plan to the members of the committee. Plan implementation and evaluation are a shared responsibility among all of the Hazard Mitigation Advisory Committee members.

Implementation through Existing Programs

The City of Newport Beach addresses statewide planning goals and legislative requirements through its General Plan, Capital Improvement Plans, and City Building and Safety Codes. The Local Natural Hazard Mitigation Plan provides a series of recommendations that are closely related to the goals and objectives of these existing planning programs. The City of Newport Beach has a responsibility to implement recommended mitigation action items through existing programs and procedures.

Economic Analysis of Mitigation Projects

A study conducted in 2005 by the National Institute of Building Sciences through its Multihazard Mitigation Council has found that on average, every dollar spent by FEMA on hazard mitigation provides the country with about four dollars in future benefits. This figure does not include the more than 200 lives and nearly 5,000 injuries that are expected to be prevented over the next 50 years by these programs. Thus, money spent on hazard mitigation is money well spent.

But, where is this pre-disaster mitigation money best spent? To answer this question, the Federal Emergency Management Agency (FEMA) uses two different but valid approaches to identify and measure the costs and benefits associated with natural hazard mitigation strategies or projects: benefit/cost analysis and cost-effectiveness analysis. Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards can provide decision makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects. These exercises can also help prioritize the implementation of action items based on the limited resources available.

Formal Review Process

Newport Beach's Local Natural Hazards Mitigation Plan will be evaluated on an annual basis to determine the effectiveness of its programs, and to reflect changes in land development or programs that may affect the mitigation priorities. The evaluation process includes a firm schedule and time line, and identifies the local agencies and organizations participating in the evaluation of the Plan. The Convener will be responsible for contacting the Hazard Mitigation Advisory Committee members and organizing the annual meeting. Committee members will be responsible for monitoring and evaluating the progress of the mitigation strategies in the Plan.

Continued Public Involvement

The City of Newport Beach is dedicated to involving the public directly in the continual review and updates of its Local Natural Hazard Mitigation Plan. Copies of the Plan and Plan Updates are to be made available at City Hall. The existence and location of these copies is published on the City's website and in City newsletters. The Plan is also published on the City's website, with links that allow the public to submit feedback. The comments are received and reviewed by the City's Emergency Services Coordinator.

SECTION 1: INTRODUCTION

Throughout history, the residents of Southern California, including the city of Newport Beach, have experienced and dealt with a variety of natural hazards common to the area. In the 1700s and 1800s, when there were fewer people in the region and almost everyone depended directly on the land and local weather for their food and welfare, the natural events that disrupted their lives were typically recorded in journals, letters, newspaper articles, and more recently, photographs. In the 1900s, as people began to attempt to understand and modify their environment to reduce the impact of natural hazards on the local population and the landscape, these events were also recorded in scientific journals. Many of these sources are referred to in the following sections in an effort to document the area's past exposure to specific natural hazards, and in the process, assess the region's potential future risks. This is especially important because as the population of Southern California increases, natural hazards have the potential to pose an even higher risk to the population and the economic welfare of the region.

California is the eighth (2012, 2013) largest economy in the world (Center for Continuing Study of the California Economy, July 2013), and Newport Beach is a vibrant and significant member of that economy. People originally from all over the United States and the world now call the city of Newport Beach home because of its gentle Mediterranean climate, geographical attributes (the bay and ocean are at their doorstep, and the mountains are within a two-hour drive) and ample job opportunities. However, the Southern California terrain is the product of powerfully active natural forces forming and tearing down mountains at remarkable rates by geological standards, and when humans interact with this changing environment, there is a high possibility for the population to be negatively impacted. Thus, a natural event, such as an earthquake or flood, clearly has the potential to cause significant damage at the personal, local, and regional levels in the forms of loss of life, injuries, destroyed or impaired structures and infrastructure, loss of income, and the high costs associated with disaster response and recovery.

In addition to earthquakes and floods, the City of Newport Beach, like most of Southern California, is also subject to wildfires, landslides and debris flows, soil erosion and expansive soils, windstorms, hurricanes, tornadoes, drought, and other natural hazards. Some of these hazards, like tornadoes, occur fairly infrequently and are difficult to predict, whereas others, such as erodible and expansive soils, can be effectively mitigated with well understood engineering methods. Being a coastal community, Newport Beach is also susceptible to coastal flooding resulting from a variety of phenomena, including storms, rogue waves, tsunamis, and sea-level rise due to global warming. The historical record and our current state of knowledge indicate that those hazards with the potential to cause the most damage in Newport Beach include earthquakes, floods (including coastal flooding), wildfires, landslides (and other forms of slope instability), and strong winds. These are the natural hazards that are covered in most detail in this document, given that it is possible to minimize the losses that result from these hazards through careful planning and community participation in the implementation of hazard reduction measures.

Why Develop a Local Natural Hazards Mitigation Plan?

As the costs of damage from natural disasters continue to increase, communities realize the importance of identifying effective ways to reduce their vulnerability to disasters. Hazard mitigation plans assist communities in reducing their risk from natural hazards by identifying resources, information, and strategies for risk reduction, while helping to guide and coordinate mitigation activities throughout the area. With these aims in mind, the City of Newport Beach completed its first Natural Hazards Mitigation Plan in 2008. Many of the actions contained therein have been implemented, helping the City be better prepared for future disasters. This update to the City's Hazards Mitigation Plan builds on the original 2008 document, and incorporates those natural disasters that impacted the Southern California area in the last five years, summarizes the mitigation strategies that Newport Beach implemented since 2008 to reduce its vulnerability to natural hazards, and provides a list of new implementation actions that will further prepare the community to resist the impact of potential future natural hazard events.

As with the original 2008 document, this updated Plan provides a set of action items that if implemented can help reduce the risk from natural hazards through education and outreach programs, by fostering the development of partnerships, and by implementing preventive activities (such as land use programs) that limit or guide development in areas at risk from natural hazards. The updated Plan discusses the City's current hazard conditions, and provides actions that are consistent with current City standards and other relevant Federal, State or regional regulations, including FEMA requirements.

The resources and information contained within the Mitigation Plan:

1) establish a basis for coordination and collaboration among agencies and the public in the city of Newport Beach,
2) identify and prioritize future mitigation projects, and
3) assist in meeting the requirements of federal assistance programs.

The Local Natural Hazards Mitigation Plan works in conjunction with other City plans, including the City's Safety Element of the General Plan and the City's Emergency Operations Plan. The updates presented here will be reflected by reference in these other plans and documents.

Section 322 (a-d) of the Federal Disaster Mitigation Act of 2000 (DMA 2000) requires that local governments, as a condition of receiving Federal disaster mitigation funds, have a mitigation plan that:

1) describes the hazards, risks and vulnerabilities specific to the community,
2) identifies and prioritizes mitigation actions,
3) encourages the development of local mitigation, and
4) provides technical support for these efforts.

This Local Hazard Mitigation Plan for the City of Newport Beach serves to meet these requirements.

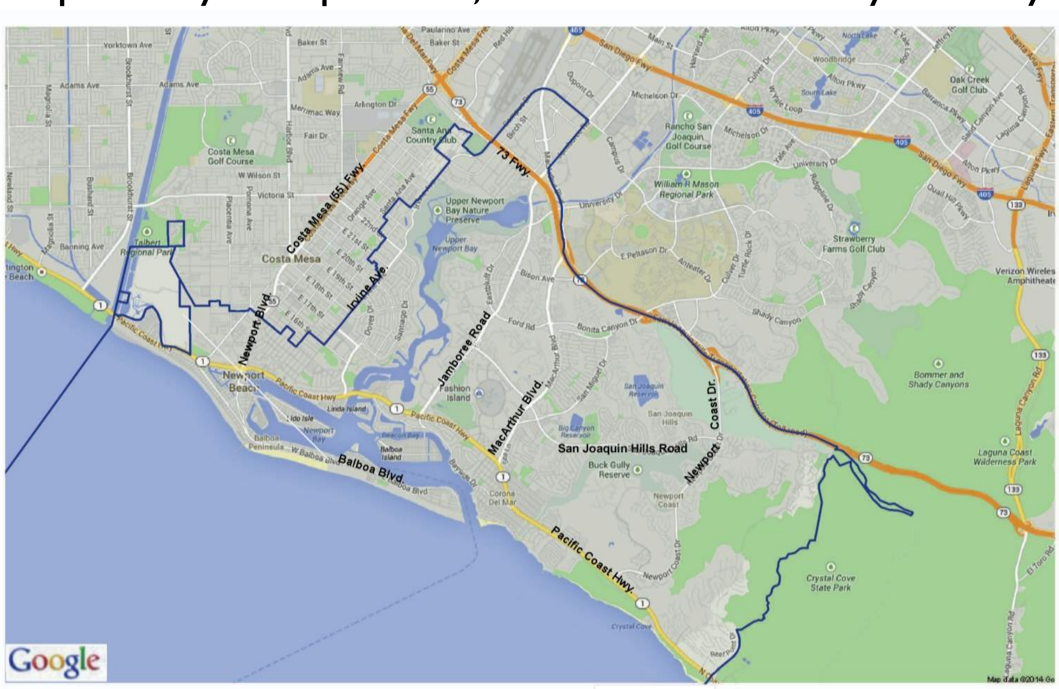
Scope and Impact of the Plan

Newport Beach's Local Natural Hazards Mitigation Plan affects the entire City (see Map 1-1 below). This Plan provides a framework for planning for the main natural hazards that have the potential to impact the Newport Beach area. The resources and background information in the Plan are applicable City-wide, and the goals and recommendations can lay the groundwork for local mitigation plans and partnerships.

Natural Hazard Land Use Policy in California

Planning for natural hazards should be an integral element of any city's land use planning program. All California cities and counties are required to have Safety Elements, one of seven mandatory elements of their General Plans, that document the natural hazards specific to the area, and provide the framework by which ordinances to reduce these hazards are implemented. However, Safety Elements are typically updated only once every 15 to 25 years, and are often superseded by other local and statewide planning regulations. With the requirements for Local Hazard Mitigation Plans, the Federal Emergency Management Agency (FEMA) has essentially exported the California municipal Safety Element idea to the rest of the United States, but they also have expanded on it by requiring a more publicly open and economically quantifiable planning process for community disaster reduction, and a process by which the document is reviewed yearly and updated every five years. Safety Elements traditionally emphasize hazard mapping and develop forward-looking land use planning policies to minimize those hazards. FEMA has directed that, following the hazard mapping effort, an emphasis be placed on hazard mitigation policies that are based on quantifiable vulnerability, loss, and risk analysis. FEMA also requires extensive public participation in this process, because they recognize that without public education and citizen buy-in of mitigation needs, it is nearly impossible to mobilize the level of support necessary to fully begin to deal with multi-hazard mitigation over multi-decadal timescales.

Map 1-1 – City of Newport Beach; dark blue lines show the City's boundary.



Source: Google Maps

The continuing challenge faced by local officials and state government is to keep the local hazard mitigation plans effective in responding to the changing conditions and needs of California's diverse and growing communities without forgetting the effect that low-probability but high-risk natural events (such as major earthquakes, which can skip entire generations and are therefore likely to be dismissed over time) can have on the built environment. This is particularly true in the case of planning for natural hazards where communities must balance development pressures with detailed information on the nature and extent of hazards. Planning for natural hazards therefore calls for local plans to include inventories, policies, and ordinances to guide the safe development of areas that history shows can be greatly impacted by infrequent but large-magnitude natural hazard events. These inventories should include the compendium of hazards facing the community, the built environment at risk, the personal property that may be damaged by hazard events, and most of all, the people who live in the shadow of these hazards.

Support for Natural Hazard Mitigation

All mitigation is local, and the primary responsibility for the development and implementation of risk reduction strategies and policies lies with local jurisdictions. Local jurisdictions, however, are not alone. Partners and resources exist at the regional, State and Federal levels. Numerous California and Federal agencies have a role in the research and public education about natural hazards and in natural hazard mitigation. Some of these key agencies include:

- The California Governor's Office of Emergency Services (Cal OES) is responsible for disaster mitigation, preparedness, response, recovery, and the administration of federal funds after a major disaster declaration. Publications by the Cal OES, including tsunami mapping released by Cal OES for the Orange County coastline were used for the Flood section of this study.

- The Southern California Earthquake Center (SCEC) gathers information about earthquakes, integrates this information on earthquake phenomena, and communicates this to end-users and the general public to increase earthquake awareness, reduce economic losses, and save lives. Many publications, research data and website information provided by SCEC were used in the Earthquake section of this report.

- The California Division of Forestry and Fire Protection (CalFire) is responsible for all aspects of wildland fire protection on state lands, and administers forest practices regulations on non-federal lands. The Wildfire section of the Plan relies extensively on data provided by and available from the CalFire website.

- The California Geological Survey (CGS) and the U.S. Geological Survey (USGS) are responsible for geologic hazard characterization, public education, and the development of partnerships aimed at reducing risk. The Earthquake and Landslide Hazards sections of the Plan utilized maps, publications and consensus reports issued by the California Geological Survey and the U.S. Geological Survey.

- The California Division of Water Resources (DWR) plans, designs, constructs, operates, and maintains the State Water Project; regulates dams; provides flood protection; and assists in emergency management. It also educates the public, and serves local water needs by providing technical assistance. Dam inundation maps and other data prepared and/or administered by the DWR and other departments under the DWR were used in the Floods section of the Plan.

- The National Oceanic and Atmospheric Administration (NOAA) keeps records of storms and other natural hazard events for all regions of the United States. The NOAA database was used extensively in the Flood, Wildfire and Windstorm sections of this Plan.

Information provided by all of these agencies was used extensively in the preparation of this document. Specific publications and webpages authored by these agencies that were referenced during the preparation of this Plan are identified in the appropriate section and are listed in

Appendix I: References.

Plan Methodology

Guidelines and Requirements for Mitigation Plans

Following are the Federal requirements for approval of a Natural Hazard Mitigation Plan:

- Open public involvement, with public meetings that introduce the process and project requirements.
- The public must be afforded opportunities for involvement in identifying and assessing risk, drafting a Plan, and public involvement in approval stages of the Plan.
- Community cooperation, with opportunity for other local government agencies, the business community, educational institutions, and non-profits to participate in the process.
- Incorporation of local documents, including the City's General Plan, the Zoning Ordinance, the Building Codes, and other pertinent documents.

The following components must be part of the planning process:

- Complete documentation of the planning process;
- A detailed risk assessment on hazard exposures in the community;
- A comprehensive mitigation strategy, which describes the goals and objectives, including proposed strategies, programs and actions that can be implemented to reduce or minimize long-term vulnerabilities;
- A plan maintenance process, which describes the method and schedule of monitoring, evaluating and updating the Plan and integration of the Hazard Mitigation Plan into other planning mechanisms;
- Formal adoption by the City Council; and
- Plan review by both FEMA and Cal OES.

These requirements are spelled out in greater detail in the following sections of the Plan and supporting documentation.

Information in the Mitigation Plan is based on research from a variety of sources, with emphasis on data previously collected by the consultant for the City's 2008 Disaster Mitigation Plan and a Hazards Assessment Study that was the basis for the City's current Safety Element of the General Plan. The consultant was helped on this effort by staff from the City of Newport Beach, who conducted data research, facilitated steering committee meetings and public workshops, and developed the final Local Hazard Mitigation Plan. The research methods and various contributions to the Plan are discussed further below.

Input From the Advisory Committee

The Hazard Mitigation Advisory Committee guided the development and update of the Mitigation Plan, and played an integral role in developing the mission, goals, and action items. The committee consisted of representatives from the following agencies in the City of Newport Beach:

- ✓ City of Newport Beach Fire Department, Emergency Services Division
- ✓ City of Newport Beach Fire Department
- ✓ City of Newport Beach Municipal Operations Department
- ✓ City of Newport Beach Community Development Department, and
- ✓ City of Newport Beach Public Works Department.

Input on specific sections of the Plan was also provided by representatives from the following agencies and private organizations:

- ✓ City of Newport Beach Police Department
- ✓ City of Newport Beach Information Services – GIS Division
- ✓ City of Newport Beach Harbor Resources Division
- ✓ City of Newport Beach Finance Department
- ✓ City of Newport Beach Library Department, and
- ✓ Hoag Memorial Presbyterian Hospital.

Hazard Specific Research

Newport Beach's consultant and staff collected data and compiled research on the natural hazards that have impacted the Southern California area historically, and identified five hazards that have the potential to cause the most damage in the City. These include earthquakes, wildfires, flooding, landslides, and windstorms. Research materials used include publications by federal agencies such as FEMA, USGS and NOAA; state agencies such as CGS, Cal OES and CalFire; the City of Newport Beach's Safety Element, and other sources. The City's consultant conducted research by referencing historical local sources, interviewing long-time City of Newport Beach employees, who provided invaluable data regarding past local disasters, and locating information specific to the City of Newport Beach in historical documents.

City of Newport Beach's staff proposed and then evaluated the feasibility and potential effectiveness of the mitigation activities, resources and programs, and potential action items based on their experience in implementing the action items in the Safety Element and the 2008 Disaster Mitigation Plan, and from feedback from stakeholder interviews.

Public Participation Process and Stakeholder Interviews

City staff has conducted interviews with individuals and specialists from organizations interested in natural hazards planning since June 2002, when the process of preparing the Safety Element of the General Plan began. The Safety Element was adopted in July 2006 after a comprehensive planning process that included public input in the form of community open-house meetings, and presentations to the public and City and County officials. Input regarding the draft document was also obtained from the Orange County Fire Authority, the California Department of Conservation – California Geological Survey, and the State Board of Forestry and Fire Protection.

The Final Draft of the 2008 Plan was placed on the City's Wide Web site the first week of April 2008, and feedback was sought from each reviewer. The Emergency Services Division printed and gave hardcopies of the Draft Plan to individuals who did not have access to the internet but expressed interest in reviewing the Plan. A hardcopy of the Draft Plan was also available at the front desk of the Fire Department's main office. Three public workshops to present the Plan and seek input regarding the contents of the Plan, with emphasis on the Goals and Action Items, were held in April 2008. Various residents and volunteers from the City's Community Emergency Response Team were present at these meetings. The workshops included a PowerPoint presentation summarizing the objective of the plan, and preliminary findings regarding the natural hazards identified. Poster-sized images of the maps prepared for the Plan were placed around the room for easy viewing by the participants. Input received from the attendees was taken into consideration when preparing the final document. Once the Plan was adopted by City Council, the final document has been available on the City's website and at City Hall.

City staff also participated extensively in the 2014 Plan Update; several individuals that worked on the 2008 Plan also participated in the 2014 effort. The consultant met with the Advisory Committee on various occasions to discuss the report update, with emphasis on the action items and implementation measures. Those action items covered in the 2008 report that have since been implemented were identified. Other action items that in 2008 were labeled for long-term implementation were reviewed to determine whether or not the City wants to implement them during the next five years, possibly upgrading them to the short-term implementation list, and new action items were identified and discussed. The final list of action items identified for the 2014 Plan update were then prioritized and assigned a responsible agency. After the Draft Plan Update was submitted for comments by City staff, a Public Workshop was held at the City's Main Library to present the Plan data to the public and obtain feedback on the Plan and request suggestions on the action items. Several other people also provided input directly to Ms. Katie Eing, the City's Emergency Services Coordinator.

For the 2014 Update, poster-sized images of the hazard maps were posted at a booth during the City's Disaster Preparedness Fair held at and outside the City's Main Library on September 14-15, 2013, and on September 13-14, 2014. A Public Workshop that included a PowerPoint presentation and posting of the hazard maps was conducted May 7, 2014 at the City's Main Library. Comments from the public were encouraged and received at the meeting, and also via e-mail, in response to the meeting announcements sent out by the City's Emergency Services Coordinator. Additional information regarding these community meetings is provided in Appendix B. The 2014 Plan Update was also posted on the City's website for review by interested residents. Comments were encouraged, with a link allowing for residents to forward their comments directly to the City's Emergency Services Coordinator.

Plan Structure

The resources and information cited in the Hazard Mitigation Plan provide a strong local perspective and help identify strategies and activities to make City of Newport Beach more disaster-resilient.

Each section of the Local Natural Hazards Mitigation Plan provides information and resources to assist City staff and the public in understanding the hazard-related issues facing Newport Beach's citizens, businesses, and the environment. Combined, the sections of the Plan work together to create a document that guides the mission to reduce risk and prevent loss from future natural hazard events.

The structure of the Plan enables the user to refer to specific sections of interest to him or her.

It also allows City government to review and update sections when new data become available. The ability to update individual sections of the Hazard Mitigation Plan places less of a financial burden on the City. Decision-makers can allocate funding and staff resources to selected pieces in need of review, thereby avoiding a full update, which can be costly and time-consuming. New data can be easily incorporated, resulting in a Local Hazards Mitigation Plan that remains current and relevant to the City of Newport Beach.

Newport Beach's Local Hazard Mitigation Plan is organized in three volumes. Volume I contains the Executive Summary followed by Sections 1 through 5: Introduction, Community Profile, Risk Assessment, Goals and Action Items, and Plan Maintenance. Sections 1 through 5 were modified the most during this 2014 update. Volume II contains the five natural hazard sections (Sections 6 through 10) and Volume III includes the appendices. Updates to these volumes include additions summarizing natural hazard events that impacted the southern California area and Newport Beach in the five-year period between 2008 and 2014, and changes or updates to the regulations issued by both the Federal and State governments aimed at reducing the impact of natural hazards. The Wildfire Hazards section in particular was updated significantly. Section 4 is completely new, presenting the action items that the City has prioritized for possible implementation during the five-year period between 2014 and 2019. The Public Participation section in Appendix B was completely re-done to describe the meetings, presentations and workshops conducted as part of this update. Each section of the Plan is described further below.

Volume I: Mitigation Action Plan

Executive Summary: Five-Year Action Plan

The Five-Year Action Plan provides an overview of the Hazard Mitigation Plan's mission, goals, and action items.

Section 1: Introduction

The Introduction describes the background and purpose of developing the Local Natural Hazard Mitigation Plan for the City of Newport Beach.

Section 2: Community Profile

This section presents the history, geography, demographics, and socioeconomics of the City of Newport Beach, with emphasis on the most recently available census data. This section serves as a tool to provide an historical perspective of natural hazards in the City, and a springboard to understand how natural hazards can impact the City in the future.

Section 3: Risk Assessment

This section provides information on hazard identification, vulnerability and risk associated with natural hazards in the City of Newport Beach.

Section 4: Multi-Hazard and Hazard-Specific Goals and Action Items

This section is the "Policy Document" that enumerates the specific action items that Newport Beach will undertake to further reduce its risk to the natural hazards described in Volume II of the document.

Section 5: Plan Maintenance

This section provides information on Plan implementation, monitoring and evaluation, and lists the action items and hazard-reduction activities completed by the City in the past five years (2008-2013).

Volume II: Hazard Specific Information

Hazard-specific information on five natural hazards is addressed in this Plan. Chronic hazards, such as flooding, occur with some regularity and may be forecast through historic evidence and scientific methods. Catastrophic hazards do not occur with the frequency of chronic hazards, but notwithstanding, they can have devastating impacts on life, property, and the environment. In Southern California, because of its geology and terrain, earthquakes, floods, wildfires, landslides and windstorms have the potential to be catastrophic as well as chronic hazards.

The hazards addressed in the Plan include:

Section 6: **Earthquakes** (including Ground Shaking, Fault Rupture, Liquefaction, and Earthquake-induced Landslides, and Loss Estimations as a result of several plausible earthquake scenarios)
Section 7: **Floods** (including Mudflows, Catastrophic Inundation due to Failure of Reservoirs, Coastal Flooding due to Storms, Tsunamis, Rogue Waves, and Sea Level Rise)
Section 8: **Wildfires** (and Fires After an Earthquake)
Section 9: **Landslides**
Section 10: **Windstorms** (including Santa Ana winds, Tornadoes, Macrobursts and Microbursts)

Each of the hazard-specific sections includes information on the history, hazard causes and characteristics, hazard and vulnerability assessment, risk analysis, and local, state, and national resources available to mitigate or reduce the impact of these hazards. Goals and action items aimed at reducing these hazards are provided in Section 4.

Volume III: Resources

The Plan appendices are designed to provide users of Newport Beach's Local Natural Hazards Mitigation Plan with additional information to assist them in understanding the contents of the Mitigation Plan, and potential resources to assist them with implementation.

Appendix A: Plan Resource Directory

This appendix provides a resource directory, which includes City, regional, State, and national resources and programs that may be of technical and/or financial assistance to the City of Newport Beach during Plan implementation.

Appendix B: Public Participation Process

This appendix includes specific information on the various public processes used during development of the 2014 Plan Update.

Appendix C: Benefit Cost Analysis

This appendix describes FEMA's requirements for benefit cost analysis in natural hazards mitigation, as well as various approaches for conducting economic analysis of proposed mitigation activities.

Appendix D: List of Acronyms

This appendix provides a list of acronyms for City, regional, state, and federal agencies and organizations that may be referred to within Newport Beach's Local Natural Hazards Mitigation Plan.

Appendix E: Glossary

This appendix provides a glossary of terms used throughout the Plan.

Appendix F: California Disasters

This appendix lists major California disasters since 1950. This list was updated to include events that occurred since 2008, and as of the writing of this document.

Appendix G: List of Dams

This appendix provides a list of major dams and reservoirs in Orange County, including new reservoirs that have been built since 2008.

Appendix H: Maps

This appendix contains the maps referenced throughout the Plan. All maps in the 2014 Update were revised to include areas incorporated by the City since 2008.

Appendix I: References

This appendix lists the references (plans, studies, technical reports and websites) used in the preparation of the Plan.

Appendix J: Plan Adoption

Documentation regarding the formal adoption of the 2008 Plan and 2014 Plan Update.

Changes from the 2008 Plan

Several sections of the 2014 Plan Update have been modified from the original 2008 Plan. Changes made to specific sections of the Plan are summarized further below.

Section 1: Summarizes the process by which the 2014 Plan was created, with emphasis on the review process and the opportunities provided for City Staff and the public to review and provide feedback on the document.

Section 2: The population and demographics sections were completely revised by the City's Community Development Department, Planning Division, to reflect the 2010 Census data findings, with modifications, as available, from U.S. Census Bureau 2012 estimates. All maps presented in the 2014 Update were modified to include those areas that were incorporated into the City since 2008.

Section 3: This section of the Plan was enhanced to identify in table format those natural hazards that the Advisory Committee agreed pose a potential hazard to the City, with rankings for probability of occurrence and potential level of risk. This section also identifies the critical facilities in the City and their vulnerability to the various natural hazards described in the Plan.

Section 4: The Action Items portion has been completely revised and updated to present the mitigation measures that the City has identified as current priorities in its effort to reduce its risk to natural hazards. The action items are classified into three groups as follows: 1) action items that are already being implemented on an on-going basis, as part of the development or re-development process; 2) action items to be implemented in the short-term, that is, the next 5-year cycle (2015-2019); and 3) long-term action items that the City is considering for implementation in the next approximately 10 years.

Section 5: This section was completely updated to discuss how the Plan will be maintained in the next 5 years, and how progress on natural hazard reduction efforts will be measured. This section also identifies those action items listed in the 2008 Plan that have already been completed.

Section 6: The Earthquake section was updated to describe the more recent earthquake events that impacted the Southern California area between 2008 and 2014, and to summarize the latest scientific findings regarding the faults offshore Newport Beach that could cause an earthquake in the area. The loss estimation section using HazUS was not updated from the 2008 report as the population figures between 2000 and 2010 did not change significantly.

Section 7: The Flood section was updated to describe the storms and tsunamis that resulted in localized flooding in the Orange County region between 2008 and 2014. The section also discusses in more detail the hazard of sea-level rise and its potential impact on the City. Finally, the risk analysis portion was expanded significantly to describe the critical facilities, essential facilities and infrastructure in Newport Beach that are vulnerable to the hazard of flooding, and activities being implemented by the City, County of Orange and other agencies to mitigate these hazards.

Section 8: The Wildfire section was updated significantly from the 2008 version. Significant wildfires that have occurred in the Southern California region between 2008 and 2014 were added. The regulatory context and Federal, State and local programs that have been developed to mitigate the hazard of wildfires are discussed extensively with an emphasis on how these programs apply to and are being implemented in Newport Beach.

Section 9: The text of the Landslides section were not modified significantly from the 2008 report, but the Slope Distribution Map (Map 9-2) and the Slope Instability Map (Map 9-3) were completely redone in response to comments from a resident with geotechnical background that requested these maps reflect the latest development in the City. As a result, the City provided us with a 2007 digital topographic map of Newport Beach that we processed and converted to a Digital Elevation Model (DEM). Slope gradients in the eastern portion of the City have changed substantially as a result of grading operations, which in turn has reduced the potential for slope instability in this area. The new maps reflect this.

Section 10: Significant windstorms, tornadoes and funnel clouds that have been reported in Orange County between 2008 and 2014 were added to the appropriate tables in this section.

All **Appendices** were updated as needed to reflect the most current information, with emphasis on changes made between 2008 and 2014.

SECTION 2: COMMUNITY PROFILE

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SECTION 2: COMMUNITY PROFILE

Past earthquakes, floods, wildfires, strong winds, and landslides have exposed Newport Beach's residents and businesses to the financial and emotional costs of recovery. These same natural hazards have the potential to pose a future negative impact on the citizens, property, environment, and economy of the City of Newport Beach. Furthermore, as more people move to areas vulnerable to these hazards, the risk associated with these natural hazards increases. Even in communities that are essentially "built-out" (i.e., have little or no vacant land remaining for development), population density often increases, either as a result of low-density housing being replaced by medium- to high-density development, or, as in Newport Beach, the result of residential development in new mixed-use areas. The increased population density can place more people at risk from the hazards that can impact the area.

Given that natural hazards are inevitable, and that populations in vulnerable areas are increasing in response to development pressures, there is a need to develop strategies, coordinate resources, and increase public awareness to reduce the risk and losses from future natural hazard events. Identifying the risks posed by natural hazards, and developing strategies to reduce the impact of a hazard event can assist in protecting life and property. In Newport Beach, local residents and businesses are working together with the City to create a natural hazards mitigation plan that addresses the potential natural hazards of most concern to Newport Beach. This document summarizes the efforts that the City has undertaken and plans to undertake in the future to reduce its vulnerability to natural hazards.

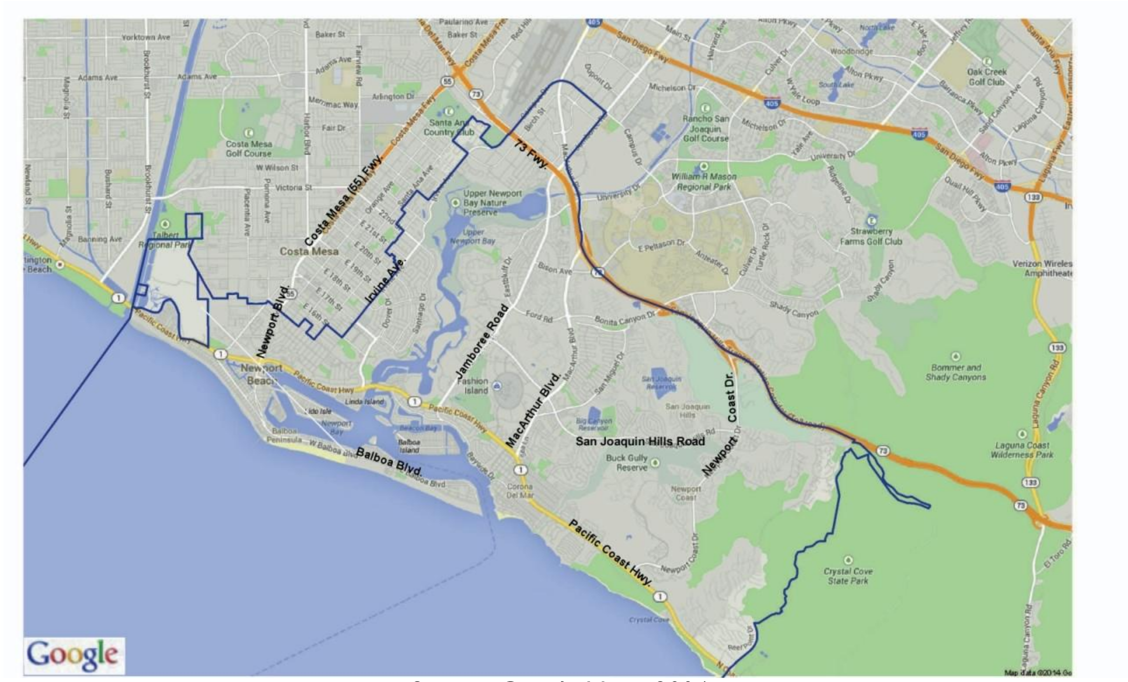
Geography and the Environment

The City of Newport Beach is located in Orange County, at the southwestern edge of the physiographic area known as the Los Angeles Basin. The City has a total area of approximately 15 square miles, with approximately 9.25 miles of shoreline along the Pacific Ocean, and nearly 35 miles of waterfront if one includes the shoreline, Newport Bay and the islands within City limits. Distinct topographic features separate the City into four specific areas: 1) the nearly flat-topped upland known as Newport Mesa, 2) the beaches, islands, sandbars, and mudflats that comprise Newport Bay, 3) the protective barrier beach known as Balboa Peninsula, and 4) the San Joaquin Hills, where the most recent large-scale developments in the area have occurred.

Newport Mesa ranges in elevation from about 50 to 75 feet above mean sea level in the Santa Ana Heights area, to about 100 feet above sea level in the Newport Heights, Westcliff, and Eastbluff areas. Elevation of the Balboa Peninsula and the harbor islands generally ranges from about 5 to 10 feet above mean sea level. The coastal platform occupied by Corona Del Mar is located at an elevation of about 95 to 100 feet above sea level, and the San Joaquin Hills rise to an elevation of 1,164 feet at Signal Peak.

The City is served by the 405, 55, and 73 freeways. Its major arterial roads include Coast Highway and San Joaquin Hills Road, which run generally east to west, and Superior Drive, Newport Boulevard, Dover Drive, Jamboree Road, MacArthur Boulevard, and Newport Coast Drive, which run primarily north to south (see Map 2-1). Passenger transportation is provided by the Orange County Transportation Authority (OCTA) bus lines and OCTA's ACCESS vans.

Map 2-1: Freeways and Major Arterial Roads in the Newport Beach Area



Source: Google Maps, 2014

Major Rivers

The two major drainages within the Newport Beach area are the Santa Ana River and the San Diego Creek Channel. At one time, the natural course of the Santa Ana River hugged the southwestern side of Newport Mesa, carving steep bluffs and feeding sediment into Newport Bay. However, in an attempt to reduce flooding on the costal plain, the river was confined to man-made levees and channels by the early 1920s. The Santa Ana River currently borders the western edge of the City where it empties into the Pacific Ocean.

San Diego Creek is the main tributary to Newport Bay. Its headwaters lie about 2.5 miles east of the Interstate 5 – Interstate 405 intersection, near the El Toro Memorial Park, at an elevation of about 500 feet. The creek flows westerly from its headwaters and empties into Newport Bay about ¾-mile west of the campus of the University of California at Irvine. Portions of San Diego Creek were channelized in 1968 for flood protection purposes. The channel collects water from numerous streams, including Peters Canyon Wash, Rattlesnake Wash, Hicks Canyon, Agua Chiñon, and Serrano Creek. The Bay also receives water from the Santa Ana Delhi Channel near Irvine Avenue and Mesa Drive.

The portion of the San Joaquin Hills that lies within the City is drained to the sea by several deep canyons, including Buck Gully, Los Trancos Canyon, and Muddy Canyon, as well as numerous smaller, unnamed canyons. Carrying significant amounts of water only during the winter, these streams flow directly into the Pacific Ocean. Drainage courses on the north side of the hills, including Bonita and Coyote Creeks, are tributaries of San Diego Creek.

Climate

Due to its coastal setting, the City of Newport Beach enjoys a mild, consistent climate with a yearly average maximum day temperature of about 68 degrees Fahrenheit (based on data between 1909 and 1996; Table 2-1). Average maximum day temperatures in the City generally range from a low of about 62 degrees in the winter month of January (the monthly mean of the maximum daily temperature) to a high of 73 degrees in August. Night temperatures are slightly lower, resulting in a 24-hour-average of 55 degrees for January, and 68.5 degrees for August (based on data collected between 1961 and 1990; Table 2-2). In the hilly areas of the City, away from the beach, higher temperatures can be reported, especially during periods of Santa Ana winds. These winds can bring low humidity and higher temperatures than those reported on Table 2-1.

Table 2-1: Average Maximum Temperature in Newport Beach (in °F) for the weather station in Newport Beach Harbor

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
°C	16.8	17.1	17.7	18.5	19.4	20.4	22.1	22.8	22.6	21.7	19.7	17.4	19.7
°F	62.2	62.8	63.9	65.3	66.9	68.7	71.8	73.0	72.7	71.1	67.5	63.3	67.5

Source: NEWPORT BEACH HARBOR, ORANGE COUNTY data derived from GHCH 2 Beta. 1005 months between 1909 and 1996. From http://www.worldclimate.com

Table 2-2: 24-Hour-Average Monthly Temperature in Newport Beach (in °F) for the weather station in Newport Beach Harbor

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
°C	12.8	13.3	13.6	14.8	16.2	17.7	19.5	20.3	19.8	18.2	15.3	13.0	16.2
°F	55.0	55.9	56.5	58.6	61.2	63.9	67.1	68.5	67.6	64.8	59.5	55.4	61.2

Source: NEWPORT BEACH HARBOR, ORANGE COUNTY data derived from NCDC TD 9641 Clim 81 1961-1990 Normals. 30 years between 1961 and 1990. From http://www.worldclimate.com

Rainfall in the City averages 11.9 inches of rain per year (based on the average of all records collected between 1931 and 1995; see Table 2-3), whereas about 14 inches of precipitation fall annually in Santa Ana. In general, areas closer to the coast receive a little less precipitation, on average, than inland areas. The term "average rainfall" is misleading, however, because over the recorded history of rainfall in Newport Beach, rainfall amounts have ranged from one-third the normal amount to more than double the normal amount. Furthermore, rainfall in Newport Beach, as in most of Southern California, tends to fall in large amounts during sporadic and often heavy storms rather than consistently in several moderate storms at somewhat regular intervals. In short, rainfall in Southern California might be characterized as "feast or famine" within a single year.

Table 2-3: Average Monthly Precipitation in Newport Beach, at Newport Beach Harbor (in inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	2.5	2.4	1.9	1.1	0.2	0.1	0.0	0.1	0.3	0.3	1.2	2.0	**11.9**

Data based on 59 complete years between 1931 and 1995.

Rocks and Soil

The properties of the soils and rocks underlying the City of Newport Beach determine to some extent the potential geologic hazards that may occur in the area, such as the susceptibility of an area to earthquake-induced liquefaction, expansive soils, and landslides. Therefore, understanding the geologic characteristics of the bedrock and soils of Newport Beach is an important step in hazard mitigation and avoiding at-risk development. The types and characteristics of the bedrock, unconsolidated sediments (weathered rock material), and soil that underlie the City also reflect the geologic and climatic processes that have affected this region over the past few million years.

Alluvial sediments of late Holocene age (less than about 11,000 years old) are present in the active and recently active stream channels throughout the City, in addition to the beach, marshland, and intertidal deposits of Newport Harbor and Upper Newport Bay. Newport Mesa is underlain primarily by shallow marine sediments ranging in age from early to late Pleistocene (less than about 1.6 million years old). East of Upper Newport Bay, these deposits are capped with a thin veneer of late Pleistocene to early Holocene alluvial fan sediments shed from the San Joaquin Hills. Where streams have deeply incised the mesa, Tertiary-age sedimentary bedrock, also of marine origin, is exposed beneath the younger deposits. Similar bedrock formations underlie the San Joaquin Hills. The geologic units that are exposed at the surface are shown on the Geologic Map (Map 2-2 and Plates H-18 and H-18a).

There are many deposits of man-made fill throughout the City, including most notably, the harbor islands, road and bridge embankments, and canyon fills associated with mass-graded hillside developments. These deposits vary widely in size, age, and composition, and although some are significantly large and thick, due to the map scale they are not shown on the Geologic Map.

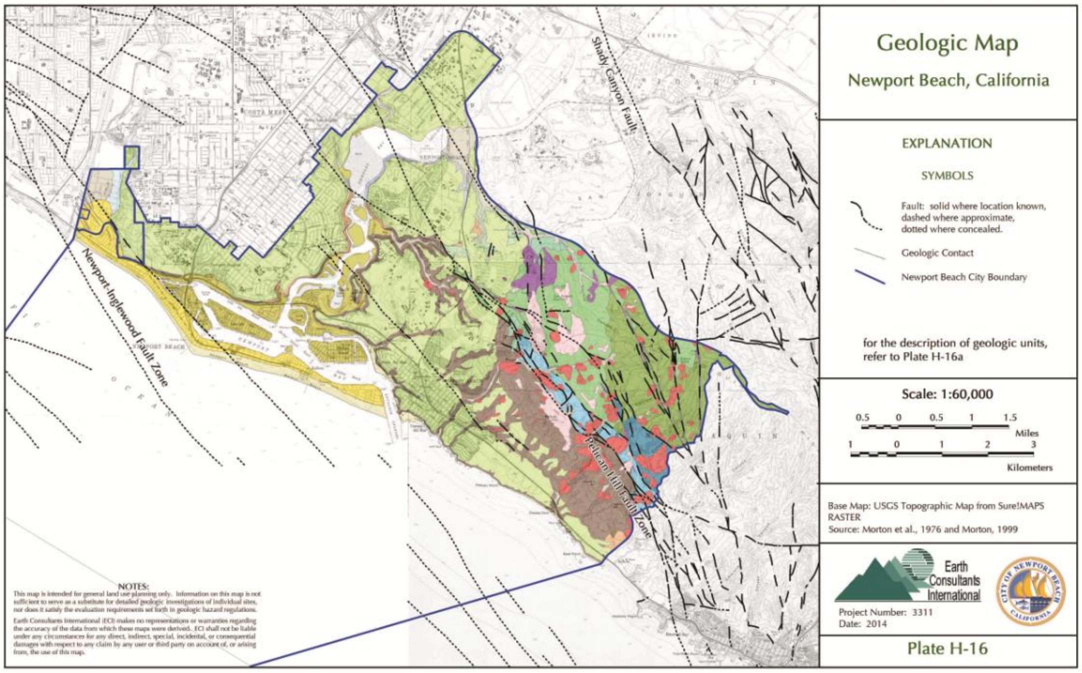
Other Significant Geologic Features

The City of Newport Beach lies in the Peninsular Ranges, a geologic/geomorphic province characterized by a northwest-trending structural grain aligned with the San Andreas fault, and represented by a series of northwest-trending faults, mountain ranges and valleys stretching from Los Angeles County to the Mexican border. Displacements on faults in this region are mainly of the strike-slip type, and where they have been most recently active, they have deformed the landscape and altered drainage patterns. An example of such faulting in the Newport Beach area is the Newport-Inglewood fault zone, which trends southeasterly across the Los Angeles Basin, leaving the coastline at the northwestern corner of Newport Beach, and continuing offshore to the south. Predominantly right-lateral in movement, the Newport-Inglewood fault is responsible for uplifting the chain of low hills and mesas that extends from Beverly Hills to Newport Beach across the relatively flat coastal plain. The location and structure of the fault zone is known primarily from a compilation of surface mapping and deep, subsurface data, driven initially by an interest in oil exploration (all of the hills and mesas, including Newport Mesa, have yielded petroleum), and later by a shift toward evaluating earthquake hazards. The fault is an active structure and was the source of the 1933 M6.4 Long Beach earthquake. Despite the name, this earthquake was actually centered closer to Newport Beach, near the mouth of the Santa Ana River (Hauksson and Gross, 1991) (see Section 6).

The San Joaquin Hills are the westernmost range in the Peninsular Ranges province. The hills are structurally complex, consisting of tilted fault blocks, and numerous north and northwest-trending Tertiary- and Quaternary-age faults. Within the hills, the major structural feature is the Pelican Hill fault zone, which trends northwesterly from Emerald Bay to the Big Canyon area. The fault zone is several hundred feet wide, and has left the adjacent bedrock in a highly sheared, folded, and fractured condition (Munro, 1992; Barrie et al., 1992). The Pelican Hill fault, as well as the other faults exposed in the hills, has largely been determined to be inactive during Holocene time (Clark et al., 1986).

In recent years, scientists have discovered that the northern end of the province, primarily the Los Angeles metropolitan area, is underlain by a series of deep-seated, low-angle thrust faults. When these faults do not reach the surface, they are called "blind thrusts." Faults of this type are thought to be responsible for the uplift of many of the low hills in the Los Angeles Basin, such as the Repetto or Montebello Hills. Previously undetected blind thrust faults were responsible for the M5.9 Whittier Narrows earthquake in 1987, and the destructive M6.7 Northridge earthquake in 1994.

Map 2-2: Geologic Map of Newport Beach, California
(for a larger scale of this map and a description of the units, refer to Plates H-16 and H-16a, respectively, in Appendix H)

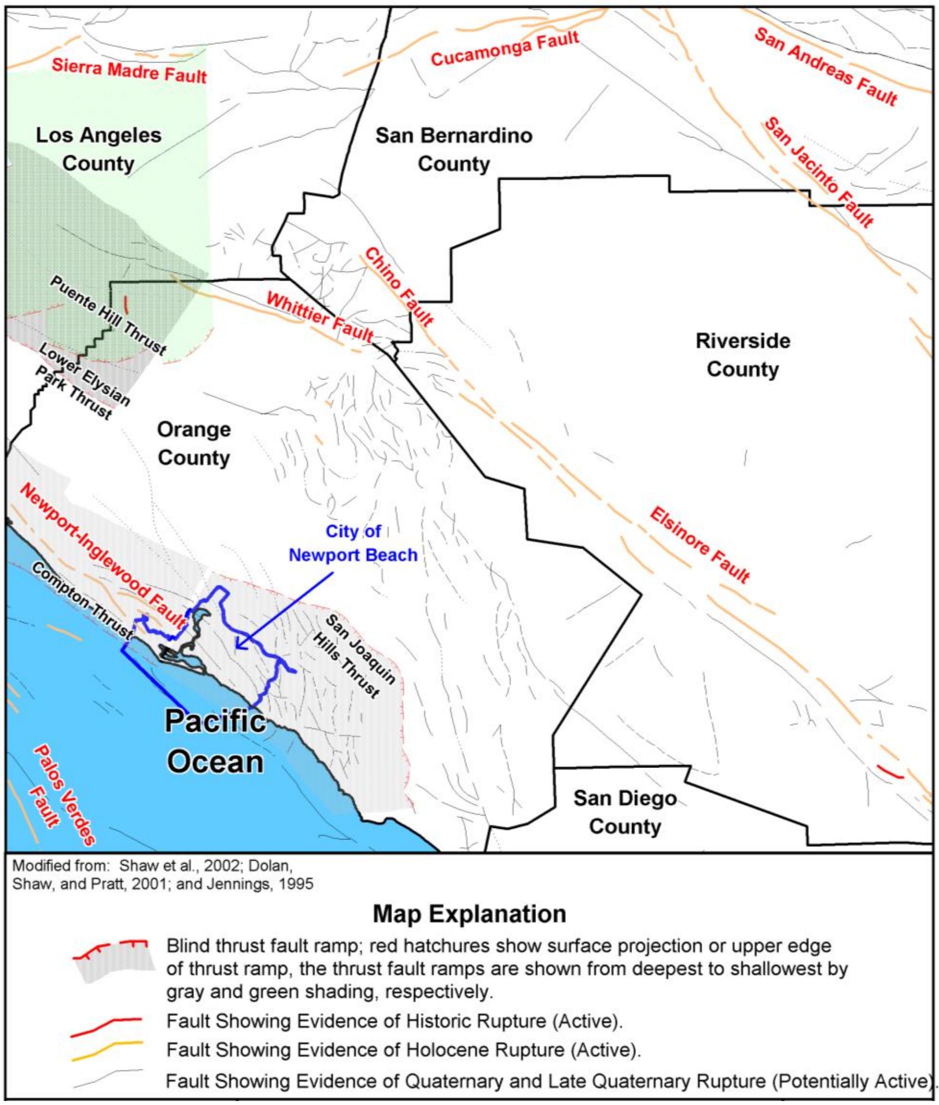


It has long been recognized that the San Joaquin Hills are part of a northwest-trending anticline (a convex fold) that extends from San Juan Capistrano to the Huntington Mesa (Vedder et al., 1957; Vedder, 1975). Recent research suggests that the anticline, which includes the Newport and Huntington Mesas as well as the San Joaquin Hills, is part of a structure that is being uplifted by an active blind thrust fault that dips southward beneath the area (Grant et al., 1999). The growth of the San Joaquin Hills has been recorded in remnants of marine terraces of various ages that cap the northern and western slopes. These terraces consist of wave-eroded, sediment-covered platforms (similar to the one present at the base of the hills today) that have been uplifted as the hills rose above sea level. Based on measurements of terrace elevations and dating of the sediments, uplift of the hills started approximately 1.2 million years ago, and is thought to have continued through the Holocene at a rate of about 0.25 meters per 1,000 years (Barrie et al., 1992; Grant et al., 1999). Recognition of the San Joaquin Hills thrust fault extends the area of active blind thrust faulting and associated folding southward from Los Angeles into the Newport Beach area, and possibly southward and westward (Grant et al., 1999; Rivero et al., 2000; Rivero and Shaw, 2011).

The Los Angeles Basin experiences many small tremors every year, but its history has been shaped by several relatively infrequent, but powerful earthquakes. The first historical earthquake was recorded in 1769, when the Portolá expedition was camped next to the Santa Ana River in what is now the Olive community in the City of Orange, but earthquakes undoubtedly have shaken the area for millennia. Other more recent earthquakes were recorded in 1812, 1857, 1933 (Long Beach), 1987 (Whittier), and 1994 (Northridge). The 1857

Fort Tejon event was a large, magnitude 8+ earthquake on the San Andreas fault that caused only minor damage because the epicentral area was largely unpopulated. A similar-sized earthquake today would result in thousands of casualties and billions of dollars in property loss. Given that paleoseismological research indicates that great earthquakes (i.e., M8+) occur on the San Andreas fault at intervals between 45 and 332 years, with an average interval of 140 years, another similar M8 earthquake on the San Andreas fault is considered likely in the not-too-distant future. This fact alone should encourage local governments to strengthen their infrastructure and prepare for "the Big One." Furthermore, as we will discuss in this document, there are other lesser-known faults closer to Newport Beach that have the potential to cause more damage to the City than the more distant San Andreas fault. The earthquake hazard to the Los Angeles basin and the cities therein is severe.

Map 2-3: Regional Active and Potentially Active Faults near Newport Beach



In addition, many areas in the region, including portions of the City of Newport Beach, have sandy soils that are subject to liquefaction. The liquefaction-susceptible zones in the City of Newport Beach are shown on Plate H-4 (Appendix H). These zones include the youthful sandy sediments along the beach, the Balboa Peninsula and West Newport, and the area surrounding

Newport Bay. Some of the larger canyons in the City are also underlain by sediments susceptible to liquefaction.

The City of Newport Beach also has areas of slope instability potential. Evidence of past slope failures are found throughout the San Joaquin Hills. The San Joaquin Hills contain numerous landslides or suspected landslides composed of highly fragmented, jumbled bedrock debris as well as largely coherent bedrock blocks. Landslides are typically identified by their distinctive morphology, which most often includes a steep, arcuate headscarp, undulating or relatively flat-topped head, and a blocked or diverted drainage at the toe. Most of the slides appear to be rotational failures, occurring in steep natural slopes composed of bedrock weakened by the intense fracturing, shearing and folding in or near the Pelican Hill fault zone. Some of the slides may be block glides associated with the failure of unsupported weak bedding planes. The larger slides are probably more than a hundred feet thick.

Landslide materials are commonly porous and very weathered in the upper portions and along the margins. They may also have open fractures and joints. The head of the slide may have a graben (pull-apart area) that has been filled with soil, bedrock blocks and fragments. Some of these slides have been reactivated in the late Holocene and pose a significant hazard to development. The larger of these landslides are shown in red on Plate H-18 (in Appendix H).

Historical Setting

The first known inhabitants of the Newport Beach area were native Americans from the Tongva, Juaneño and Luiseño nations. These groups occupied the area for thousands of years, taking advantage of the food supplies provided by both the coastal and littoral/back bay environments found in what is today Newport Beach. Europeans first sighted the California coastline in 1542, when Juan Cabrillo sailed past Southern California. The first land expedition by Europeans into what is now Orange County was led by Gaspar de Portolá in 1769. Many of the officers of the Spanish Army that accompanied Portola's expedition were given permission to settle these lands, with land titles awarded to them by the Spanish King for their years of service. Don Jose Antonio Yorba received title to more than 62,500 acres of land in 1801; his ranch included the lands now occupied by the community of Olive, and the cities of Orange, Villa Park, Santa Ana, Tustin, Costa Mesa and Newport Beach.

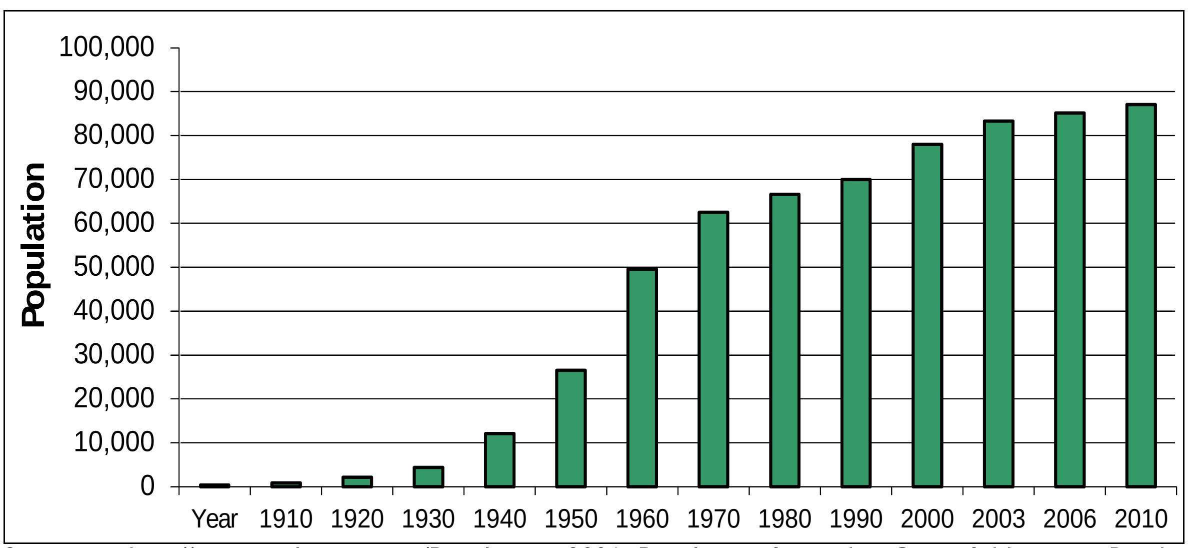
When Mr. Yorba took possession of this property, the Santa Ana River flowed out to sea through Alamitos Bay, near the present-day boundary between Los Angeles and Orange counties. In 1825, however, severe storms caused extensive flooding in the area, and the Santa Ana River resumed its ancient course through the Santa Ana Gap and around the toe of Newport Mesa. The down-coast littoral drift, plus continuing floods, caused the river to build what is today known as the Balboa Peninsula. During the floods of 1861-62, the river mouth swept farther to the southeast, to the rock bluffs that form the east side of the present channel entrance. For the next several decades, and until 1919, the river outlet to the sea continued to migrate back and forth from the rock bluffs to a point about 2,000 feet up-coast from the present channel entrance. Then, in 1919, a year after another serious flood, local interests built a dam at Bitter Point (near present-day 57th Street and Seashore Drive) to stop the flow into Newport Bay, and cut a new outlet for the Santa Ana River, where it has remained to date.

Local citizens' interest in developing a harbor reportedly date back to the 1870s, when Captain Samuel S. Dunnells guided a ship called the "Vaquero" into what was then an unnamed harbor that became known as the "New Port." Up to then, the bay had been considered too treacherous for ships, but arrival of the "Vaquero" proved differently. By this time, the Newport Beach area belonged to the McFadden brothers, James and Robert. In 1879, the brothers established a commercial trade and shipping business at Newport Landing that they operated successfully for 15 years. Then, in the late 1880s, the brothers built a large ocean pier near McFadden Square (the Newport Pier) and moved their entire business to the wharf. The wharf soon became the largest business in the newly created County of Orange, especially after completion of the Santa Ana – Newport Railroad (later the Southern Pacific Railroad) in 1891. Residential development of the area began at the turn of the century, first around the wharf, and then along the peninsula. Soils dredged from the bay to widen and deepen the channels were used to construct Balboa Island, Lido Isle, and the other islands in the bay. As soon as Balboa Island and Lido Isle were constructed, they were subdivided into lots. West Newport, Balboa, Balboa Island and Corona del Mar were subdivided between 1903 and 1907, and in 1906, the City of Newport Beach, consisting of West Newport and the Balboa Peninsula, was incorporated. Balboa Island was annexed in 1916, and Corona del Mar in 1923.

Population and Demographics

According to the 2010 Census data, in the year 2010, the City of Newport Beach had a population of 85,186. By 2012, the U.S. Census Bureau estimates the City had grown to 87,068. The City's population has steadily increased since 1910, with a sharp increase between 1940 and 1950, when the population tripled, and between 1950 and 1970, when the population doubled every decade (see Table 2-4 below). The City's growth rate slowed to about 6.5 percent from 1980 to 1990, and 5 percent between 1990 and 2000, but between 2000 and 2010, the population in Newport Beach increased at a rate of more than 24 percent. A substantial portion of this growth occurred in response to the recently developed areas in the San Joaquin Hills. Although much growth has occurred in the areas of the City away from the coast, its population is concentrated along the beach, in the Balboa Peninsula, West Newport and Corona del Mar, and in the tracts surrounding Newport Bay. Some of the population growth is also the result of infilling in the older communities, where mixed-use projects have sprung. In the year 2010, the population density in Newport Beach was estimated at 3,579 people per square mile, about one quarter the population density of San Francisco.

Table 2-4: Population Growth Through Time in Newport Beach



Sources: http://www.ocalmanac.com/Population; 2006 Population from the City of Newport Beach; http://quickfacts.census.gov/qfd/states/06/0651182.html.

An increase in population creates more community exposure in the face of natural hazards, and changes how agencies prepare for and respond to natural hazards. For example, more people living at the wildland/urban interface, such as in the San Joaquin Hills, can increase the risk of wildland fire. This increased potential for wildfires results from the fact that most fires are caused by human activities, and as there are more people living and playing in the interface, there are more opportunities for fires to get started. At the same time, a larger number of people at the wildland/urban interface means that a larger population is exposed to and can therefore be injured by fire, and there is also an increased potential for property damage. As a result, the City of Newport Beach has developed and implemented a series of mitigation measures designed to reduce the potential for wildland fire. Similarly, given that many people live and play in the low-lying areas of the City that are susceptible to inundation in the event of a tsunami, Newport Beach has taken a proactive approach, marking tsunami evacuation routes, and educating its residents on what to do in the event of an earthquake. These hazards and mitigation programs are discussed in more detail in other sections of this document.

Urban/wildland fires are not the only concern in Newport Beach. In the 1987 publication, "Fire Following Earthquake" issued by the All Industry Research Advisory Council, Charles Scawthorn explains how a post-earthquake urban conflagration would develop. The conflagration would be started by fires resulting from earthquake damage, but made much worse by the loss of pressure in the fire mains, caused by either lack of electricity to power water pumps, and/or loss of water pressure resulting from broken water mains. Furthermore, increased density can affect risk. High-density housing increases the chances of fire spreading from one structure to the next. Also, narrow streets in residential areas (and in the hillside areas) are more difficult for emergency service vehicles to navigate, and the higher ratio of residents to emergency responders affects response times.

Natural hazards do not discriminate, but the impacts in terms of vulnerability and the ability to recover vary greatly among the population. According to Peggy Stahl of FEMA's Preparedness, Training, and Exercise Directorate, 80 percent of the disaster burden falls on the public, and a disproportionate percentage of the burden is placed upon special-needs groups, including the elderly, women, children, minorities, and the poor. As the events associated with the hurricane Katrina in the Gulf Coast showed, vulnerable populations, including seniors, disabled citizens, women, and children, as well as those people living in poverty, are often disproportionately impacted by natural hazards.

The cost of natural hazards recovery can also place an unequal financial responsibility on the general population when only a small proportion may benefit from governmental funds used to rebuild private structures. Discussions about natural hazards that include local citizen groups, insurance companies, and other public and private sector organizations can help ensure that all members of the population are a part of the decision-making processes.

Land and Development

In the earliest days, development in Southern California was a cycle of boom and bust. The Second World War, however, dramatically changed that cycle. Military personnel and defense workers came to Southern California to fill the logistical needs created by the war effort. The available housing was rapidly exhausted and existing commercial centers proved inadequate for the influx of people. Immediately after the war, construction began on the freeway system, and the face of Southern California was forever changed. Home developments and shopping centers sprung up everywhere, and within a few decades the Los Angeles Basin, including the northern portion of Orange County was virtually built out. This pushed new development farther and farther away from the urban center. The largest growth period in the history of Newport Beach indeed occurred in the decade between 1940 and 1950, as discussed previously, when the

City's population tripled. More recently, with the development of planned residential communities in the San Joaquin Hills area, the City has again seen a rapid increase in population.

Newport Beach's General Plan addresses the use and development of private land, including residential and commercial areas. This plan is one of the City's most important tools in addressing environmental challenges, including transportation and air quality, growth management, and the conservation of natural resources such as clean water and open spaces. However, the environment of most cities in Southern California is nearly identical with that of their immediate neighbors and the transition from one incorporated municipality to another is often seamless to most people. This means that many of the environmental challenges listed above need to be addressed on a regional scale, rather than on a city-by-city basis, to effect change. Similarly, the area's exposure to natural hazards is similar to that of several neighboring communities, but a city's response to that vulnerability can often be addressed independently. For example, liquefaction susceptible sediments underlie large portions of the Santa Ana River floodplain, oblivious to corporate boundaries. However, a city can choose to implement more strict building codes to study and mitigate the hazard posed by liquefaction, or even restrict development in the most highly susceptible areas, thereby reducing its risk to a level below that of adjoining municipalities with a similar susceptibility but less stringent development codes.

Housing and Community Development

Housing stock is in many direct and indirect ways one of the most important commodities in a city. If a natural disaster, such as an earthquake, flood or landslide, damages several houses, this has a significant impact not only on the residents of those structures, but on the city also. An extreme, but real example of this is New Orleans; more than two years after Hurricane Katrina, entire neighborhoods were vacant, the houses still in ruins. Many past residents of these communities started new lives in other cities and states and have not come back. In 2013, there were 120,000 less people in New Orleans than in 2005, substantially diminishing New Orleans' tax base. The city is rebuilding and recovering, but it has taken time.

In the year 2000, the median value of homes in the City of Newport Beach was estimated at $708,200, whereas in 2010, the median home price in Newport Beach was estimated at $1 million. According to the U.S. Census Bureau, in the year 2010, there were 44,193 total housing units in the City of Newport Beach, of which 38,751 were occupied (2,841 of these are used occasionally, for seasonal or recreation use). Of the total housing units in 2010, 27,123 (62.1 percent) were single-family homes (1-unit, detached and attached), and 15,685 (35.9 percent) were duplexes, condominiums and apartments (2 or more units). There were approximately 792 (1.8 percent) mobile homes in the City. Sixty-four (64) percent of these housing units were built before the 1980s, before the more recent (and stringent) building and fire codes for public safety were adopted.

Subtle but very measurable changes that can result in an increase in potential loss during a major disaster are occurring constantly in our communities. First, populations are increasing, putting more people at risk within a defined geographic space. Second, inflation constantly increases the worth of real property and permanent improvements. Third, the amount of property owned per capita has increased over time. Information from the U.S. Census Bureau shows gains in average housing standards in the United States over time. The data show that the average size of new homes has continued to increase. The percentage of new houses with large numbers of bedrooms and bathrooms had decreased slightly between 2008 and 2011, but rose again in 2012 (Table 2-7).

Table 2-5: Historical Trends in Housing Standards in the United States

Property per Person	United States			
	1970	1990	2005	2012
Average size of new homes (in square feet)	1,500.	2,080	2,434	2,505
Homes with 4+ bedrooms	24%	2%	39%	41%
Homes with 2½ or more baths	16%	45%	59%	61%

Source: Housing Facts, Figures and Trends: National Association of Home Builders, Public Affairs and National Association of Home Builders Economics, May 2007; Characteristics of New Single-Family Houses Completed, https://www.census.gov/construction/chars/completed.html

If we look at the greatest recorded earthquakes in American history, and compare the level of population and development today with that which existed at the time of these events, the scale of potential damage is staggering (Source: Risk Management Solutions).

- 1886 Charleston, South Carolina M7.3 earthquake. Estimated insured damage if it happened today: $10 Billion.
- 1906 San Francisco earthquake, significant fire following seismic damage. Estimated insured damage if it happened today: $36 Billion.
- 1811-12 New Madrid, Missouri earthquakes, series of 4 earthquakes over 7 weeks. Estimated insured damage if this happened today: $88 Billion.

Employment and Industry

Since the late 1880s, when the McFadden brothers built the Newport Pier and moved their business interests to the wharf, Newport Beach has had a strong financial presence in the area. Traditionally, Newport Beach has been strong in retail, wholesale trade, professional services, and real estate. Other employment and industrial activities with a strong presence in Newport Beach include the service industries, manufacturing, entertainment, and tourism. In 2010, Newport Beach provided about 43,761 jobs; the professional, scientific, management and administrative services sectors combined accounted for the largest percentage (19.7%), followed by education and health-related services (16.9%). Finance, insurance, and real estate services accounted for the third largest percentage (15.7%), followed by retail trade (10.7%), manufacturing (9.9%); art, entertainment, accommodation and food services (8.7%); and construction (4.5%). Occupations of persons 16 years and older, per the 2010 Census, were apportioned as listed in Table 2-8.

Mitigation activities are needed at the business level to ensure the safety and welfare of workers and limit damage to industrial infrastructure. Employees are highly mobile, commuting from surrounding areas to retail, office, and industrial centers. This creates a greater dependency on roads, communications, accessibility and emergency plans to reunite people with their families. Before a natural hazard event, large and small businesses can develop strategies to prepare for natural hazards, respond efficiently, and prevent loss of life and property.

Table 2-6: Employment in Newport Beach by Industry

Employment by Industry	Percent
Agriculture, forestry, fishing and hunting, and mining	0.3
Construction	4.5
Manufacturing	9.9
Wholesale trade	4.3
Retail trade	10.7
Transportation and warehousing, and utilities	1.9
Information	2.4
Finance, insurance, real estate, and rental and leasing	15.7
Professional, scientific, management, administrative and waste mgt.	19.7
Educational, health care and social assistance	16.9
Arts, entertainment, recreation, accommodation and food services	8.7
Other services (except public administration)	3.0
Public administration	1.9

Source: U.S. Census Bureau, 2010 American Community Survey

One of the largest employers in the City is Hoag Memorial Hospital, with over 1,000 physicians on staff, and more than 4,000 employees. Hoag Memorial Hospital Presbyterian is a not-for-profit, acute care hospital. Its campus consists of two hospital towers (West Tower and the Sue & Bill Gross Women's Pavilion), the Hoag Heart and Vascular Institute, the Hoag Cancer Center, an ambulatory surgery center (James Irvine Surgical Center), a childcare center and conference center. Fully accredited by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and designated as a Magnet hospital by the American Nurses Credentialing Center (ANCC), Hoag offers a comprehensive mix of health care services, including Centers of Excellence in cancer, heart and vascular, neurosciences, orthopedics and women's health services. Additional information regarding Hoag Memorial Hospital is provided in Section 6. Hoag Memorial Hospital was an active participant in the development of the City of Newport Beach Disaster Mitigation Plan.

Transportation and Commuting Patterns

Private automobiles are the dominant means of transportation in Southern California and in the City of Newport Beach, where 81.6 percent of workers 16 years old and over commute to work by car, truck or van that they drive themselves (2010 Census data). Only 3.9 percent of the work force carpools, less than 1 percent use public transportation, and 2.0 percent walk to work. 9.5 percent of the workers in the City work from home.

Public transportation in Newport Beach is provided by the OCTA through an established network of bus routes that link residential areas with employment centers, shopping and recreational areas. There are also paratransit programs, such as the one provided by the Oasis Senior Center and/or OCTA, which provide local transportation to seniors for a nominal fee. The City promotes alternative transportation activities, including bicycle trails, and pedestrian corridors. Equestrian trails are present locally in the Santa Ana Heights area, but these are used solely for recreational purposes, and not for transportation.

Newport Beach has included a mobility plan in its General Plan. The City benefits from a diverse transportation system that includes transit, bicycle, and pedestrian links, as well as vehicular links. The City's local system connects with the larger regional system, and the operation of the two systems is interdependent. The mobility plan establishes how the City manages the local system to provide for the safe and convenient movement of people and goods. It also addresses how the City influences and manages connections with the regional transportation system. Of significant importance is the effective operation of this system especially in the summer, when there is substantially increased traffic in and through the City due to the significant seasonal increase in visitors and population (the City's summer population increases to more than 200,000).

The vision of the mobility plan is to promote an overall transportation system that facilitates the movement of people and goods within and through the City of Newport Beach and accommodates conservative growth within the City.

SECTION 3: RISK ASSESSMENT

What is a Risk Assessment?

Risk assessment is the process of estimating or calculating the potential losses (in terms of life, injuries, and property and economic damage) resulting from a hazard event. To conduct this analysis, it is necessary to identify and understand the hazards that can impact the community (hazard identification and hazard profiling), assess the vulnerability of the people, buildings and infrastructure that can be impacted by each hazard identified (vulnerability assessment and asset inventory), and estimate the potential losses (risk analysis). Each of these tasks or steps in the process, as it pertains to the city of Newport Beach, is described further below:

Hazard Identification

This is the description of the geographic extent, potential intensity and the probability of occurrence of a given hazard. Maps are frequently used to display hazard identification data. The city of Newport Beach and its residents and visitors can be impacted by earthquakes (and secondary hazards triggered by earthquakes, including fault rupture, liquefaction, tsunami and seiche, slope failures, dam and water reservoir failures, accidental releases of hazardous materials and after-earthquake fires), flooding (due to storms, tsunami and sea level rise), wildfires, slope failures, and strong winds (such as Santa Anas and tornadoes).

Man-made hazards that could impact the area include urban fires, terrorist attacks using weapons of mass destruction, accidental releases of hazardous materials, aviation accidents, and civil unrest events. At this time, and for this document, the City has chosen to address only natural hazards, and specifically the hazards of earthquakes, floods, wildfires, slope failures and strong winds. These are the natural hazards with the potential to cause the most damage, in terms of losses, at the city. Each of these hazards is described in detail in the following sections. The geographic impact that each of these identified hazards may pose on Newport Beach is identified where possible, although several of the hazards have a regional extent that exceeds the boundaries of the city. Maps that show the estimated geographic reach of these hazards in the city of Newport Beach are an important component of this document. These maps are included within the section that describes the hazard being considered (Section 6: Earthquakes; Section 7: Floods; Section 8: Wildfires; Section 9: Landslides), and all together in Appendix H (see list of maps in Table 3-1 below). There are no city-specific maps provided in Section 10: Windstorms, because the entire region is susceptible to strong winds, and there is not one specific area in the city more likely to be impacted by this hazard.

Table 3-1: List of Maps that are Part of this Plan

Map / Plate	Map Title	Section of the Plan
2-1	Freeways and Major Arterial Roads in the Newport Beach Area	Section 2
2-2 / H-16	Geologic map of Newport Beach, California	Section 2
2-3	Regional Active and Potentially Active Faults Near Newport Beach	Section 2
3-1 / H-1	Essential Facilities In Newport Beach, California	Section 3
6-1	Faults In and Near Newport Beach	Section 6
6-2A 6-2B	Ground Shaking Zones in California Ground Shaking Zones in Orange County and Surrounding Areas	Section 6
6-3 / H-2	Historical Seismicity in Newport Beach (1855- March 2014)	Section 6
6-4 / H-3	Faults Mapped in the Newport Beach Area	Section 6
6-5	Intensity Map for a Magnitude 6.6 Earthquake Scenario on the San Joaquin Hills	Section 6

Map / Plate	Map Title	Section of the Plan
	Fault	
6-6	Intensity Map for a Magnitude 6.8 Earthquake Scenario on the Whittier Fault	Section 6
6-7	Intensity Map for a Magnitude 7.8 Earthquake Scenario on the San Andreas Fault (Repeat of the 1857 Fort Tejon Earthquake)	Section 6
6-8 / H-4	Seismic Hazards in Newport Beach	Section 6
6-9	Census Tracts Used in the HazUS Analysis (in red) Compared to the City Boundaries (in blue)	Section 6
6-10 / H-1	Essential Facilities in Newport Beach (in 2014)	Section 6
6-11 / H-5	Damage Distribution to Residential Structures as a Result of Four Earthquake Scenarios	Section 6
6-12 / H-6	Damage Distribution to Commercial Structures as a Result of Four Earthquake Scenarios	Section 6
7-1	Shaded Relief Map Showing General Drainage Areas Within the City of Newport Beach	Section 7
7-2	Map Showing the Course of the Santa Ana River and Location of Newport Beach, Huntington Beach, Prado Dam, and the San Bernardino Mountains	Section 7
7-3 / H-7	Geomorphic Map of Newport Beach Showing the Canyons Draining the San Joaquin Hills and Low-Lying Areas in the City	Section 7
7-4	Location Map Showing the San Diego Creek Watershed	Section 7
7-5	Wave Exposure Map for Newport Beach	Section 7
7-6 / H-8	FEMA Flood Zones Map for Newport Beach	Section 7
7-7 / H-10	Tsunami Inundation Map at Mean Sea Level and Mean Higher High Water Level	Section 7
7-8 / H-11	Tsunami Runup Inundation Caused by a Potential Submarine Landslide	Section 7
7-9 / H-9	Dam Failure Inundation Map	Section 7
8-1 / H-12	Historical Wildfires in the Newport Beach Area	Section 8
8-2 / H-13	Wildfire Hazard Map for Newport Beach Showing Local and State Responsibility Areas	Section 8
8-3 / H-14	Areas with Vegetation Management Requirements in Newport Beach	Section 8
9-1 / H-16	Geologic Map of Newport Beach The red zones show areas still undeveloped where landslides have been mapped. Previously mapped landslides in now-graded areas are shown in purple. (for an explanation of the geologic units refer to Plate H-16a)	Section 9
9-2 / H-18	Slope Distribution Map of Newport Beach	Section 9
9-3 / H-19	Slope Instability Map of Newport Beach Red zones are mapped landslides in still mostly undeveloped land; purple and green zones are previously mapped landslides in or near now-graded areas, respectively; orange zones have a very high instability rating, yellow areas have a high slope instability rating.	Section 9
H-17	Engineering Materials Map of Newport Beach	Appendix H

Note: These maps were derived from publicly available sources. Care was taken in the creation of these maps, but the maps are provided "as is." The City of Newport Beach and its consultant cannot accept any responsibility for errors, omissions or positional accuracy, and therefore, there are no warranties that accompany these maps. Although information from land surveys may have been used in the creation of these maps, this does not mean that the maps represent or constitute a land survey. Users are cautioned to field verify the information on these products before making any decisions.

Profiling Hazard Events

This process describes the causes and characteristics of each hazard, how these hazards have affected the city of Newport Beach in the past, and what parts of Newport Beach (and its population, infrastructure, and environment) have historically been vulnerable to each specific hazard. A profile of each hazard discussed in this Plan is provided in Sections 6 through 10, with specific historical events known to have impacted the community highlighted where possible. Refer to the appropriate section of the report for these historical descriptions of past hazard events. .

Vulnerability Assessment/Inventorying Assets

This is a combination of hazard identification with an inventory of the existing property development(s) and population(s) exposed to a hazard. The city of Newport Beach is mostly built out. New development can be anticipated in the Newport Coast area, with infill or replacement of existing structures anticipated in the older portions of the City. Re-development will provide an opportunity to build more seismically resistant structures, potentially with green components that make better use of existing natural resources, and that incorporate new technologies that make buildings more earthquake and fire resistant.

During the vulnerability assessment it is especially important to assess the expected performance of critical facilities. Critical facilities provide essential products and services to the general public that are necessary to preserve the welfare and quality of life, and fulfill important public safety, emergency response, and/or disaster recovery functions (additional information on critical facilities is provided in a subsection below). The critical facilities in Newport Beach have been identified and their locations are shown on Map 3-1 and Plate H-1 (Appendix H).

It is important to realize that in the urban setting that defines Newport Beach and the surrounding communities, a large-scale disaster, such as an earthquake or flood, will not be confined to corporate boundaries. Differences in the magnitude of the disaster, however, will be defined in great part by how each city in the impact area has prepared for, responds to, and recovers from the event. Thus, having a detailed plan in place that addresses the specific vulnerabilities of the city, and provides mitigation measures that are implemented to reduce the hazard to critical facilities and other public and private properties can make the community significantly more disaster-resistant. That is the main goal of this Plan.

Risk Analysis

The purpose of this task is to estimate the potential losses in a geographic area over a given period of time by assessing the damage, injuries, and financial costs likely to be sustained. This level of analysis involves using mathematical models. The two measurable components of risk analysis are: 1) magnitude of the harm that may result, and 2) the likelihood (probability) of the harm occurring. Describing vulnerability in terms of dollar losses provides the community and the State with a common framework by which to measure the potential effects of a given hazard on the assets in the area.

Assessing Vulnerability/ Analyzing Development Trends

This task provides a general description of land uses and development trends within the community so that mitigation options can be considered in land use planning and future land use decisions. This Plan provides comprehensive description of the character of Newport Beach in the Community Profile section (see Section 2). This description includes the geography and environment, population and demographics, land use and development, housing and community development, employment and industry, and transportation and commuting patterns. Analyzing these components of Newport Beach can help to identify potential problem areas, and can serve as a guide for incorporating the goals and ideas contained in this Mitigation Plan into other community development plans.

Hazard assessments are subject to the availability of hazard-specific data. Gathering data for a hazard assessment requires a commitment of resources on the part of the community being analyzed, in addition to participating organizations and agencies. Each hazard-specific section of the Plan includes a section on hazard identification using data and information obtained from City, County or State agency sources.

A loss estimate for the city of Newport Beach was conducted for the hazard of earthquakes (see Section 6). Four earthquake scenarios were considered. These estimates were done using HazUS, a standardized methodology for earthquake loss estimation based on a geographic information system (GIS). HazUS was created as a project of the National Institute of Building Sciences, funded by the Federal Emergency Management Agency (FEMA), and it is based on guidelines and procedures developed to make standardized loss estimates at a regional scale (allowing estimates to be compared from region to region). HazUS is designed for use by State, regional and local governments in planning for loss mitigation, emergency preparedness, response and recovery. HazUS addresses nearly all aspects of the built environment, and many different types of losses. The earthquake component has been tested against the experience of several past earthquakes, and against the judgment of experts.

The HazUS program also has components to estimate losses as a result hurricanes and floods. HazUS was used to estimate the assets that would be impacted by both a 100- and 500-year flood event in the City (see Section 7). A quantitative vulnerability assessment for strong wind events was not conducted, but qualitative assessments based on the losses reported in past (historical) similar events are provided where data were available (Section 10).

There are numerous strategies that Newport Beach can take to reduce risk. These strategies are described in the action items in Section 4, classified by priority and timeline. Action items that address a multitude of hazards simultaneously are also presented in Section 4. Mitigation strategies can help reduce disruption to critical services, reduce the risk to human life, and alleviate damage to personal and public property and infrastructure.

Critical Facilities and Infrastructure

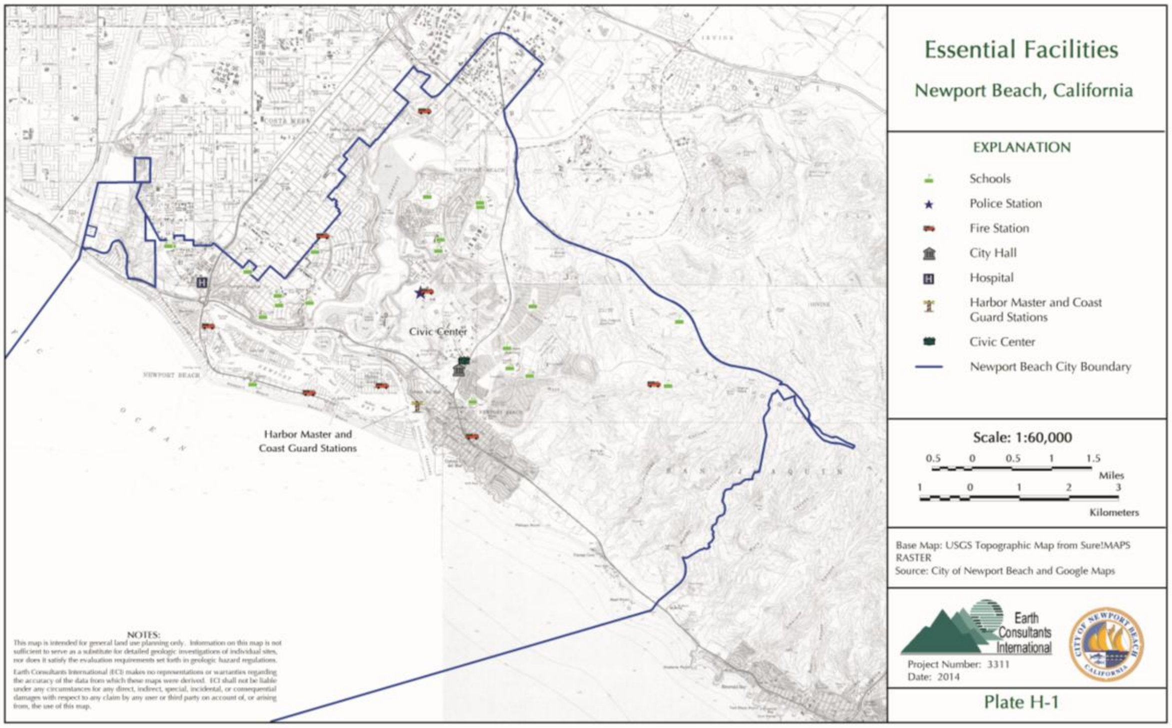
Essential facilities are those parts of a community's infrastructure that must remain operational after a disaster. Essential facilities include schools, hospitals, fire and police stations, emergency operation centers, and communication centers (see Map 3-1). A vulnerability assessment for these facilities involves comparing the locations of these facilities to the hazardous areas identified in the city. Other important (critical) facilities often considered in risk assessments include:

- **High-risk facilities**, if severely damaged, may result in a disaster far beyond the facilities themselves. Examples include power plants, dams and flood control structures, freeway interchanges, bridges, and industrial plants that use or store explosives, toxic materials or petroleum products.

- **High-occupancy facilities** have the potential of resulting in a large number of casualties or crowd-control problems. This category includes high-rise buildings, large assembly facilities, large malls and shopping centers (such as Fashion Island), and large multifamily residential complexes.

- **Dependent-care facilities**, such as preschools and schools, rehabilitation centers, prisons, group care homes, and nursing homes, house populations with special evacuation considerations.

Map 3-1: Map Showing Location of the Essential Facilities In Newport Beach
(a larger version of this map is provided in Appendix H, Plate H-1)



- **Economic facilities** are those facilities that should remain operational to avoid severe economic impacts. These facilities include banks, archiving and vital record-keeping facilities, airports, and large industrial or commercial centers.

- Facilities critical to **government response and recovery** activities (i.e., life safety and property and environmental protection) include: 911 centers, emergency operations centers, police and fire stations, public works facilities, communications centers, sewer and water facilities, hospitals, bridges and roads, and shelters.

- **Lifelines** are those services that are critical to the health, safety and functioning of the community. They are particularly essential for emergency response and recovery after a disaster. Furthermore, certain critical facilities designed to remain functional during and immediately after a disaster, such as an earthquake, may be able to provide only limited services if the lifelines they depend on are disrupted. Lifeline systems include water, sewage, electrical power, communication, transportation (highways, bridges, railroads, and airports), natural gas, and liquid fuel systems.

Federal Requirements for Risk Assessment

Federal regulations for hazard mitigation plans outlined in 44 CFR Part 201 include a requirement for risk assessment. This requirement is intended to provide information that will help communities identify and prioritize mitigation activities that will reduce losses from the identified hazards. There are five natural hazards profiled in this Mitigation Plan, including earthquakes, floods, wildfires, landslides and windstorms. The Federal criteria for risk assessment and information on how Newport Beach's Natural Hazard Mitigation Plan meets those criteria are outlined in Table 3-2 below.

Table 3-2 - Federal Criteria for Risk Assessment

Section 322 Plan Requirement	How is this addressed?
Identifying Hazards	Each hazard section (Sections 6 through 10) provides a description of the natural condition or phenomenon and its potential impact on the city of Newport Beach. To the extent GIS data are available for these hazards, maps that identify the areas most likely to be impacted by each hazard have been developed for the City of Newport Beach. These Hazard Maps are listed in Table 3-1 and are included in Appendix H.
Profiling Hazard Events	Each hazard section (Sections 6 through 10) includes documentation on the history of past hazard events, and the causes and characteristics of the hazard in the city. Where the data were available, the cost to life and property resulting from these events is provided.
Assessing Vulnerability: Identifying Assets	Where data are available, the vulnerability assessment for each hazard addressed in the mitigation plan includes an inventory of critical facilities within hazardous areas. Each hazard section provides information on vulnerable areas in the city (Sections 6 - 10). Potential mitigation strategies for each hazard type are provided in the appropriate section. Mitigation actions that the City of Newport Beach proposes to implement in the next 5-year period are listed in Section 4. Mitigation actions that the City has already completed or that are being implemented as part of day-to-day operations, are listed in Section 5.
Assessing Vulnerability: Estimating Potential Losses	The Risk Assessment Section of this Plan (Section 3) identifies key critical facilities and lifelines in the city, and includes a map of the essential facilities. Vulnerability assessments have been completed for the hazards addressed in the plan, and quantitative estimates were made for each hazard where data were available (Sections 6 and 7).
Assessing Vulnerability: Analyzing Development Trends	The Community Profile Section of this Plan (Section 2) provides a description of development trends in the city, including its geography and environment, population and demographics, land use and development, housing and community development, employment and industry, and transportation and commuting patterns.

Summary of Risk Assessment for the City of Newport Beach

Disaster (or Hazard) Mitigation Plans such as this one are to evaluate the hazards that are most likely to impact the community for which the Plan is being prepared. There are many types of natural hazards, but not all apply to a given area. A qualitative assessment of Newport Beach's vulnerability to a variety of natural hazards was conducted as part of the discussions with the Advisory Committee and the residents that participated in the Public Workshop, and based on the findings of the literature search for past natural disaster events that have impacted this part of the Los Angeles basin. The results of this assessment are presented in Table 3-3 below.

The analyses conducted for this study indicate that three hazards most likely to impact Newport Beach are strong ground shaking due to earthquakes, wildfires, and Santa Ana winds. Although a strong earthquake is not a high probability event, its effects would be severe. An earthquake on a fault nearby, or directly under the City, would be the worst-case scenario for Newport Beach, with extensive structural, economic, and social implications. Although such an event is not expected to occur frequently, perhaps only once every few generations, the potential damage to the City and the surrounding area can be so severe as to defer growth of the region for years. At the other end of the spectrum, Santa Ana winds are high probability events with a wide geographic extent but relatively lower risk potential (Table 3-3). Other hazards with the potential to significantly impact Newport Beach include surface fault rupture, liquefaction, storm flooding, coastal flooding due to tsunami, and thunderstorm-related strong winds.

Hazards with a widespread geographic extent received 3 points; those with moderate extent received 2 points, those with small geographic extent received 1 point. Similarly, hazards with a high probability of occurrence received 3 points, those with medium probability received 2 points, and those with low probability received 1 point. Finally, the potential risk posed by the hazard was quantified, with those posing a high risk receiving 3 points, moderate risk 2 points, and low risk receiving 1 point. Thus, the highest possible score for each hazard is 9 points - this would be a worst-case scenario for the City. Based on the scores achieved, the hazard with the highest score was ranked 1st (i.e., ground shaking), and so on down the list to the hazards with the least number of points.

The HazUS analyses conducted for Newport Beach indicate that a moderate to large magnitude earthquake on either the San Joaquin Hills thrust fault (M7.1) or the segment of the Newport-Inglewood fault (M6.9) that extends through the city has the potential to cause significant damage in Newport Beach. Thousands of structures, amounting to more than 70 percent of the City's residential stock, are anticipated to experience at least moderate damage as a result of either of these two earthquakes. The commercial and industrial structures in the city are also expected to be impacted, with approximately 60 percent of the combined commercial and industrial buildings in the City experiencing at least moderate damage. The damage projections indicate that approximately 2,000 casualties can be expected as a result of these earthquake scenarios, especially if an earthquake occurs during the maximum educational, industrial and commercial occupancy, in the middle of the day. Although most of these casualties are expected to require only minor medical treatment without hospitalization, the models suggest that as many as 150 fatalities could occur. The medical needs prompted by these earthquake scenarios are anticipated to exceed the capacity of the local hospital. Both of these earthquake scenarios would also impact the essential facilities in the city, with most of them not expected to be more than 50 percent functional even seven days after the earthquake. Total economic losses as a result of any of these two earthquake scenarios are estimated to exceed $3.1 billion in Newport Beach alone.

The potable water system is expected to perform moderately well as a result of either of these two earthquake sources, but thousands of households are expected to be without potable water for at least three days after the earthquake. The electric power system is expected to experience more significant damage, such that between 7,000 and 9,000 households are expected to be without power on day 7, and between 1,500 and 2,000 households may not have power a month after either of these two earthquakes. Specifics regarding these earthquake loss estimates are provided in Section 6 of this report.

An earthquake on the more-distant Whittier fault could cause slight to moderate damage, whereas an earthquake on the San Andreas fault, given its distance from Newport Beach, would generate mostly slight damage. Economic losses in Newport Beach as a result of these earthquakes is estimated at $100 million and $42 million, respectively. Neither of these earthquake sources is expected to cause significant damage to the essential facilities in the city. Both of these earthquakes are expected to cause only minor injuries to a few residents.

Table 3-3: Natural Hazards With the Potential to Impact the City of Newport Beach

Hazard	Geographic Extent			Historical Occurrence in Newport Beach	Probability of Occurrence			Potential Risk			Score*	Rank
	Widespread	Moderate	Small		High	Med.	Low	High	Med.	Low		
Earthquake												
Strong ground shaking	X			Yes (most recently in 1933)		X		X			8	1
Surface fault rupture		X		No		X		X			7	2
Liquefaction		X		Most likely during 1933		X		X			7	2
Flooding												
Riverine flooding due to storm		X		Yes	X				X		7	2
Coastal flooding		X		Yes	X				X		7	2
Dam inundation			X	No			X		X		4	5
Tsunami		X		Possibly in 1934			X		X		5	4
Sea-level rise			X	Ongoing	X				X		6	3
Wildfires		X		Yes	X			X			8	1
Landslides			X	Yes		X				X	4	5
Erosion			X	Yes		X				X	4	5
Windstorms												
Santa Ana winds	X			Yes	X				X		8	1
Thunderstorms		X		Yes	X				X		7	2
Tornadoes			X	Yes		X			X		5	4
Hurricanes		X		Yes			X			X	4	5
Volcanic Eruptions	(as a result of a distant source)		X	No			X			X	3	6

Score: Based on the number of points earned by summing the geographic extent, probability of occurrence and potential risk as follows: Widespread or high = 3 points; moderate or medium = 2 points; and small or low = 1 point. Maximum number of points = 9.
Rank: 1 = highest; 6 = lowest.

Damage as a result of a 100- year or 500-year flood event along the Santa Ana River is not expected to impact a large portion of the city of Newport Beach, yet, hundreds of residential structures are located within the flood zone and thus have the potential to be flooded. A much larger number of residential and commercial structures, up to 6,500, are located within the San Diego Creek 500-year flood zone. Flooding of roadways in the northwestern portion of the City, including the Balboa Peninsula, and in the area where Newport Avenue and Coast Highway intersect, has the potential to severely impact thousands of motorists, and restrict access to Hoag Presbyterian Hospital. Several schools and at least two of the fire stations serving Newport Beach are located within the 500-year flood zone. Even if the facilities themselves are not impacted, the roads providing ingress and/or egress from these facilities could be flooded, hindering evacuation efforts and emergency response. Flooded streets can also result in significant traffic delays, causing short-lived but substantial economic losses to the community, in addition to posing a hazard or nuisance to residents and motorists (depending on the water level reached). Although flooding at this scale is not expected to occur often, it has happened before, and thus has the potential to occur again in the future.

Coastal flooding as a result of a tsunami has not occurred historically in the Newport Beach area (except for a three-story high wave of unknown causes in 1934). However, an earthquake on an offshore fault nearby, or a submarine landslide off the coast of Newport Beach, could result in a tsunami in the area, with very little warning to evacuate the low-lying areas. Given that thousands of people visit the beach daily, and that there is a large number of residential and commercial structures in the inundation zone, a tsunami in Newport Beach has the potential to cause significant losses to life and property. This is a a very low probability but high risk event.

Wildland fires occur on a regular basis in the Southern California region; in fact, the historical record suggests that the fire risk is increasing. Most of Newport Beach is not located in a fire risk area, but the Newport Coast area is not only identified as a very high fire hazard severity zone, but it is located adjacent to wildlands with a very high fire hazard risk.

High winds occur more often than earthquakes, wildfires and flooding. Although high winds are regional in extent, damage as a result of high winds tends to be localized. The costs associated with wind damage are, on a per event basis, fairly small, but because they occur fairly often, over the long-term, the costs can add up. There are several strategies that communities can implement to reduce the impact of high wind events. Some of these potential mitigation actions are discussed in Section 8; strategies that Newport Beach has chosen to implement are discussed in Section 4.

Table 3-4: Critical Facilities at Potential Risk from the Natural Hazards Discussed in this Plan

Hazard	Earthquakes			Flooding						Windstorms	
Facility	**Strong Ground Shaking**	**Surface Rupture**	**Liquefaction or Earthquake-Induced Landslide**	**Storm-Induced Flooding**	**Coastal Flooding / Tsunami**	**Sea Level Rise**	**Dam Inundation**	**Wildfires**	**Landslides**	**Santa Anas**	**Tornadoes/ Waterspouts**
City Hall and EOC	✓									✓	
Fire Station 1 110 Balboa Blvd.	✓		✓	✓	✓	✓				✓	✓
Fire Station 2 475 32nd St.	✓	✓	✓	✓	✓	✓				✓	✓
Fire Station 3 868 Santa Barbara	✓						✓			✓	
Fire Station 4 124 Marine Ave.	✓		✓	✓	✓	✓				✓	✓
Fire Station 5 410 Marigold Ave	✓						✓			✓	
Fire Station 6 1348 Irvine Ave	✓									✓	
Fire Station 7 20401 Acacia St	✓		✓	✓	✓		✓			✓	
Fire Station 8 6502 Ridge Park Rd	✓		✓	✓				✓	✓	✓	
Hoag Presbyterian	✓		✓		✓					✓	
Police Station	✓						✓			✓	
Anderson Elementary	✓									✓	
Harbor View Elementary	✓						✓			✓	
Harbor Day Elementary	✓		✓							✓	
Lincoln Elementary	✓						✓			✓	
Mariners Elementary	✓									✓	
Newport Coast Elementary	✓		✓	✓				✓	✓	✓	
Newport Elementary	✓	✓	✓	✓	✓	✓				✓	✓
Newport Heights Elementary	✓									✓	
Carden Hall Jr HS	✓	✓								✓	
Horace Ensign Jr. HS	✓		✓						✓	✓	
Carden Hall HS	✓									✓	
Corona del Mar HS	✓								✓	✓	
Newport Harbor HS	✓									✓	
Childtime Pre-School	✓						✓			✓	
Eastbluff Pre-School	✓									✓	
Liberty Baptist Elementary	✓		✓							✓	

Hazard	Earthquakes			Flooding						Windstorms	
Facility	Strong Ground Shaking	Surface Rupture	Liquefaction or Earthquake-Induced Landslide	Storm-Induced Flooding	Coastal Flooding / Tsunami	Sea Level Rise	Dam Inundation	Wildfires	Landslides	Santa Anas	Tornadoes/ Waterspouts
Liberty Baptist HS	✓		✓							✓	
Newport Harbor Lutheran Pre-School	✓		✓							✓	
Our Lady Queen of Angels Elementary	✓		✓				✓		✓	✓	
Sage Hill School	✓		✓					**✓**	**✓**	✓	
St. Andrews Presbyterian MS	✓									✓	
Harbor Master and Coast Guard Station			**✓**	**✓**	**✓**	**✓**	**✓**		✓	✓	✓

Notes:

Bold checkmarks signify that the given facility is directly on or within the zone of potential impact, and is thus at greater risk than other nearby facilities. Non-bold checkmarks identify hazards that the facilities are susceptible to, but where the risk is about the same as that for other nearby structures. Non-bold checkmarks have also been assigned to essential facilities that are not located directly in an area susceptible to a given hazard, but are located nearby, such that access to/from the facility could be hindered.

All facilities are susceptible to the effects of strong ground motion and windstorms. The damages resulting from windstorms are expected to be significantly less than those resulting from an earthquake.

SECTION 4: GOALS AND MITIGATION ACTIONS

The ultimate goal of Local Hazard Mitigation Plans is hazard mitigation, that is, a risk-based approach to reduce or eliminate, if possible, the long-term risk to life, property and infrastructure from natural hazards. Thus, a successful hazard mitigation strategy provides a mechanism by which, during the process of preparing for, responding to and recovering from natural hazards, the community reduces its vulnerability to future hazard events. Historically, communities impacted by a natural hazard will repair the damage and reconstruct to similar pre-disaster conditions. Such efforts may expedite the return to normalcy, but in the process engender a cycle of damage, reconstruction, and repeated damage. Hazard mitigation involves the implementation of actions that enable the community to not only respond effectively to a disaster, but to recover in such a way that the post-disaster repairs and reconstruction truly strengthen it. This Local Hazards Mitigation Plan Update outlines opportunities that Newport Beach can use to increase its resiliency to future natural hazard events.

This section provides information on the process used to develop goals and action items aimed at reducing the impact of several natural hazards on the City of Newport Beach. The action items were developed after an in-depth review of the City's vulnerabilities and capabilities as described in Sections 2, and 6 through 10. The mitigation actions presented here are organized by implementation timing as follows: 1) actions that are already being implemented on an on-going basis, 2) actions that the City wants to implement in the next five (5) years, and 3) action items that the City would like to implement in the next ten (10) years. This organization takes into account the City's priorities and the realities of funding and personnel availability. Action items identified in the 2008 Plan that have already been implemented and completed are listed in Section 5. The mitigation actions are also classified by the hazard that they address, with action items that address two or more hazards at the same time referred to as multi-hazard action items.

Hazard Mitigation Overview

Many Federal and State programs have been implemented over the years to reduce losses created by natural hazards. These programs are described in detail in the appropriate sections of the Plan – the reader is referred to Sections 6 through 10 for additional information. The most significant of these programs are summarized below.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) was created by the U.S. Congress in 1968. Although a community's participation in the NFIP is voluntary, in order to receive assistance and funding from FEMA following a flood, the community must participate in the program. The City of Newport Beach has participated in the NFIP since September 1, 1978 (City ID No. 060227). Development in the flood prone areas of the City is regulated in accordance with Chapter 15.50 – Floodplain Management of the City's Municipal Code.

The Community Rating System (CRS) is a voluntary part of the National Flood Insurance Program (NFIP) that seeks to coordinate all flood-related activities, reduce flood losses, facilitate accurate insurance rating, and promote public awareness of flood insurance by creating incentives for a community to pursue beyond the minimum requirements of the NFIP. CRS ratings are on a ten-point scale, from 1 to 10, with 1 being the best rating. Residents who live within FEMA's Special Flood Hazard Areas (SFHA) receive a 5% reduction in flood insurance rates for every one-point improvement in the Community's CRS rating. As of October 1, 2014, the City of Newport Beach has a CRS rating of 8, which means that residents within the SFHA receive a 10% discount on their flood insurance rates, and residents in non-SFHA areas that purchase flood insurance can get a 5% discount.

FEMA's records include 263 flood claims filed by residents of Newport Beach, including Balboa Island and Corona del Mar, between 1977 and 2010. The amounts paid by FEMA on these claims range from $0 to nearly $275,000.00, with an average of $6,040.00. Of the properties impacted, twelve (12) have filed repetitive losses (Repetitive Loss Properties). As of the end of 2010, five of these properties had been mitigated. According to FEMA's records, of the remaining seven properties that have not been mitigated, only three are currently insured for flooding.

Senate Bill 1241

At the State level, and to address the increasing losses associated with wildfires at the wildland-urban interface, Senate Bill 1241 (2012 Kehoe Statutes) requires that cities revising their Housing Element of the General Plan on or after January 1, 2014 to also review and update their Safety Element to address the risk of fire in State Responsibility Areas and in very high fire hazard severity zones. The City of Newport Beach will update the Fire Hazards section of the Safety Element to comply with this requirement, utilizing the data presented in Section 8 of this Plan.

Assembly Bill 2140

AB 2140 provides a financial incentive for local agencies to adopt a Local Hazard Mitigation Plan as a component of the Safety Element of their General Plan. The City of Newport Beach adopted its 2008 Hazard Mitigation Plan and linked it, by reference, to their 2006 Safety Element. This 2014 Update will be treated similarly, recognizing that sections of the Safety Element need to be updated to comply with the requirements of Senate Bill 1241, as discussed above.

Plan Components

Mission

The mission of the City of Newport Beach's Natural Hazards Mitigation Plan is "to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards."

This is being achieved by increasing public awareness, documenting the resources available for risk reduction and loss-prevention, and identifying and implementing activities that will help the City of Newport Beach become a safer, more disaster-resilient and sustainable community.

Goals

The Plan Goals describe the overall direction that City agencies, organizations, and citizens are taking and will continue to take to minimize the impacts of natural hazards. The goals are stepping-stones between the broad direction of the mission statement and the specific recommendations that are outlined in the action items.

Action Items

The Action Items are activities that City departments, other organizations, businesses and residents can implement to reduce risk. Each action item includes an estimate of the time line for implementation. Short-term action items are activities that City departments may implement with existing resources and authorities within the next five years or sooner. Short-term action items also include activities that, although the resources to implement them are not readily available, are considered priorities that need to be implemented within this update cycle (that is, in the next five years). Long-term action items are considered less of a priority, and because they may require new or additional resources or authorities, are not likely to be implemented within the next five years, but may be implemented in years six through ten. There are also several mitigation activities that the City conducts on an on-going basis, as part of its development and permit processing, or upgrading of existing facilities. These activities are also listed in this document, as they are an important component in the City's efforts to reduce its vulnerability to natural disasters.

Mitigation Plan Goals and Public Participation

The Plan Goals help guide the direction of future activities aimed at reducing risk and preventing loss from natural hazards. Essentially, the goals provide a framework by which to promote sound public policy designed to protect from natural hazards the City's residents and visitors, the City's critical facilities and infrastructure, private property and the environment. The goals listed here serve as checklist items that City staff, Council members and the public can refer back as City departments and other organizations begin implementing the action items. These goals have been prioritized, with the most important goal (protect life and property) listed first. Other goals include public awareness, public participation, natural systems, emergency services, and partnerships and implementation. Elements of each of these goals are described further below.

Protect Life and Property

- Implement activities that assist in protecting lives by making homes, businesses, infrastructure, critical facilities, and other property more resistant to natural hazards.

- Reduce losses and repetitive damages from chronic (frequently recurring) hazard events while promoting insurance coverage for catastrophic hazards.

- Improve hazard assessment information from which to make recommendations to discourage new development and encourage preventive measures for existing development in areas particularly vulnerable to natural hazards.

Public Awareness

- Develop and implement educational and outreach programs that increase public awareness of the risks associated with natural hazards.

- Keep the public informed of natural hazards mitigation initiatives and activities through local newspapers, the local access channel, the City's website, newsletters, utility bill inserts, and other similar media.

- Provide information on tools, partnership opportunities, and funding resources that can help in the implementation of mitigation activities.

Public Participation

- Obtain input from City staff and the public when updating the Disaster Mitigation Plan and other similar efforts, including during the process of developing and prioritizing the Plan goals and action items and the assignment of responsibilities, taking into consideration the expected efficacy of the proposed action items and the proposed timelines.

Natural Systems

- Balance the need to protect and manage the natural resources and areas in the City (such as Newport Bay, the aquifers, watershed, etc.) with the need for hazard mitigation to protect lives and property in the developed areas, to reduce any conflict that may arise between these two objectives.

- Whenever possible, preserve, rehabilitate, and enhance the natural systems in ways that also provide natural hazard mitigation functions.

Emergency Services

- Establish policy to ensure that mitigation projects to strengthen critical and essential facilities, services, and infrastructure, where needed, are considered and prioritized.

- Coordinate and integrate natural hazard mitigation activities, where appropriate, with emergency operations, plans and procedures.

- Strengthen emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, businesses, and industry.

Partnerships and Implementation

- Strengthen communication and coordinate participation among and within City departments, other agencies, citizens, non-profit organizations, businesses, and industry so that there is a mutual, vested interest in the implementation of the action items.

- Encourage leadership within public and private sector organizations to prioritize and implement local, county, and regional hazard mitigation activities.

Hazard Mitigation Plan Action Items

As discussed above, this Hazards Mitigation Plan identifies both short- and long-term action items, and multi-hazard (MH) and hazard-specific action items. The action items are listed all together in this Section to make this document as user-friendly as possible. This provides the reader with a concise document that clearly establishes the path the City has chosen to reduce its vulnerability to natural hazards over the next five- and ten-year period. It also allows the City departments and organizations identified as responsible for the implementation of the action items to see and manage their charges more effectively.

Mitigation Plan activities may be considered for funding through Federal and State grant programs, and when other funds are made available through the City. To help ensure activity implementation, each action item includes information on its timeline and coordinating organization(s). Upon implementation, the coordinating organization(s) may look to partner with other organizations for resources and technical assistance. A description of possible partner organizations is provided in Appendix A, the Resource Directory of this Plan.

Many of the action items in the City's 2008 Disaster Mitigation Plan mirrored or complemented the policies in the City's 2006 Safety Element of the General Plan, but were more specific in that they identified the coordinating organization, timeline for implementation, goal(s) being addressed, and potential constraints, in accordance with FEMA's requirements. In the Safety Element, the policies are not prioritized, and are typically not assigned to a specific department. By critically assessing the policies of the Safety Element, several policies were found to be "orphans," with no City department willing to take on and implement them. A few initiatives were deemed unfeasible. Other action items in the 2008 Plan were developed as a result of the data collection and research process, whereby specific concerns were identified, or as a result of input from City departments or the public, during the public participation process.

The action items presented in this updated (2014) Disaster Mitigation Plan were developed during meetings of the Advisory Committee, and input from the public during the workshops and document review phases. Action items first identified in the 2008 document that the City performs on an ongoing basis, and will continue to implement, are listed here under separate header. Other mitigation measures that were included in the 2008 Plan that are considered important by the City but have not yet been implemented have moved up in priority.

Coordinating Organization

The coordinating organization is the organization that is willing and able to organize resources, find appropriate funding, or oversee activity implementation, monitoring, and evaluation. Coordinating organizations may include local, City, or regional agencies or departments, and private entities that are capable of or responsible for implementing activities and programs.

Timeline

Action items include both short- and long-term activities. Each action item includes an estimate of the timeline for implementation.

Plan Goals Addressed

The Plan goals addressed by each action item are included as a way to monitor and evaluate how well the Hazards Mitigation Plan is achieving its goals once implementation begins.

Constraints

Constraints to the immediate implementation of the action items are typical, usually because of limited resources, as described further below. Constraints may include a lack of City staff to do the work, lack of funds, or vested property rights that might expose the City to legal action as a result of adverse impacts on private property.

Project Evaluation Worksheets

Every jurisdiction has limitations on the number of mitigation activities that can be completed within a given period of time, usually because of limited economic resources. This forces jurisdictions and agencies to review and select the most cost-effective mitigation projects first, in essence prioritizing mitigation projects by their return on investment. Given the competition for available funding, multi-hazard action items are generally attractive and more likely to be implemented first. The challenge is to maintain a balance between mitigating projects that can be implemented readily and for a relatively small amount of money, with longer-term projects that cost more but have the potential to more significantly reduce the City's vulnerability to natural hazards.

The committee prioritized the action items identified in this document using the FEMA-endorsed STAPLEE (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) review and analysis, with each coordinating organization ranking the action items identified as under its jurisdiction. This methodology requires that the social, technical, administrative, political, legal, economic, and environmental implications and considerations of implementing a given action item be taken into account and weighted. By following this process, the committee identified those action items most beneficial or more feasible that can be undertaken to reduce the City's unique vulnerabilities.

FEMA also requires local governments to analyze the benefits and costs of a range of mitigation actions. Benefit-cost analysis is used in hazard mitigation to evaluate whether the benefits to life and property protected through mitigation efforts exceed the cost of the mitigation activity.

Conducing a benefit-cost analysis (BCA) for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related losses later. The analysis is based on calculating the frequency and severity of a hazard, avoided future damage, and risk.

A hazard mitigation plan must demonstrate that a process was employed that emphasized a review of benefits and costs when prioritizing the mitigation actions. The BCA review must be comprehensive to the extent that it can evaluate the monetary and non-monetary benefits and costs associated with each action. The BCA should at least consider the following questions:

1. How many people will benefit from the action?
2. How large is the area that would be impacted?
3. How critical are the facilities that benefit from the action?
4. Are there any environmental constraints associated with the action, and if so, is the overall benefit to the community greater than the environmental costs?

To assist the committee in the Benefit Cost Analysis (BCA) required by FEMA, a Project Evaluation Worksheet is included at the end of this section (Table 4-5). This worksheet is based on the "STAPLEE" process, whereby the Social, Technical, Administrative, Political, Legal, Economic, and Environmental benefits of a given proposed action item are weighed against the costs of implementing it (see Tables 4-1 and 4-2 below). The data on these worksheets can help the committee determine the most cost-effective mitigation solutions for the community. Some projects may need a more detailed BCA, but this worksheet provides a first-screening methodology.

Table 4-1: The STAPLEE Process

SOCIAL	Community Acceptance	Effect on Segment of Population			
TECHNICAL	Technical Feasibility	Long-term Solution	Secondary Impacts		
ADMINISTRATIVE	Staffing	Funding Allocated	Maintenance/Operations		
POLITICAL	Political Support	Local Champion	Public Support		
LEGAL	State Authority	Existing Local Authority	Potential Legal Challenge		
ECONOMIC	Benefit of Action	Cost of Action	Contributes to Economic Goals	Outside Funding Required	
ENVIRONMENTAL	Effects on Land/Water	Effect on Endangered Species	Effect on HAZMAT / Waste Sites	Consistent with Community Environmental Goals	Consistent with Federal Laws

Table 4-2: STAPLEE Review and Selection Criteria

CRITERIA	SPECIFIC IMPACT	DESCRIPTION of GRADING SCALE for EACH IMPACT
Social	Acceptance	Is the action perceived as socially acceptable to a wide segment of the population? Values range from 0 to 3, with 0 = public indifferent to action; 1 = somewhat popular; 2 = popular; 3 = very popular.
	Effect on Segment of Population	Is the action item likely to impact (positively or negatively) a particular segment of the population? Values range from -3 to 3 with -3 = will negatively impact a segment of the population; 0 = will have no effect; 3 = will have a very positive effect on a segment of the population.
Technical	Feasibility	Is the action feasible given our current knowledge or science? 0 = No; 1 = somewhat; 2 = moderately; 3 = absolutely.
	Long-Term Solution	Is implementation of this action going to reduce the hazard permanently? 0 = no; 1= slightly; 2= somewhat; 3 = yes.
Administrative	Staffing	Is there staff currently at the City doing this work? Does it involve 1 person, or more? The resulting number is a weighted sum of individual components, as described below:
		Is there staff currently at the City doing this work? 0 = no; 1 = yes, 1 person; 2 = yes, 2 or more but not enough to do the proposed work; 3 = yes, several, enough to get the work done. -1 = City needs to hire someone to do the work; -2 = City needs to hire 2 people to do the work; -3 = City needs to hire several people to get this done.
	Funding allocated	0 = no funding currently allocated; 1 = some funding allocated, need a lot more $; 2 = funding available, enough to do the basics; 3 = funding available to do the work without cutting corners.
	Maintenance	Does this action require constant maintenance and upgrade? 0 = no, this is a one-time expenditure; -1= some minor maintenance required; -2 = constant maintenance by 1 individual required; -3 = constant maintenance and upgrade required, effort requires 2 or more individuals assigned to task.
Political	Public support	Is the action going to be popular with the public? -3 to 3, with -3 = very unpopular; 0 = no public reaction, indifferent; and 3 = very popular.
	Political support	Is the action going to be popular with the Mayor and City Council? -3 to 3, with -3 = very unpopular; 0 = no reaction, indifferent; and 3 = very popular.
Legal	State authority	Is there a State mandate or a recommendation to have this done? 0 = no; 1= there is minor State interest in doing this; 2= there is a strong support at the State level to do this; 3 = there is a State mandate to do this, generally with a target date for implementation.
	Local authority	Is there a local mandate or recommendation to implement this action? 0 = no; 1 = there is minor local support to get this done; 2 = there is strong local support to get this done; 3 = there is a City mandate to get this done.
	Possible legal action?	Is this action likely to get challenged in court? 0 = no; -1 = a small possibility; -2 = yes, some people might object enough to go to court; -3 = yes, expect several neighbors to challenge this in court.
Economic	Benefit	The economic benefits of implementing this action. 0 = no benefit; 1= small benefit; 2= benefit; 3 = great benefit.
	Cost	The economic costs of implementing this action: 0 = no costs; -1 = small cost; -2 = some cost; -3= very expensive.
	Outside Funding	Is there outside funding available to implement this action? 0 = no; 1 = small amounts of money, not enough to get it done; 2 = funding available; 3 = enough money available to get this done.
Environmental	Impacts on Environment (Land, Water, Endangered Species, etc.)	Does this action have a positive or negative impact on the environment? -3 = severe negative impact on environment; 0 = no impact; 3 = very positive impact on environment.
	Consistent with Community's Environmental Goals	Is the proposed action consistent with the City's environmental goals? -3 = goes against all goals to protect the environment; 0 = has no impact on the local environmental goals; 3 = is very consistent with the City's environmental goals.

Hazard Action Items

The hazard mitigation actions that the City of Newport Beach has chosen to implement to reduce its vulnerability to the natural hazards discussed in this Plan are listed in Table 4-3, below, with ongoing actions identified under the green headers, actions to be implemented in the short-term identified under the orange headers, and actions to be implemented in the long-term identified under the purple headers. Multi-hazard action items are those activities that pertain to two or more of the five natural hazards identified in the Mitigation Plan: earthquakes, floods, wildfires, landslides and windstorms.

The action items are listed in order based on the results of the prioritization conducted using a simplified STAPLEE analysis based on the criteria and grading scale described in Table 4-2 above. Only the short-term and long-term action items were prioritized, with the responsible department(s) providing input for the STAPLEE assessment. The spreadsheet supporting the prioritization results is presented as Table 4-4.

Table 4-3: City of Newport Beach Hazard Mitigation Actions

Ongoing Actions	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
Multi-Hazards: To prepare for, and respond to a variety of potential natural and man-made hazards, the City of Newport Beach conducts the following activities:			
1. Pursues funding opportunities to develop and implement local and citywide mitigation activities. A. Supports a position to monitor the availability of Federal, State and local funds that can be used to implement specific action items in the Local Hazard Mitigation Plan. B. As action items are identified for potential grant funding, City staff conducts a Benefit Cost Analysis to assess the cost-effectiveness of the proposed measure. C. Monitors the effectiveness of mitigation measures or conditions of approval being applied to projects. The Committee meets regularly to evaluate the progress and success (or failure) of the action items in the Plan.	Emergency Preparedness Committee with support from other City departments as needed	FEMA (Hazard Mitigation Grant Program, Pre-Disaster Mitigation grants), Staff Budget, City's General Fund; dependent on personnel available to pursue and apply for grants, and funding availability.	Partnerships and Implementation, Public Participation
2. Fosters public and private partnerships to improve hazard mitigation program coordination and collaboration. A. Develops and conducts natural hazards awareness programs that are presented at schools, community centers, and other venues. B. Conducts public outreach programs aimed at businesses, residents, and organizations that are most likely to be impacted	Hazard Mitigation Advisory Committee with support from Municipal Operations, Fire, Public Works, Utilities, and Community Development (Planning Division) Departments, as needed, in addition to the City's Public Information Office.	City's General Fund, FEMA's Pre-Disaster Mitigation grant; dependent on funding and personnel availability.	Partnerships and Implementation, Emergency Services, Public Participation

Ongoing Actions	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
by flooding, seismic shaking, slope instability, and wildfire events. C. Makes the Local Hazard Mitigation Plan available to the public by publishing it electronically on the City's website. Hardcopies of the plan are available at City Hall and in the City's main library. D. Continues to strengthen emergency preparedness and response by linking emergency services with hazard mitigation measures and by enhancing public education on a regional scale. E. Works with community planning organizations and other neighboring groups and has formed community response teams. F. Provides training to the Disaster Mitigation Committee members so they remain current on developing issues in the natural hazard-reduction field.			
Seismic and Geologic Hazards: To reduce its vulnerability to seismic and geologic hazards, the City of Newport Beach conducts, in an ongoing basis, the following activities:			
3. Reviews all proposed developments during the project feasibility stage, and compares the location of the proposed project with the hazard maps developed for the LHMP to ensure that the project is not located in an area identified as susceptible to damage from a natural hazard.	Community Development Dept., Planning Division	Development processing fees; no constraints.	Protect Life and Property, Public Awareness
4. Updates, adopts and enforces the most up-to-date California Building Code with local amendments, and City staff train in the provisions of the latest codes.	Community Development Dept., Building Division	Development processing fees; no constraints.	Protect Life and Property, Partnerships and Implementation
5. City staff review all plans for new construction and re-development projects to identify potential structural or fire-code deficiencies that need to be addressed and mitigated as a condition of approval of the project.	Community Development Dept., Building Division, with support from the Fire Department	Development processing fees; no constraints.	Protect Life and Property, Partnership and Implementation
6. Requires geotechnical reviews, conducted by California-certified professionals that address seismic vulnerability, liquefaction potential, and slope stability for all new construction and re-development projects.	Community Development Dept., Building Division	Development processing fees; no constraints.	Protect Life and Property
7. Is supporting the seismic retrofitting and strengthening of essential and critical facilities, such as hospitals and schools, to minimize damage to these facilities and reduce the potential losses of life, limb and property resulting from a seismic or geologic event.	Community Development Department (Building Division), Fire Department	FEMA Pre-Disaster Mitigation grants, Cal OES grants; dependent on funding and personnel availability.	Protect Life and Property, Emergency Services

Ongoing Actions	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
8. Requires slope stability analyses for all new developments and re-developments that have the potential to be impacted by or have the potential to result in coastal erosion or slope damage. These analyses and erosion rate estimates are to be completed by an experienced and licensed Certified Engineering Geologist and/or Geotechnical Engineer.	Community Development Department (Building Division)	Development processing fees; no constraints.	Protect Life and Property, Natural Systems
9. Requires developments or re-developments adjacent to coastal bluffs to incorporate drainage improvements, irrigation systems, and/or native or drought-resistant vegetation into the design to minimize coastal bluff recession.	Community Development Dept., Building Division with support from the Municipal Operations Department if needed	Development processing fees; no constraints.	Protect Life and Property, Natural Systems
10. Prohibits shoreline and bluff protective devices intended for the economic life (75 years) of new structures unless an environmentally acceptable design that stabilizes the bluff and prevents bluff retreat is devised.	Community Development Department (Building Division), with support from the Public Works Department	Development processing fees, Staff Budget; no constraints.	Natural Systems, Protect Life and Property, Public Awareness
Flood Hazards: To reduce its vulnerability to flood hazards, the City of Newport Beach implements the following activities in an ongoing basis:			
11. Monitors the ocean sand to develop a history of its movement and develop trends along the City's coastline.	Public Works Department (Harbor Resources Division)	City's General fund, Staff Budget; dependent on funding and personnel availability.	Natural Systems, Public Awareness
12. Conducts in-bay beach sand replenishment. This entails dredging sand, and if necessary, importing sand for elsewhere in the watershed, and placing it back up on the beach for recreation and stabilization purposes	Public Works Department (Harbor Resources Division)	City's Tidelands fund; dependent on funding and personnel availability.	Natural Systems, Public Awareness, Protect Life and Property
13. Conducts annual reviews of the water storage basins and dams in the City in accordance California Division of Dam Safety guidelines.	Municipal Operations Department in cooperation with the California Division of Dam Safety and the dam owners/operators	City's Water fund, dam owners; dependent on funding and follow-through by the dam owners/operators.	Emergency Services, Partnerships and Implementation, Protect Life and Property
14. Requires that all new development and re-development in areas susceptible to flooding (such as the 100-year floodplain and areas susceptible to coastal flooding) incorporate mitigation measures to reduce or eliminate the hazard of flooding. These measures may include the design of onsite drainage systems that are connected to the City's storm drainage system, grading of the site so that runoff does not impact adjacent properties, and buildings elevated above the anticipated flood levels.	Community Development Department (Building Division), in cooperation with Municipal Operations Department	Development processing fees; no constraints.	Protect Life and Property, Natural Systems, Public Awareness

Ongoing Actions	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
15. Requires all new facilities within the flood zones that store, use, or are otherwise involved with substantial quantities of onsite hazardous materials to comply with standards of elevation, anchoring, and flood proofing, and that the hazardous materials are stored in watertight containers.	Community Development Department (Building Division) in cooperation with Fire Department	Development processing fees, Staff Budget, City's General Fund; no constraints.	Protect Life and Property, Public Awareness
16. Limits the use of flood protective devices to the minimum required to protect existing development, and prohibits their use to enlarge or expand areas for new development. Existing development for the purposes of this activity consists only of a principal structure (e.g., residential dwelling, required garage, or second residential unit) and does not include accessory or ancillary structures such as decks, pools, tennis courts, cabanas, stairs, landscaping, etc.	Community Development Department (Planning and Building Divisions) with support as needed from the Public Works Department (Harbor Resources Division)	Development processing fees, Staff Budget, City's General Fund; no constraints.	Protect Life and Property, Public Awareness, Natural Systems
17. Requires all new or remodeled residential structures in areas susceptible to storm surge to raise their floor elevations as required by the latest building code in effect.	Community Development Department (Building Division)	Development processing fees, FEMA's Flood Mitigation Assistance; no constraints	Protect Life and Property, Public Awareness
18. Reviews local and distant tsunami inundation maps for Newport Beach and adjacent communities as they are developed to confirm that the mitigation measures currently in place are adequate.	Emergency Preparedness Committee	City's General fund; dependent on funding and personnel availability.	Protect Life and Property, Public Awareness, Partnerships and Implementation
19. Maintains and regularly cleans out, as needed, the storm drains in low-lying areas, to help reduce the potential for floodwaters to impact the structures in those areas.	Municipal Operations Department	Staff Budget, City's General fund, impacted district fees; FEMA's Flood Mitigation Assistance; no constraints.	Protect Life and Property, Natural Systems
Fire Hazards: To reduce the potential for wildland fires to impact the community, the City of Newport Beach conducts on an ongoing basis the following activities:			
20. Continues to develop and implement educational and public information programs that inform Newport Coast and Corona del Mar residents of the value of the installed Fuel Modification and Hazard Reduction Zones, and continues to enforce their maintenance and upkeep.	Fire Department, with support from the Public Information Office	City's General fund, FEMA's Pre-Disaster Mitigation grants; dependent on funding and personnel availability.	Protect Life and Property, Public Awareness, Natural Systems
21. Continues to enforce the removal of non-native, invasive vegetation and re-landscaping with fire-resistant native vegetation from the City-approved plant list.	Fire Department	Homeowners, Homeowners' Associations, City's General Fund; no constraints.	Protect Life and Property, Natural Systems, Public Awareness

Ongoing Actions	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
22. Continues to enhance its emergency services to provide effective wildfire response. Activities included in this effort include the constant training of City's fire response personnel.	Fire Department	City's General Fund, Staff Budget, FEMA's Pre-Disaster Mitigation grants; level of preparedness dependent on funding availability.	Emergency Services, Protect Life and Property
23. Enforces hazard reduction activities, including fuel modification and fuel reduction, to reduce wildfire hazards to existing development in the urban-wildland interface areas.	Fire Department	City's General Fund, FEMA's Pre-Disaster Mitigation grants, homeowners and Homeowners' Associations; no constraints.	Natural Systems, Public Awareness, Protect Life and Property
24. Continues to work with the Irvine Ranch Conservancy to develop long-term vegetation management plans for Middle and Upper Buck Gully.	Fire Department, Irvine Ranch Conservancy, and the Recreation and Senior Services Department	City's General Fund; dependent on funding and personnel availability.	Partnerships and Implementation, Public Awareness, Natural Systems
Windstorm Hazards: To reduce the impact that high winds may have on infrastructure and utilities, the City does the following:			
25. Continues to enforce Chapter 7A of the California Building Code in regard to wind construction.	Community Development Department (Building Division)	Development fees	Protect Life and Property, Public Awareness
26. Trims 13,000 to 14,000 trees annually to help reduce the potential for wind-downed branches and trees that could disrupt overhead utilities.	Southern California Edison and Municipal Operations Department	Edison fund, City's General fund, staff budget; dependent on funding and personnel availability.	Protect Life and Property, Natural Systems

Short-Term Actions (To be Implemented in Next 5 Years)	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
Multi-Hazards: To prepare for, and be better prepared to respond to a variety of potential natural and man-made hazards, the City of Newport Beach will implement the following activities:			
27. Will coordinate with utility providers to strengthen and/or replace the sections of the water distribution network that have been identified as most vulnerable due to their age or location in areas susceptible to ground failure.	Municipal Operations and Public Works Departments in cooperation with the Irvine Ranch and Mesa Consolidated Water Districts	Utilities user fees, FEMA's Pre-Disaster Mitigation grants; dependent on funding and personnel availability.	Emergency Services, Protect Life and Property, Partnerships and Implementation
28. Will assess the storage capacity of its water facilities to ensure that at all times there are at least seven days worth of emergency potable water that can be tapped into in the event of a disaster.	Municipal Operations and Public Works Departments in cooperation with the Irvine Ranch and Mesa	City's Water Fund, staff budget; importance of this issue requires that it be done	Emergency Services, Protect Life and Property,

Short-Term Actions (To be Implemented in Next 5 Years)	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
	Consolidated Water Districts	regardless of any potential constraints.	Partnerships and Implementation
29. Will identify and engage organizations in the area that have programs or interests in natural hazards mitigation.	Disaster Mitigation Committee	City's General Fund; FEMA's Pre-Disaster Mitigation grants; dependent on the availability of these programs locally, and their interest in partnering with City.	Partnerships and Implementation, Public Awareness
30. Will identify opportunities to partner with citizens, private contractors, and other jurisdictions to increase availability of equipment and manpower available to respond to a disaster, and to increase the efficiency and efficacy of emergency response efforts.	Disaster Mitigation Committee with support from the Fire, Public Works and Municipal Operations Departments	FEMA's Pre-Disaster Mitigation grants; dependent on funding and personnel availability to regularly update the contact information.	Partnerships and Implementation, Public Awareness
31. Will develop incentives for local agencies, residents and businesses to pursue hazard mitigation projects.	Disaster Mitigation Committee	Staff Budget, City's General Fund, FEMA's Pre-Disaster Mitigation grant; dependent on funding and personnel availability.	Partnerships and Implementation, Public Awareness
32. Will monitor hazard mitigation implementation by City divisions and participating organizations through surveys and other reporting methods.	Disaster Mitigation Committee with assistance from the Public Information Office	Staff Budget, City's Funds; dependent on funding and personnel availability.	Public Participation, Public Awareness, Partnerships and Implementation
Seismic and Geologic (Slope Instability) Hazards: To reduce the impact that seismic events and adverse geologic conditions may have on the community, the City will implement the following actions:			
33. Will support and encourage the seismic retrofitting and strengthening of critical facilities, such as schools, to minimize damage in the event of a seismic or geologic disaster.	Community Development Department (Building Division), in cooperation with the Newport-Mesa Unified School District and other school owners	FEMA's Hazard Mitigation grants, Cal-EMA grants, school-retrofit bonds; dependent on funding availability.	Emergency Services, Protect Life and Property
34. Will upgrade and maintain existing essential facilities that are located in areas susceptible to seismic and geologic hazards to prevent or reduce loss.	Municipal Operations Department with support from the Community Development Department (Building Division) as needed	FEMA's Hazard Mitigation grants, Cal-OES grants; dependent on funding availability.	Emergency Services, Partnerships and Implementation
35. Will maintain and update as necessary a map of landslides and slope failures in the City to identify those areas most susceptible to debris flows, surficial mass wasting events, and landslides, especially	Community Development Department (Planning Division) with support from the IT Division	Staff Budget; dependent on personnel availability.	Public Awareness

Short-Term Actions (To be Implemented in Next 5 Years)	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
during wet winters.			
Fire Hazards: To reduce the hazard of wildland fires in the City, Newport Beach will conduct the following activities:			
36. Will encourage non-sprinklered property owners to retrofit their buildings to include fire sprinklers.	Community Development Department (Building Division) with support from the Fire Department	Staff Budget.	Public Awareness, Partnerships and Implementation, Protect Life and Property
37. Will improve the fuel management program in Lower Buck Gully. This will include an evaluation of alternatives for removing undesirable vegetation from property beyond homeowner's responsibility areas.	Fire Department, and Municipal Operations Department		Natural Systems, Public Awareness, Public Participation
38. Will revise the Hazard Reduction regulations and procedures for existing canyon neighborhoods in Corona del Mar. These changes will include the development and enforcement of defensible space, changes to the existing City ordinances to better regulate vegetation in canyon properties, and the removal of combustible vegetation and replacement with fire-resistive native plant species from the City's approved plant list.	Fire Department	City's General Fund; no constraints.	Public Awareness, Natural Systems, Public Participation

Long-Term Activities (To be Completed in the Next 10 Years)	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
Multi-Hazards: To further reduce its vulnerability to a variety of natural and man-made hazards, the City will consider implementing these long-term activities:			
39. Will study the impacts that sea-level rise over the next century may have on the City, and develop potential mitigation measures appropriate for the area.	Public Works Department	City's General Fund, Tidelands Fund	Natural Systems, Public Awareness
40. Provide electronic mapping capabilities by creating a City-supported website that provides City-specific information that residents and local businesses can refer to for decision-making purposes. The site would include site-specific hazards information, potential mitigation measures, list of companies that provide earthquake and flood insurance for Newport Beach residents, and educational materials on disaster preparedness and response.	Emergency Preparedness Committee in cooperation with the Community Development, Public Works, and Municipal Services Departments, and support from the Public Information Office and the IT Division	City's General Fund; no constraints.	Public Awareness, Public Participation
41. Will develop education and outreach programs that focus on protecting the natural systems as a mitigation activity.	Emergency Preparedness Committee with support from the Public Works, Municipal Operations, and Community	City's General Fund	Public Awareness, Natural Systems

Long-Term Activities (To be Completed in the Next 10 Years)	Responsible Department, Agency or Committee	Potential Funding Source(s); Constraints	Plan Goals Addressed
	Development Departments, and the Public Information Office		
42. Expand the City's Local Hazard Mitigation Plan to include man-made hazards (e.g., hazardous materials releases, terrorism, civil unrest, aviation hazards, etc.).	Emergency Preparedness Committee with support from other City departments as needed	FEMA's Pre-Disaster Mitigation grants, Hazard Mitigation Grant Program, City's General Fund; dependent on available funding.	Public Awareness, Emergency Services, Protect Life and Property

Table 4-4: STAPLEE Ranking of Action Items

SHORT DESCRIPTION (Refer to Text in Plan for the Complete Description of Each Action Item)	STAPLEE COMPONENTS																	TOTAL	RANK	Responsible Agency (PW = Public Works, CD = Community Development)
	Social		Technical		Administrative			Political		Legal			Economic			Environmental				
	Acceptance	Effect on Segment Population	Feasibility	Long-Term Solution	Staffing	Funding Allocated	Maintenance	Public Support	Political Support	State Authority	Existing Local Authority	Potential Challenge	Benefit	Cost	Outside Funding	Effects on Environment	Consistent with City Goals			
Strengthen and/or replace vulnerable sections of water distribution system.	3	1	3	1	3	3	-1	3	2	2	3	0	3	-2	0	0	3	27	1	PW
Assess storage capacity of water storage facilities to ensure 7-days worth of emergency potable water.	3	3	3	1	3	3	-1	3	2	0	1	-1	3	-2	0	0	3	24	2	PW
Identify and engage organizations with interest in natural hazard mitigation.	1	3	2	3	1	0	1	0	0	2	1	-1	3	-2	0	1	2	17	3	Fire

SHORT DESCRIPTION (Refer to Text in Plan for the Complete Description of Each Action Item)	STAPLEE COMPONENTS																	TOTAL	RANK	Responsible Agency (PW = Public Works, CD = Community Development)
	Social		Technical		Administrative			Political		Legal			Economic			Environmental				
	Acceptance	Effect on Segment Population	Feasibility	Long-Term Solution	Staffing	Funding Allocated	Maintenance	Public Support	Political Support	State Authority	Existing Local Authority	Potential Challenge	Benefit	Cost	Outside Funding	Effects on Environment	Consistent with City Goals			
Develop incentives to pursue hazard mitigation projects.	1	2	1	3	0	0	1	1	1	1	0	-1	2	-3	0	2	0	11	5	Fire
Identify opportunities to partner with others to increase availability of equipment and manpower available during a disaster.	1	1	2	2	1	1	-2	1	1	1	0	0	3	-1	0	0	1	12	4	Fire
Monitor hazard mitigation implementation.	1	2	1	2	1	0	-3	1	1	2	1	-1	2	-3	1	2	1	11	6	Fire
Develop and conduct hazard awareness programs.	2	2	2	1	1	0	-3	1	1	2	1	0	1	-2	0	0	0	9	7	Fire
Support seismic retrofitting and strengthening of essential facilities like schools and hospital.	1	-1	1	3	0	0	-1	0	0	2	1	0	2	-2	0	0	0	6	1	CD
Upgrade and maintain essential facilities located in vulnerable areas to reduce loss.	1	-1	1	3	0	0	-1	0	0	2	1	0	2	-2	0	0	0	6	1	CD
Maintain and update map of landslides and slope failures.	2	3	3	2	3	0	-2	2	2	2	3	0	2	-1	0	0	0	21	1	CD

SHORT DESCRIPTION (Refer to Text in Plan for the Complete Description of Each Action Item)	STAPLEE COMPONENTS																	TOTAL	RANK	Responsible Agency (PW = Public Works, CD = Community Development)
	Social		Technical		Administrative			Political		Legal			Economic			Environmental				
	Acceptance	Effect on Segment Population	Feasibility	Long-Term Solution	Staffing	Funding Allocated	Maintenance	Public Support	Political Support	State Authority	Existing Local Authority	Potential Challenge	Benefit	Cost	Outside Funding	Effects on Environment	Consistent with City Goals			
Develop a tsunami educational program.	1	2	2	0	1	1	-2	1	1	1	0	0	1	-1	0	0	0	8	1	Fire
	2	3	3	0	1	0	-2	1	2	0	3	0	2	-1	0	0	0	14		CD
Develop vegetation management plans for Middle and Upper Buck Gully.	1	0	3	2	-1	0	-2	0	0	2	1	-2	0	-2	0	0	0	2	4	Fire
Improve fuel management plan for Lower Buck Gully.	1	-3	3	2	1	0	-2	0	0	2	1	-2	0	-2	0	0	0	1	5	Fire
Revise the Hazard Reduction regulations and procedures for canyon neighborhoods in CDM.	1	-3	3	2	1	0	-2	0	0	2	1	-2	0	-2	0	0	0	1	6	Fire
Evaluate the relocation of existing fire stations and need for additional fire stations.	0	1	2	1	1	1	-2	-1	1	0	1	-2	2	-3	0	0	1	3	2	Fire
	0	3	3	3	0	0	1	0	0	0	2	0	2	-2	0	0	0	12		CD
Encourage non-sprinklered property owners to retrofit their buildings.	0	-3	3	2	1	0	1	0	0	1	0	0	0	-3	0	0	0	2	3	Fire
	0	-1	3	3	3	0	-2	-1	0	3	3	-1	2	-2	0	0	0	10		CD
Develop educational program for HOAs and residents near Fuel	2	3	3	2	0	0	-1	0	0	1	0	0	0	-2	1	3	3	15	1	Fire

SHORT DESCRIPTION (Refer to Text in Plan for the Complete Description of Each Action Item)	STAPLEE COMPONENTS: Social		Technical		Administrative			Political		Legal			Economic			Environmental		TOTAL	RANK	Responsible Agency (PW = Public Works, CD = Community Development)
	Acceptance	Effect on Segment Population	Feasibility	Long-Term Solution	Staffing	Funding Allocated	Maintenance	Public Support	Political Support	State Authority	Existing Local Authority	Potential Challenge	Benefit	Cost	Outside Funding	Effects on Environment	Consistent with City Goals			
Modification Zone.																				
Expand the City's LHMP to include man-made hazards	1	1	1	-2	0	0	-1	1	0	1	0	0	1	-2	0	0	0	1	8	Fire
Provide electronic mapping capabilities by providing website with City-specific information to assist with decision making.	2	3	3	2	3	0	-2	2	2	2	3	0	2	-1	0	0	0	21	2	CD
	3	3	3	1	3	1	-3	3	3	1	2	-1	2	-3	0	0	0	18	4	PW
Develop educational and outreach programs that focus on protection of natural system.	2	2	3	1	2	1	-3	2	3	1	1	-1	1	-2	0	3	3	19	3	PW
	2	1	1	1	1	1	-1	1	1	1	2	0	2	-2	1	1	1	14	5	Fire
	1	1	3	3	0	0	-2	0	2	0	2	0	2	-2	0	0	0	10	6	CD
Identify safe evacuation routes in landslide-prone areas.	0	1	3	3	0	0	-2	0	2	0	0	0	2	-2	0	0	0	7	7	CD
Study the impacts of sea-level rise on the City, and develop potential mitigation measures.	3	3	3	2	2	1	-1	3	3	1	1	-2	3	-3	1	0	3	23	1	PW

PW = Public Works, CD = Community Development

Table 4-5: Project Evaluation Worksheet for Individual Projects

Jurisdiction:		Contact:	
Project Title		Phone:	
Agency:		E-mail:	
Hazard(s):			

Flood Zone:		Base Flood Elevation:		Erosion Rate:
Critical Facility/Population At Risk:				

Environmental Impact:						Historic Preservation Impact:					
High		Medium		Low		High		Medium		Low	
Importance to Protection of Life/Property and Disaster Recovery						Risk of Hazard Impact:					
High		Medium		Low		High		Medium		Low	

Estimated Cost:		Project Duration:	
Value of Facility:		Value of Contents:	
Source(s) of Financing:			
Project Objectives:			
Project Description:			
Proposal Date:			

Evaluation Category	Considerations	Comments
Social	Community Acceptance	
	Adversely Affects Segments of the Population	
Technical	Technical Feasibility	
	Long Term Solution	
	Secondary Impacts	
Administrative	Staffing	
	Funding Allocated	
	Maintenance / Operations	
Political	Political Support	
	Plan Proponent	
	Public Support	
Legal	Authority	
	Action Subject to Legal Challenge	
Economic	Benefit	
	Cost of Action	
	Contributes to Economic Goals	
	Outside Funding Required	
Environmental	Affects Land / Water Bodies	
	Affects Endangered Species	
	Affects Hazardous Materials and Waste Sites	
	Consistent with Community Environmental Goals	
	Consistent with Federal Laws	

SECTION 5: PLAN MAINTENANCE PROCESS and PROGRESS MADE SINCE 2008

Hazards Mitigation Plans need to remain active and relevant. To that end, these Plans are to be evaluated on an annual basis, and updated every five years. This section describes the process by which the City of Newport Beach has and will continue to maintain this document, including the integration of public awareness programs designed to make local residents and businesses more resilient to natural hazards. This section also provides an explanation of how the City of Newport Beach has and will continue to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms such as the City's General Plan, Capital Improvement Plans, and Building and Safety Codes. Finally, this section identifies the mitigation actions that were implemented and completed since the City's first Local Hazards Mitigation Plan was completed in 2008. Mitigation actions that are still being implemented on an ongoing basis are included in Section 4.

Evaluating and Updating the Plan Every Five 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 (DMA). The City intends to continue updating the Plan on a five-year cycle from the date of initial plan adoption. It is anticipated that this update process will begin one year prior to expiration of the existing plan. The cycle may be accelerated, with updates issued in less than five years if one of the following events occurs:

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

The main purpose of the update process is to keep the Plan current, reflecting the latest planning process methods, community profile data, hazard data and events, vulnerability analyses, mitigation actions and goals. The updates should, at a minimum, include the following elements:

1. The update process will be convened through a committee that consists of at least one member of the General Plan Update Advisory Committee or staff to ensure consistency between Plans.
2. The hazard risk assessment will be reviewed on an annual basis and updated using best available information and technologies.
3. The evaluation of critical structures and mapping will be updated and improved as funding becomes available.
4. The mitigation actions will be reviewed and revised to account for any actions completed, deferred, or changed to account for changes in the risk assessment or new City policies identified under other planning mechanisms, as appropriate (such as the General Plan).
5. The draft update will be sent to appropriate agencies for comment.
6. The public will be given an opportunity to comment prior to adoption.
7. The Newport Beach City Council will adopt the updated Plan.

Some of these items are described in more detail in the sub-sections below.

Plan Adoption and Maintenance

The Newport Beach City Council, being the governing body with the authority to promote sound public policy regarding natural hazard mitigation, adopted the City's 2008 Hazards Mitigation Plan on October 14, 2008. The adopted Plan was then submitted, also in October 2008, to the State Hazard Mitigation Officer at the Governor's Office of Emergency Services (Cal OES). On January 21, 2014, the Governor's Office of Emergency Services submitted the Plan to the Federal Emergency Management Agency (FEMA) for review. This review addressed the federal criteria outlined in FEMA's Interim Final Rule 44 CFR Part 201. FEMA approved the City's 2008 Plan on March 15, 2009. With approval of the Plan by FEMA, Newport Beach gained eligibility for Hazard Mitigation Grant Program (HMGP) funds. As with the 2008 Plan, the City Emergency Services Coordinator is responsible for submitting the 2014 Plan Update to the State Hazard Mitigation Officer at the Governor's Office of Emergency Services. Adoption and approval of the 2014 Plan Update will allow the City to continue being eligible for HMGP funds.

Coordinating Body

The City of Newport Beach Hazard Mitigation Steering Committee is responsible for coordinating implementation of the Plan's action items, undertaking the formal review process, and maintaining and updating the Plan. The City Manager, or designee, assigns representatives from City agencies, including, but not limited to, the current Hazard Mitigation Steering Committee members. At this time, the Hazard Mitigation Steering Committee consists of a representative from the following City Departments or agencies:

- City of Newport Beach Fire Department, Emergency Services Division
- City of Newport Beach Community Development Department, Planning Division
- City of Newport Beach Municipal Operations Department, and
- City of Newport Beach Public Works Department.

The Steering Committee is supported by a larger body of advisors representing several other agencies and organizations that have a vested interest in managing or reducing the natural hazards in the city of Newport Beach. This larger body, referred to as the Hazard Mitigation Advisory Committee, has responsibility for reviewing the Plan and providing input on the action items proposed and their prioritization. The current Advisory Committee members include representatives from the following local agencies and organizations:

- City of Newport Beach Fire Department
- City of Newport Beach, Fire Department, Emergency Services Division
- City of Newport Beach, Fire Department, Lifeguards
- City of Newport Beach Municipal Operations Department
- City of Newport Beach Community Development Department, Planning Division
- City of Newport Beach Community Development Department, Building Division
- City of Newport Beach Public Works Department
- City of Newport Beach Information Technology Division

In order to make this committee as broad and useful as possible, the City Mayor, or designee, may engage other relevant organizations and agencies, including:

- An elected official
- A representative from the Chamber of Commerce
- An insurance company representative
- Community planning organization representatives

- A representative from the City Manager's office
- Representatives from professional organizations such as the Home Builders Association
- Representatives from local universities and community colleges, and
- Local residents.

Additional resources at the state and federal levels, in the form of ad-hoc committee members that could participate in Newport Beach's Natural Hazards Mitigation program can be drawn from the following agencies:

- California Geological Survey
- Federal Emergency Management Agency
- California Governor's Office of Emergency Services
- Red Cross
- Salvation Army.

The Hazard Mitigation Steering Committee meets at least quarterly. These meetings provide an opportunity to discuss progress in the implementation of the action items and maintain the partnerships that are essential for the sustainability of the Mitigation Plan.

Convener

As with the 2008 Plan, the Hazard Mitigation Steering Committee is responsible for Plan implementation. The City's Emergency Services Coordinator facilitates the Hazard Mitigation Planning Team meetings, and assigns tasks such as updating and presenting the Plan to other City Departments, Stakeholder Groups, elected officials and the general public. Plan implementation and evaluation are a shared responsibility among all of the Hazard Steering Committee members. This update and future updates of the Plan require the participation of the Advisory Committee.

Continued Public Involvement

The City of Newport Beach is dedicated to involving the public directly in review and updates of the Hazard Mitigation Plan. To that end, the public will continue to be apprised, through the City's website, of the City's Hazard Mitigation Plan and the action items that have been implemented, either by posting a digital copy of the Plan directly onto the website, and/or by publicizing the existence of the Plan, and identifying physical locations where hard-copies of the Plan are available for public review. Copies of the Plan will be kept at all of the appropriate agencies in the City, as well as at the Central Library and branches. The website will also provide an e-mail address and phone number of a point of contact to whom members of the public can direct their comments and concerns. The public will continue to have the opportunity to provide feedback on the Plan.

Economic Analysis of Mitigation Projects

FEMA's approaches to identify the costs and benefits associated with natural hazard mitigation strategies, measures, or projects, fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. Conducting a benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards can provide decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects.

Given federal funding, the Hazard Mitigation Advisory Committee will use a FEMA-approved benefit/cost analysis approach to identify and prioritize mitigation action items. A copy of a Project Evaluation Worksheet modeled after the STAPPLE cost benefit analysis process preferred by FEMA, is included at the end of Chapter 4. For other projects and funding sources, the Hazard Mitigation Advisory Committee may use other approaches to understand the costs and benefits of each action item and develop a prioritized list. For more information regarding economic analysis of mitigation action items, please see Appendix C of the Plan.

Formal Review Process

The City of Newport Beach Hazards Mitigation Plan is to be evaluated on an annual basis to determine the effectiveness of the programs contained therein, and to reflect any changes in land development or programs that may affect mitigation priorities. The evaluation process includes a firm schedule and time line, and identifies the local agencies and organizations participating in Plan evaluation. The convener, or designee, will be responsible for contacting the Hazard Mitigation Advisory Committee members and organizing the annual meeting. Committee members will be responsible for monitoring and evaluating the progress of the mitigation strategies in the Plan.

The Committee will review the goals and action items to determine their relevance to changing situations in the City, as well as changes in State or Federal policy, and to ensure they are addressing current and expected conditions. The Committee will also review the risk assessment portion of the Plan to determine if this information should be updated or modified, given new available data. The coordinating organizations responsible for the various action items will report on the status of their projects, the success of various implementation processes, difficulties encountered, success of coordination efforts, and which strategies should be revised.

The convener will assign the duty of updating the Plan to one or more of the Steering Committee members. The designated committee members will have three months to make appropriate changes to the Plan before submitting it to the Hazard Mitigation Advisory Committee members, and presenting it to City Council. The Hazard Mitigation Steering Committee will also notify all holders of the City Plan when changes have been made. Every five years the updated Plan will be submitted to the State Hazard Mitigation Officer and the Federal Emergency Management Agency for review.

Implementation through Existing Programs

Given that this Hazard Mitigation Plan is a non-regulatory document its effectiveness depends on the City being able to implement the Plan by incorporating the outlined mitigation action items into existing City plans, policies and programs. The City of Newport Beach addresses statewide planning goals and legislative requirements through its General Plan, Capital Improvement Plans, and City Building and Safety Codes. Fortunately, many of the recommendation and action items in the Hazard Mitigation Plan are closely related to the goals and objectives of existing planning programs. Thus, several of the ongoing and recommended mitigation action items are either being implemented or can be implemented through existing programs and procedures.

More specifically, the City of Newport Beach Community Development, Fire, and Public Works Departments are responsible for administering the Building and Fire Codes, and other regulations designed to improve safety of the community, such as the policies in the Safety

Element of the General Plan. In addition, members of the Hazard Steering Committee work with other agencies at the state level to review, develop and implement Building and Safety Codes that are adequate to mitigate or reduce the damage posed by natural hazards. This ensures that life-safety criteria are met for new construction.

The goals and action items in the Mitigation Plan may be achieved through activities recommended in the City's Capital Improvement Plans (CIP). Various City departments develop CIP plans and review them on an annual basis. Upon annual review of the CIPs, the Hazard Mitigation Advisory Committee will work with the City departments to identify areas that the Hazard Mitigation Plan action items are consistent with CIP planning goals and integrate them where appropriate.

The information on hazards, risk, vulnerability and mitigation methods provided in this updated Plan is based on the best data and technology available at the time this document was prepared. This Disaster Mitigation Plan and the City's General are to be viewed as complementary planning documents that, when used together, can help the City achieve the ultimate goal of reducing its risk to natural hazards. Many of the ongoing recommendations identified herein are mitigation actions also identified in the Safety Element of the General Plan and other adopted plans. The City will continue to coordinate implementation of the recommendations of the Hazard Mitigation Plan with other planning processes and programs including the City's Capital Improvement Program, the City's Building and Fire Codes, and the City's Emergency Operations Plan.

Within six months of formal adoption of the Mitigation Plan, the recommendations listed above will be incorporated into the process of existing planning mechanisms at the City level. The meetings of the Hazard Mitigation Steering and Advisory Committees will provide an opportunity for committee members to report back on the progress made on the integration of mitigation planning elements into City planning documents and procedures.

Progress Made Since Adoption of the 2008 Hazard Mitigation Plan

The City of Newport Beach is committed to reducing the impact that natural hazards can have on its residents, businesses, infrastructure, and critical and essential facilities. With adoption of the 2008 Disaster Mitigation Plan, several goals and action items were identified and targeted for implementation in the short-term, within the next five years. Those action items that were implemented and completed during the 2008-2013 timeframe are listed in Table 5-1 below. Action items that were implemented during the same time period, but that are still being implemented, or are to be implemented on an ongoing basis, as development or re-development occurs, are included in Section 4.

Action Item	Action No. in 2008 Plan
As part of the City's Master Plan, those sections of the water distribution network that are the oldest and therefore more likely to be weakened and corroded have been identified, and have been prioritized for replacement or strengthening.	Short-Term – Multi-Hazard #1
Sections of the water distribution network that are located in areas susceptible to liquefaction and slope instability have been identified, and have been prioritized for replacement	Short-Term – Multi-Hazard #1

and/or strengthening.	
Hoag Hospital has developed and implemented plans to use the water tank in their central plant should they need additional drinking water in the event of a natural disaster.	Short-Term – Multi-Hazard #3
The City moved its Civic Center, including the Fire Department's headquarters and its Emergency Operations Center, to a location that is not susceptible to liquefaction, tsunami runup, or flooding – a significant improvement over the location of the original Civic Center. The new structure was designed to withstand the peak ground motions anticipated in the region.	Short-Term – Multi-Hazard #8 Long-Term – Multi-Hazard #2
The City conducted seismic evaluations of critical and essential facilities to identify the vulnerabilities of public infrastructure and critical facilities, and developed an inventory of critical facilities that do not meet current seismic standards.	Short-Term – Multi-Hazard #10
Adopted a public notification system (reverse 9-1-1) designed to warn residents of a fire or other impending disaster, and provide evacuation instructions.	Multi-Hazard, not included in 2008 Plan
All unreinforced masonry buildings in the City have been retrofitted to minimize damage from seismic events.	Short- Term – Earthquake #2
The City has developed and implemented a response plan for evacuation of low-lying areas in the case of a tsunami warning. This effort includes the installation of warning sirens, signs identifying evacuation routes, and public education training	Short-Term – Flood #2
Developed a tsunami educational program for residents, visitors, and people who work in the tsunami- and rogue wave-susceptible areas. The brochures and other educational materials developed discuss what to expect, what to do in the event of a possible tsunami-generating earthquake, and how to make homes and businesses more flood resistant.	Short-Term – Flood #2
Repetitive flood properties in the City have been reviewed by FEMA to evaluate potential mitigation measures. Flood insurance has been recommended for all of these properties.	Short-Term – Flood #3
A database of parcels in the urban-wildland interface area has been developed and is being maintained.	Short-Term – Wildfire #1
Developed an educational program for Homeowner's Associations (HOAs) meetings and informational mailers that are sent to homeowners adjacent to the Fuel Modification Zone explaining the fire risk in the area and the fuel modification zone requirements.	Short-Term – Wildfire #1
Identified safe evacuation routes for areas at risk from debris flows and landslides.	Short-Term – Landslide #1

SECTION 6: EARTHQUAKES

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SECTION 6: EARTHQUAKES

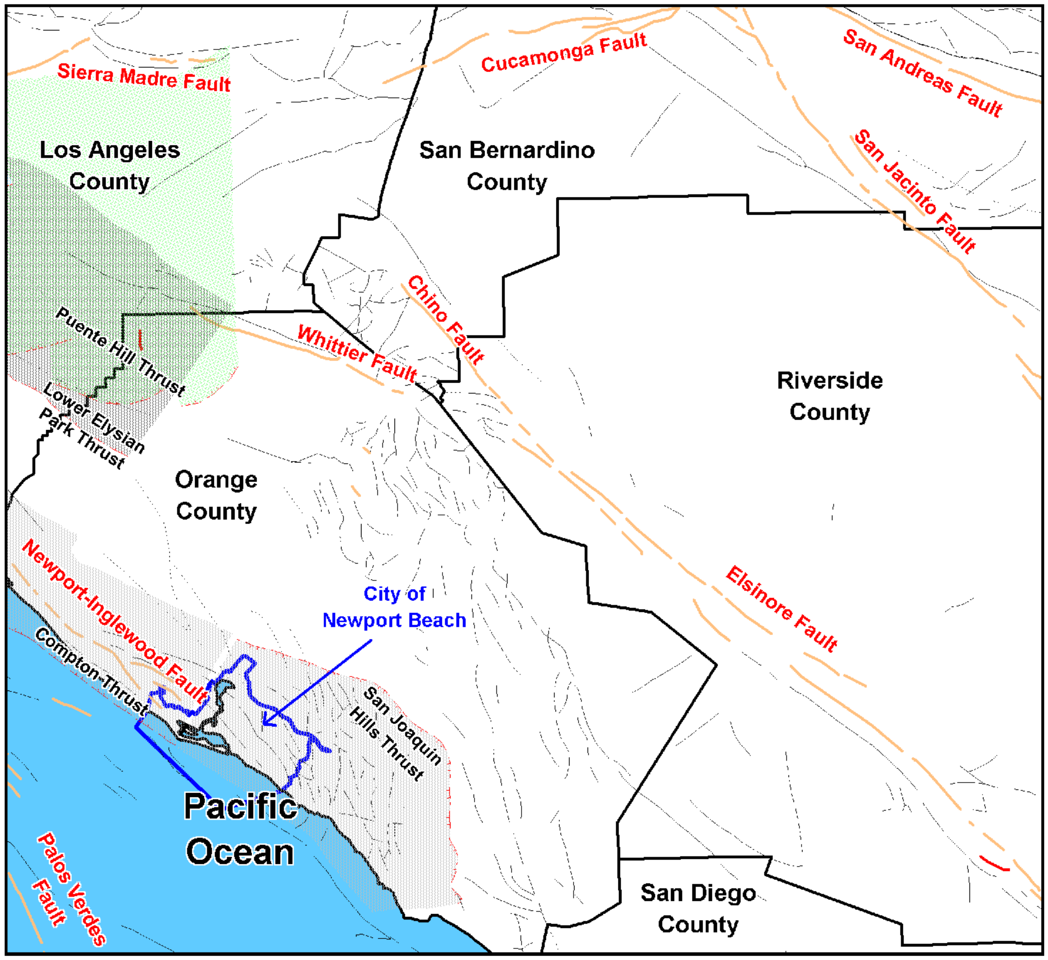
Why Are Earthquakes a Threat to the City of Newport Beach?

While Newport Beach is at risk from several natural and man-made hazards, an earthquake is the event with the greatest potential for far-reaching loss of life or property, and economic damage. This is true for most of Southern California, since damaging earthquakes occur relatively frequently, affect widespread areas, trigger many secondary effects, and can overwhelm the ability of local jurisdictions to respond. Earthquake-triggered geologic effects include ground shaking, surface fault rupture, landslides, liquefaction, subsidence, and seiches. Earthquakes can also cause human-made hazards such as urban fires, dam failures, and toxic chemical releases.

In California, recent earthquakes in or near urban environments have caused relatively few casualties. This is due more to luck than design. For example, when a portion of the Nimitz Freeway in Oakland collapsed at rush hour during the 1989, M_W 7.1 Loma Prieta earthquake, the freeway was uncommonly empty because so many were watching the World Series. The 1994 M_W6.7 Northridge earthquake occurred before dawn, when most people were home safely in bed. Despite such good luck, California's urban earthquakes have resulted in significant losses. The moderate-sized Northridge earthquake caused 54 deaths, more than 1,500 injuries and nearly $30 billion in damage. For days afterward, thousands of homes and businesses were without electricity; tens of thousands had no gas; and nearly 50,000 had little or no water. Approximately 15,000 structures were moderately to severely damaged, which left thousands of people temporarily homeless. Several collapsed bridges and overpasses created commuter havoc on the freeway system. Extensive damage was caused by ground shaking, with shaking-induced liquefaction and dozens of fires after the earthquake causing additional damage. This moderately sized earthquake resulted in record economic losses, and yet Newport Beach is at risk from earthquakes that could release more than ten times the seismic energy of the Northridge earthquake.

Historical and geological records show that California has a long history of seismic events. The state is probably best known for the San Andreas fault, a 750-mile-long fault running from the Mexican border to a point offshore west of San Francisco. Geologic studies show that over the past 1,400 to 1,500 years, large earthquakes have occurred on the southern San Andreas fault at about 130-year intervals. As the last large earthquake on the southern San Andreas occurred in 1857, that section of the fault is considered a likely location for an earthquake within the next few decades. The San Andreas fault, however, is only one of dozens of known faults that underlie southern California. Some of the better-known faults include the Sierra Madre, Newport-Inglewood, Whittier, Elsinore, Hollywood, and Palos Verdes faults. Of these, the Newport-Inglewood fault zone extends through the southwestern portion of Newport Beach (see Map 6.1), whereas the Whittier fault, although not extending through the city is sufficiently close to still cause extensive damage in Newport Beach. Seismologists are in agreement that a magnitude 6.0 to 6.5 earthquake on the Newport-Inglewood fault has the potential to cause more damage and casualties than a "great" quake on the San Andreas fault, because the San Andreas fault is farther away from the urban centers of southern California. There are also several "blind" faults that underlie southern California. ["Blind" faults do not break the surface, but rather occur thousands of feet below the ground. They are not less of a seismic hazard, though.] Newport Beach is underlain by one of these "blind" faults, namely, the San Joaquin Hills fault.

Map 6-1: Faults In and Near Newport Beach



Modified from: Shaw et al., 2002; Dolan, Shaw, and Pratt, 2001; and Jennings, 1995

Map Explanation

- Blind thrust fault ramp; red hatchures show surface projection or upper edge of thrust ramp, the thrust fault ramps are shown from deepest to shallowest by gray and green shading, respectively.
- Fault Showing Evidence of Historic Rupture (Active).
- Fault Showing Evidence of Holocene Rupture (Active).
- Fault Showing Evidence of Quaternary and Late Quaternary Rupture (Potentially Active).

Although great advances in earthquake engineering have been made in the last two decades, in great part as a result of the lessons learned from the 1994 Northridge, California, 1995 Kobe, Japan, 1999 Izmit, Turkey and 1999 Chi-Chi, Taiwan earthquakes, the majority of California communities remain unprepared because there is a general lack of understanding regarding earthquake hazards among Californians. Yet, although it is not possible to prevent earthquakes, their destructive effects can be minimized. Comprehensive hazard mitigation programs that include the identification and mapping of hazards, prudent planning, public education, emergency exercises, enforcement of building codes, and expedient retrofitting and rehabilitation of weak structures can significantly reduce the scope of an earthquake's effects and avoid disaster. Local governments, emergency relief organizations, and residents must take action to develop and implement policies and programs to reduce the effects of earthquakes.

Earthquake Basics - Definitions

The outer 10 to 70 kilometers of the Earth consist of enormous blocks of moving rock, called **plates**. There are about a dozen major plates, which slowly collide, separate, and grind past each other. In the uppermost plates, friction locks the plate edges together, while movement continues at depth. Consequently, the near-surface rocks bend and deform near plate boundaries, storing strain energy. Eventually, the frictional forces are overcome and the locked portions of the plates move. The stored strain energy is released in waves.

By definition, the break or fracture between moving blocks of rock is called a **fault**, and such differential movement produces a **fault rupture**. The place where the fault first ruptures is called the **focus** (or **hypocenter**). The released energy waves radiate out in all directions from the rupture surface, making the earth vibrate and shake as the waves travel through. This shaking is what we feel in an **earthquake**.

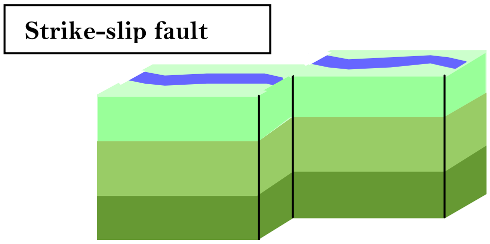
Although earthquakes can occur in areas with no known faults, most earthquakes occur on or near plate boundaries. Given that California straddles the boundary between the North American and Pacific plates, it experiences many earthquakes, and relatively often. The Pacific Plate is moving northwesterly, relative to the North American Plate, at about 50 mm/yr. This is about the rate at which fingernails grow, and seems unimpressive. However, it is enough to accumulate enormous amounts of strain energy over dozens to thousands of years. Despite being locked in place most of the time, in another 15 million years (a short time in the context of the Earth's history), due to plate movements, Newport Beach will be hundreds of kilometers north of San Francisco.

Although the San Andreas fault marks the actual separation between the Pacific and North American plates, only about 70 percent of the plate motion occurs on the San Andreas fault itself. The rest is distributed among other faults of the San Andreas system, including the San Jacinto, Whittier-Elsinore, Newport-Inglewood, Palos Verdes, plus several offshore faults; and among faults of the Eastern Mojave Shear Zone, a series of faults east of the San Andreas fault, that were responsible for the 1992 Landers and 1999 Hector Mine earthquakes. Thus, the zone of plate-boundary earthquakes and ground deformation covers an area that stretches from the Pacific Ocean to Nevada.

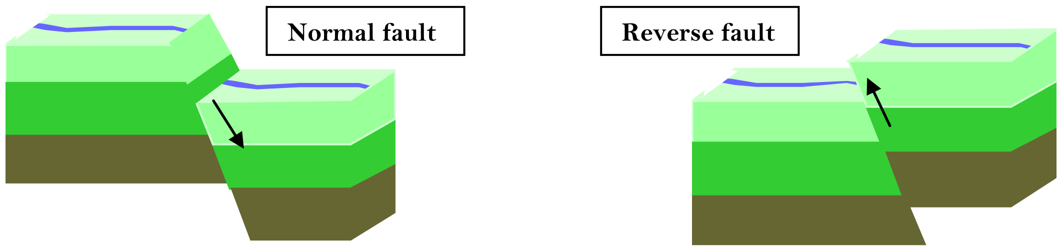
Because the Pacific and North American plates are sliding past each other, with relative motions to the northwest and southeast, respectively, all of the faults mentioned above are aligned northwest-southeast, and are **strike-slip faults** (see Figure 6-1). On average, strike-slip faults are nearly vertical breaks in the rock, and when a strike-slip fault ruptures, the rocks on either side of the fault slide horizontally past each other.

However, about 75 miles northeast of Newport Beach, there is a kink in the San Andreas fault, commonly referred to as the "Big Bend." Near the Big Bend, the two plates do not slide past each other. Instead, they collide, causing localized compression, resulting in folding and **thrust faulting** (see Figure 6-1). Thrust faults meet the surface of the Earth at a low angle, dipping 25 to 45 degrees from the horizontal. Thrusts are a type of **dip-slip fault**, where rocks on opposite sides of the fault move up or down relative to each other. When a thrust fault ruptures, the top block of rock moves up and over the rock on the other side of the fault.

Figure 6-1: Main Types of Faults



Strike-slip faults are vertical or almost vertical rifts where the earth's plates move mostly horizontally. From the observer's perspective, if the opposite block, looking across the fault, moves to the right, the fault is a right- lateral fault; if the block moves left, the fault is a left-lateral fault.



Dip-slip faults are slanted structures where the blocks mostly shift vertically. If the rock above an inclined fault moves down, the fault is called a normal fault; when the rock above the fault moves up, the fault is called a reverse fault. Thrust faults are reverse faults with a dip of 45° or less.

Few faults are simple, planar breaks in the Earth. They more often consist of smaller **strands**, with a similar orientation and sense of movement. Sometimes geologists group strands into **sections** or **segments**, which are believed capable of rupturing together during a single earthquake. The more extensive the fault, the bigger the earthquake it can produce. Therefore, multi-strand fault ruptures generally produce larger earthquakes.

Large-magnitude earthquakes that occur near urban centers have the potential to cause the most damage. Thus, fault dimensions and proximity to urban centers are key parameters in any hazard assessment. In addition, it is important to know a fault's style of movement (i.e. is it dip-slip or strike-slip), the age of its most recent activity, its total displacement, and its slip rate (all discussed below). These values are helpful in estimating how often a fault produces damaging earthquakes, and the size of the earthquake that will be generated the next time that fault ruptures.

Total displacement is the length, measured in kilometers (km), of the total movement that has occurred along the fault over as long a time as the geologic record reveals. It is usually estimated by measuring the distance between geologic features (such as a distinctive rock formation) that have been split apart and separated (**offset**) by the cumulative movement of the fault over many earthquakes. **Slip rate** is a speed, expressed in millimeters per year (mm/yr). Slip rate is estimated by measuring an amount of offset accrued during a known amount of time, obtained by dating the ages of geologic features. Slip rate data also are used to estimate a fault's **earthquake recurrence interval**. Sometimes referred to as "repeat time" or "return interval," the recurrence interval represents the average amount of time that elapses between major earthquakes on a fault. Geologists generally derive the recurrence interval for a fault by excavating a series of trenches across the fault to obtain **paleoseismic** evidence of the earthquakes that have occurred during prehistoric time. If the sediments exposed in the trenches are suitable for dating and the earthquake record is well preserved, geologists can date (typically with a certain margin of error) the past earthquakes, and from that data, develop an average earthquake recurrence interval for that fault segment.

In southern California, ruptures along thrust faults have built the Transverse Ranges geologic province, a region with an east-west trend to its landforms and underlying geologic structures. This orientation is anomalous, virtually unique in the western United States, and a direct consequence of the plates colliding at the Big Bend. Many of southern California's most recent damaging earthquakes have occurred on thrust faults that are uplifting the Transverse Ranges, including the 1971 San Fernando, the 1987 Whittier Narrows, the 1991 Sierra Madre, and the 1994 Northridge earthquakes. In addition to generating stronger ground shaking than a similar-magnitude earthquake on a strike-slip fault, thrust faults are also particularly hazardous because many are **blind**, that is, they do not extend to the surface of the Earth. These blind thrust faults are extremely difficult to detect before they rupture. Some of the most recent earthquakes, like the 1987 Whittier Narrows earthquake, and the 1994 Northridge earthquake, occurred on blind thrust faults.

When comparing the sizes of earthquakes, the most meaningful feature is the amount of energy released. Thus scientists most often consider **seismic moment**, a measure of the energy released when a fault ruptures. We are more familiar, however, with scales of **magnitude,** which measure amplitude of ground motion. Magnitude scales are logarithmic. Each one-point increase in magnitude represents a ten-fold increase in amplitude of the waves as measured at a specific location, and a 32-fold increase in energy. That is, a magnitude 7 earthquake produces 100 times (10 x 10) the ground motion amplitude of a magnitude 5 earthquake. Similarly, a magnitude 7 earthquake releases approximately 1,000 times more energy (32 x 32) than a magnitude 5 earthquake. Scientists now use the **moment magnitude (M_w)** scale to relate energy release to magnitude; this scale has replaced the Richter scale, which is no longer used by seismologists.

An early measure of earthquake size still used today is the seismic **intensity scale**, which is a qualitative assessment of an earthquake's effects at a given location. Although it has limited scientific application, intensity is still widely used because it is intuitively clear and quick to determine. The most commonly used measure of seismic intensity is called the Modified Mercalli Intensity (MMI) scale, which has 12 levels of damage (see Table 6-1).

A given earthquake will have one moment and, in principle, one magnitude, although there are several methods of calculating magnitude, which give slightly different results. However, one earthquake will produce many intensities because intensity effects vary with the location (distance), soil conditions, and perceptions of the observer.

Table 6-1: Abridged Modified Mercalli Intensity Scale

Intensity Value and Description		Average Peak Velocity (cm/sec)	Average Peak Acceleration (g = gravity)
I.	Not felt except by a very few under especially favorable circumstances (I Rossi-Forel scale). Damage potential: None.	<0.1	<0.0017
II.	Felt only by a few persons at rest, especially on upper floors of high-rise buildings. Delicately suspended objects may swing. (I to II Rossi-Forel scale). Damage potential: None.	0.1 – 1.1	0.0017 – 0.014
III.	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel scale). Damage potential: None.		
IV.	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like a heavy truck striking building. Standing automobiles rocked noticeably. (IV to V Rossi-Forel scale). Damage potential: None. Perceived shaking: Light.	1.1 – 3.4	0.014 - 0.039
V.	Felt by nearly everyone; many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel scale). Damage potential: Very light. Perceived shaking: Moderate.	3.4 – 8.1	0.039-0.092
VI.	Felt by all; many frightened and run outdoors. Some heavy furniture moved, few instances of fallen plaster and damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale). Damage potential: Light. Perceived shaking: Strong.	8.1 - 16	0.092 -0.18
VII.	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars. (VIII Rossi-Forel scale). Damage potential: Moderate. Perceived shaking: Very strong.	16 - 31	0.18 - 0.34
VIII.	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed. (VIII+ to IX Rossi-Forel scale). Damage potential: Moderate to heavy. Perceived shaking: Severe.	31 - 60	0.34 - 0.65
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale). Damage potential: Heavy. Perceived shaking: Violent.	60 - 116	0.65 – 1.24
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks. (X Rossi-Forel scale). Damage potential: Very heavy. Perceived shaking: Extreme.	> 116	> 1.24
XI.	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.		
XII.	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into air.		

Modified from Bolt (1999); Wald et al. (1999).

Causes of Earthquake Damage

Causes of earthquake damage can be categorized into three general areas: strong shaking, various types of ground failure that are a result of shaking, and ground displacement along the rupturing fault.

Ground Shaking

Ground shaking is the motion felt on the earth's surface caused by seismic waves generated by the earthquake. It is the primary cause of earthquake damage, and is typically reported as the peak horizontal ground acceleration estimated as a percentage of **g**, the acceleration of gravity. Full characterization of shaking potential, though, requires estimates of peak (maximum) ground displacement and velocity, the duration of strong shaking, and the periods (lengths) of waves that will control each of these factors at a given location. The strength of ground shaking also depends on the source, path, and site effects. Estimates of the ground shaking that different locations in California are likely to experience have been mapped, as shown on Map 6-2.

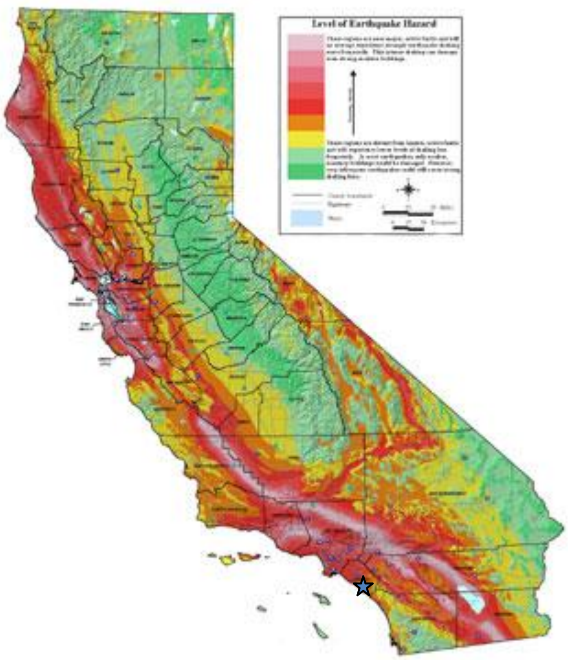
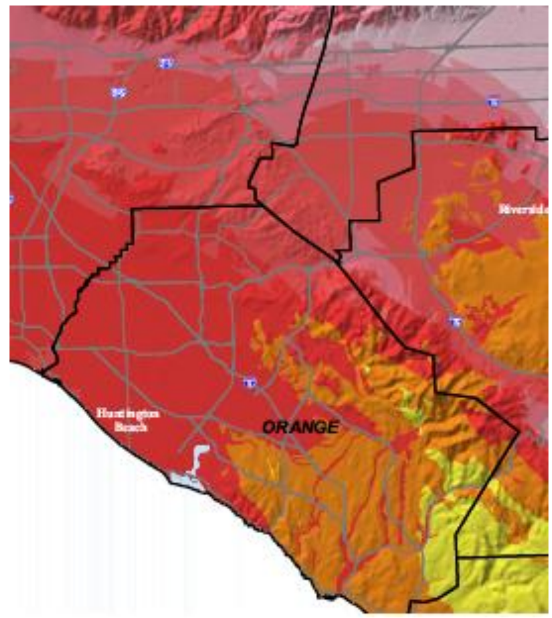
- **Source effects** include earthquake size, location, and distance, plus directivity of the seismic waves (for example, the 1995, M_W 6.9, Kobe, Japan earthquake was not much bigger than the 1994, M_W 6.7 Northridge, California earthquake, but Kobe caused much worse damage. During the Kobe earthquake, the fault's orientation and movement directed seismic waves into the city, whereas during the Northridge earthquake, the fault's motion directed waves away from populous areas.

- **Path effects** refer to how the seismic waves change direction as they travel through the Earth's contrasting layers, just as light bounces (reflects) and bends (refracts) as it moves from air to water. Sometimes seismic energy gets focused into one location and causes damage in unexpected areas (focusing of the seismic waves generated by the 1989 M_W 7.1 Loma Prieta earthquake caused damage in San Francisco's Marina district, some 100 km distant from the rupturing fault).

- **Site effects** refer to how seismic waves interact with the ground surface. Seismic waves slow down in the loose sediments and weathered rock at the Earth's surface; as they slow, their energy converts from speed to amplitude, which heightens shaking (amplification). Therefore, buildings on poorly consolidated and thick soils will typically see more damage than buildings on consolidated soils and bedrock. Amplification can also occur in areas on deep, sediment-filled basins and on ridge tops. Seismic waves can also get trapped at the surface and reverberate (resonate). Whether resonance will occur depends on the period (the length) of the incoming waves – long-period seismic waves, which are created by large earthquakes, are most likely to reverberate and cause damage in long-period structures, like bridges and high-rises. ("Long-period structures" are those that respond to long-period waves.) Shorter-period seismic waves, which tend to die out quickly, will most often cause damage fairly near the fault, and they will cause most damage in shorter-period structures such as one- to three-story buildings. Very short-period waves are most likely to cause near-fault, interior damage, such as to equipment.

Earthquake damage also depends on the characteristics of human-made structures. The interaction of ground motion with the built environment is complex. Governing factors include a structure's height, construction, and stiffness, architectural design, condition, and age.

Map 6-2A: Ground Shaking Zones in California
Map 6-2B: Ground Shaking Zones in Orange County and Surrounding Areas
(Maps show the level of ground shaking with a 10 percent chance of exceedance in 50 years – the pink and red zones can experience higher ground shaking because they are closer to active faults. The blue star in Map 6-2A shows the approximate location of Newport Beach).

Map 6-2A	Map 6-2B
	

Source: http://www.consrv.ca.gov/cgs/rghm/psha/Pages/index.aspx

Liquefaction

Liquefaction typically occurs within the upper 50 feet of the surface, where saturated, loose, fine- to medium-grained soils (sand and silt) are present. Earthquake shaking suddenly increases pressure in the water that fills the pores between soil grains, causing the soil to lose strength and behave as a liquid. This process can be observed at the beach by standing on the wet sand near the surf zone. Standing still, the sand will support your weight. However, when you tap the sand with your feet, water comes to the surface, the sand liquefies, and your feet sink.

Liquefaction-related effects include loss of bearing strength, ground oscillations, lateral spreading and flow failures or slumping. The excess water pressure is relieved by the ejection of material upward through fissures and cracks. When soils liquefy, the structures built on them can sink, tilt, and suffer significant structural damage. Buildings and their occupants are at risk when the ground can no longer support the buildings.

Earthquake-Induced Landslides and Rockfalls

Earthquake-induced landslides and rockfalls are secondary earthquake hazards that occur from ground shaking. Gravity inexorably pulls hillsides down, and earthquake shaking enhances this on-going process. Landslides and rockfalls can destroy roads, buildings, utilities, and other critical facilities necessary to respond and recover from an earthquake. Many communities in southern

California with steep slopes have a high likelihood of being impacted by earthquake-induced landslides or rockfalls.

Fault Rupture

Primary ground rupture due to fault movement typically results in a relatively small percentage of the total damage in an earthquake, yet being too close to a rupturing fault can result in extensive damage. It is difficult to safely reduce the effects of this hazard through building and foundation design. Therefore, the primary mitigation measure is to avoid active faults by setting structures back from the fault zone. Application of this measure is subject to the requirements of the Alquist-Priolo Earthquake Fault Zoning Act and guidelines established by the California Geological Survey – previously known as the California Division of Mines and Geology – and the State Mining and Geology Board.

History of Earthquake Events in Southern California

To better understand earthquake hazards, scientists study past earthquakes by looking at their records, and by studying the effects that past earthquakes had on the ground surface and the built environment. Historical earthquake records are either from the instrumental period (since about 1932, when the first seismographs were deployed), or pre-instrumental. In the absence of instrumentation, the detection and record of earthquakes are based on observations and felt reports, and are dependent upon population density and distribution. Since California was sparsely populated in the 1800s, our record of pre-instrumental earthquakes is relatively incomplete. However, two very large earthquakes, the Fort Tejon in 1857 (M7.9) and the Owens Valley in 1872 (M7.6), are evidence of the tremendously damaging potential of earthquakes in southern California. More recently, two M7.3 earthquakes struck southern California, in Kern County (1952) and Landers (1992), and a M7.1 earthquake struck the Mojave Desert (Hector Mine, in 1999). The damage from these five large earthquakes was limited because they occurred in sparsely populated areas. A similarly sized earthquake closer to southern California's population centers has the potential to place millions of people at risk.

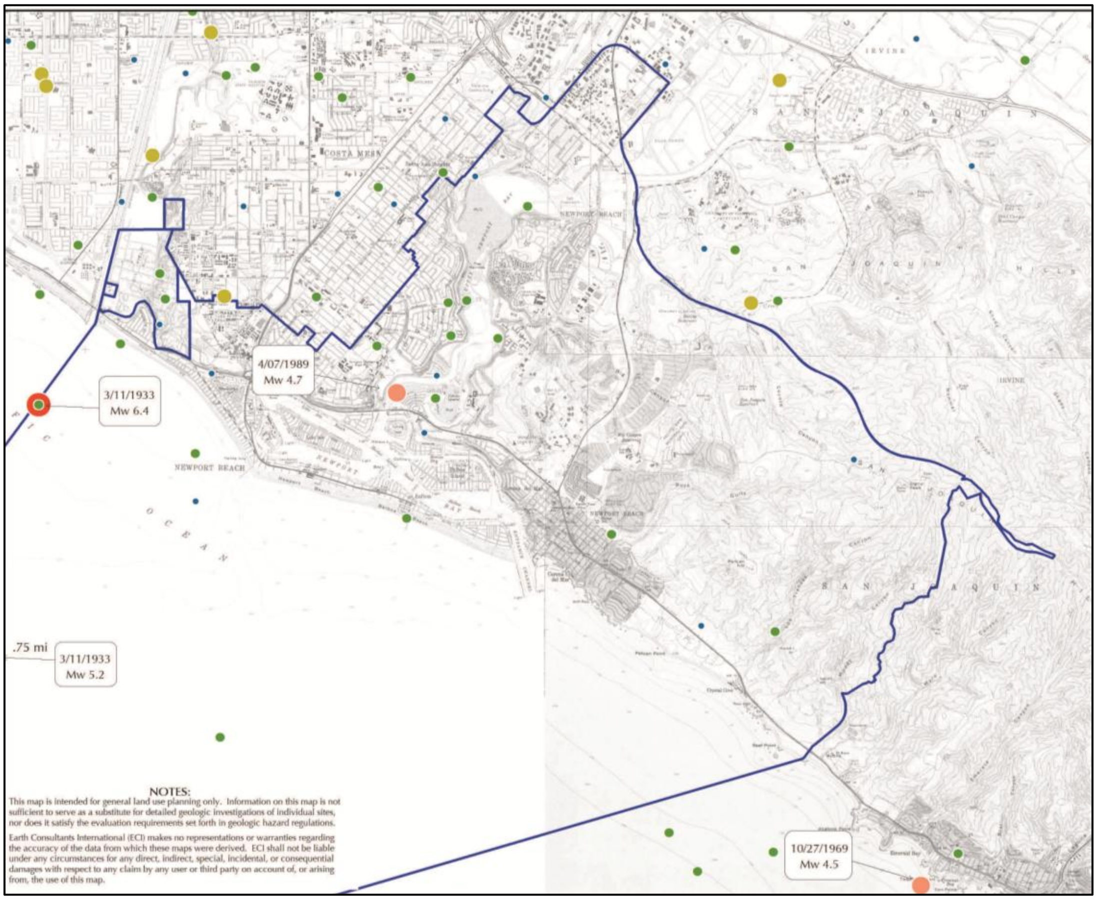
Since seismologists started recording and measuring earthquakes, there have been tens of thousands of recorded earthquakes in southern California, most with a magnitude below 3.0. These recordings show that only the easternmost portion of southern California may be beyond the reach of a damaging earthquake (see Map 6-2). Table 6-2 lists the moderate to large historical earthquake events that have affected southern California. The most significant of these events, either because they were felt strongly in the Newport Beach area, or because they led to the passage of important legislation, are summarized below. Map 6-3 shows the historical seismicity in the immediate vicinity of Newport Beach. The map shows that small earthquakes, of magnitude between 1 and 3, have occurred historically in the area, but, except for the 1933 earthquake, no other moderate to large earthquakes have occurred beneath Newport Beach in historical times.

Table 6-2: Historical (1769 – March 2014) Earthquakes in the Southern California Region with Magnitudes > 5.0

1769	Orange County - Los Angeles Basin	1941	Wilmington
1800	San Diego Region	1943	Big Bear Lake Region
1812	Wrightwood	1944	Desert Hot Springs – Cabazon Region
1812	Santa Barbara Channel	1947	Desert Hot Springs – Yucca Valley Region
1827	Los Angeles Region, offshore Malibu	1951	San Clemente Island
1852	Fort Tejon area, east of Lebec	1952	Tehachapi, Kern County Region
1855	Los Angeles Region	1952	Tehachapi aftershocks
1857	Great Fort Tejon Earthquake	1954	West of Wheeler Ridge
1858	San Bernardino Region	1968	Near Santa Cruz Island
1862	San Diego Region	1969	Offshore San Nicolas Island
1880	Moreno Valley – Perris Region	1970	Lytle Creek, east of Mount Baldy
1883	West of Frazier Park	1971	San Fernando
1889	Mountains north of Morongo Valley	1971	San Fernando aftershocks
1892	San Jacinto or Elsinore Fault	1973	Point Mugu
1893	Pico Canyon	1978	Offshore Santa Barbara
1894	Lytle Creek Region	1981	Offshore, Channel Islands Region
1894	San Diego Region	1986	North Palm Springs
1899	Lytle Creek region	1987	Whittier Narrows
1899	San Jacinto and Hemet	1987	Whittier Narrows aftershock
1899	San Jacinto and Hemet aftershocks	1988	Between Lebec and Tehachapi
1905	San Bernardino Region	1990	Claremont area
1907	San Bernardino Region	1991	North of Pasadena
1910	Glen Ivy Hot Springs	1992	Landers
1912	Offshore, west of Malibu	1992-199	Landers aftershocks
1916	Tejon Pass Region	1992	Big Bear
1918	San Jacinto	1994	Northridge
1923	San Bernardino Region	1994	Northridge aftershocks
1925	Santa Barbara	1997	West of Santa Clarita
1925	Santa Barbara aftershocks	1999	Hector Mine
1926	Mountains north of Carpinteria	1999	Hector Mine aftershocks
1930	Offshore Malibu	2005	Southeast of Anza
1930	Seven Oaks Dam area, two events	2005	South shores of Salton Sea
1933	Long Beach	2008	Chino Hills
1933	Long Beach aftershocks	2010	Baja California, South of Mexicali
1935	Mountains north of Morongo Valley	2010	Baja California aftershocks
1938	Santa Ana Mountains	2010	Northwest of Borrego Springs
1940	Mountains north of Northridge	2012	North of Brawley
1941	Carpinteria and Santa Barbara	2012	North of Brawley
1941	Lebec	2014	La Habra

Map 6-3: Historical Seismicity in Newport Beach (1855- March 2014)

(Blue circles represent earthquakes of magnitude 1-2; green circles represent earthquakes of magnitude 2-3; yellow circles are magnitude 3-4 earthquakes; orange circles are magnitude 4-5 earthquakes; and red circle shows epicenter of 1933 M_w 6.4 earthquake. For a larger version of this map, refer to Plate H-2 in Appendix H.)



Unnamed Earthquake of 1769

On July 28, 1769 the first recorded earthquake in southern California was noted by the Spanish explorers traveling north with Gaspar de Portolá. At the time of the earthquake, the explorers were camped about 10 miles north of present-day Newport Beach, on the east bank of the Santa Ana River. Father Juan Crespo, who kept a daily account of the expedition, reported a strong mainshock followed by five days of moderate aftershocks; an estimated magnitude of at least 6.0 has been assigned to the event based on the explorers' account (Teggart, 1911). The source for this earthquake is unknown, and is still being debated by the paleoseismology community. Some researchers have suggested that this earthquake, of possible magnitude 7.3, may have caused coastal uplift in the northern Orange County region, with the causative fault being the blind thrust under the San Joaquin Hills (Grant et al., 2002). The nearby Elsinore and Newport-Inglewood faults are also considered possible sources for this earthquake.

Unnamed Earthquake of 1800

An earthquake with an estimated magnitude of 6.5 occurred on November 22, 1800 in the coastal region of southern California. Based on the distribution of damage attributed to the earthquake, the epicenter is thought to have been between Newport Beach and San Diego, and was possibly located offshore (Ellsworth, 1990). The earthquake damaged the mission at San Juan Capistrano, located less than 20 miles from present-day Newport Beach and collapsed a barracks in San Diego (www.sfmuseum.org/alm/quakeso.html).

Wrightwood Earthquake of December 12, 1812

This large earthquake occurred on December 8, 1812 and was felt throughout southern California. Based on accounts of damage recorded at missions in the earthquake-affected area, an estimated magnitude of 7.5 has been calculated for the event (Toppozada et al., 1981). Subsurface investigations and tree ring studies show that the earthquake likely ruptured the Mojave section of the San Andreas fault near Wrightwood, and may have been accompanied by a significant surface rupture between Cajon Pass and Tejon Pass (Jacoby, Sheppard and Sieh, 1988; www.scecdc.scec.org/quakedex.html). The worst damage caused by the earthquake occurred significantly west of the San Andreas fault at San Juan Capistrano Mission, where the roof of the church collapsed, killing 40 people. The earthquake also damaged walls and destroyed statues at San Gabriel Mission and damaged missions in the Santa Barbara area. Strong aftershocks caused earthquake-damaged buildings to collapse for several days after the mainshock.

Unnamed Earthquake of December 21, 1812

The Wrightwood earthquake was followed by a strong earthquake on December 21st that caused widespread damage in the Santa Barbara area. The effects of this second earthquake are sometimes attributed to the December 12th event, giving the impression that a single large earthquake caused significant damage from Santa Barbara to San Diego. The second earthquake had an estimated magnitude 7 and was likely located offshore, within the Santa Barbara Channel, although it may have occurred inland, in Santa Barbara or Ventura counties (www.scecdc.scec.org/quakedex.html). The earthquake destroyed the church at the Mission in Santa Barbara, the Mission of Purísima Concepción near present-day Lompoc, and the Mission at Santa Inéz (www.johnmartin.com/eqs/00000077.htm). The earthquake also caused a tsunami that may have traveled up to 1/2 mile inland near Santa Barbara (see Section on Flood Hazards).

Unnamed Earthquake of 1855

This earthquake occurred on July 11, 1855 and was felt across southern California from Santa Barbara to San Bernardino. Light to moderate damage was reported in the Los Angeles area, where 26 houses experienced cracked walls and the bell tower of the San Gabriel Mission was knocked down (www.sfmuseum.org/alm/quakeso.html). Because damage was limited primarily to the Los Angeles area, this earthquake is postulated to have occurred on a local fault such as the Hollywood, Raymond, Whittier or Newport-Inglewood faults, or on one of the many blind thrust faults that underlie this area.

San Jacinto Earthquake of 1899

This earthquake occurred at 4:25 in the morning on Christmas Day, in 1899. The main shock is estimated to have had a magnitude of 6.5. Several smaller aftershocks followed the main shock, and in the town of San Jacinto, as many as thirty smaller tremors were felt throughout the day. The epicenter of this earthquake is not well located, but damage patterns suggest it occurred near the town of San Jacinto, with the causative fault most likely being the San Jacinto fault. Both the towns of San Jacinto and Hemet reported extensive damage, with nearly all brick buildings either badly damaged or destroyed. Six people were killed in the Soboba Indian Reservation as a result of falling adobe walls. In Riverside, chimneys toppled and walls cracked (Claypole, 1900). The main earthquake was felt over a broad area that included San Diego to the southwest, Needles to the northeast, and Arizona to the east. No surface rupture was reported, but several large “sinks” or subsidence areas were reported about 10 miles to the southeast of San Jacinto.

Elsinore Earthquake of 1910

This magnitude 6 earthquake occurred on May 15, 1910 at 7:47 A.M. Pacific Standard Time, following two moderate tremors that occurred on April 10 and May 12, 1910. The Glen Ivy North section of the Elsinore fault is thought to have caused the earthquake, although no surface rupture along this fault was reported at the time. Damage as a result of this earthquake was minor; toppled chimneys were reported in the Corona, Temescal and Wildomar areas, and a 14-inch offset in a cement flume is also attributed to this event (Brake, 1987; Rockwell and Brake, 1987). The epicentral location of this earthquake is very poorly defined, a direct result of the area being scarcely populated.

San Jacinto Earthquake of 1918

The magnitude 6.8 San Jacinto earthquake occurred on April 21, 1918 at 2:32 P.M. Pacific Standard Time, near the town of San Jacinto. The earthquake caused extensive damage to the business districts of San Jacinto and Hemet, where many masonry structures collapsed, but because it occurred on a Sunday, when these businesses were closed, the number of fatalities and injuries was low. Several people were injured, but only one death was reported. Minor damage as a result of this earthquake was reported outside the San Jacinto area, and the earthquake was felt as far away as Taft (west of Bakersfield), Seligman (Arizona), and Baja California.

Long Beach Earthquake of 1933

This M_w 6.4 earthquake occurred on March 10, 1933, at 5:54 in the afternoon, following a strong foreshock the day before. The location of the earthquake's epicenter has been re-evaluated, and determined to have occurred approximately 3 miles south of present-day Huntington Beach, offshore of Newport Beach (see Map 6.3). However, it caused extensive damage in Long Beach, hence its name. The earthquake occurred on the Newport-Inglewood fault, a right-lateral strike slip fault that extends across the western portion of the Los Angeles basin. The Newport-Inglewood fault did not rupture the surface during this earthquake, but substantial liquefaction-induced damage was reported. The earthquake caused 120 deaths, and over $50 million in property damage (Wood, 1933). In the Newport Beach area, the earthquake produced Modified Mercalli Intensities of VII-VIII (http://pasadena.wr.usgs.gov/shake/ca/). Many strong aftershocks occurred through March 16th.

Although primary ground rupture of the Newport-Inglewood fault was not observed, secondary cracking, minor slumping, and lateral movement of unconsolidated sediments occurred throughout the region. Road surfaces along the shore between Long Beach and Newport Beach were damaged by settlement of road fills that had been placed on marshy land. In urban areas, unreinforced masonry buildings were most severely damaged, especially in areas of artificial fill or water-soaked alluvium. In one part of Compton, most buildings built on unconsolidated sediments and artificial fill were destroyed. In Long Beach, many buildings collapsed, were pushed off their foundations, or had walls or chimneys knocked down. In Newport Beach, 800 chimneys were knocked down at the roofline and hundreds of houses were destroyed (www.anaheimcocom.com/quake.htm). As a result, building codes were improved. Damage to school buildings was especially severe; fortunately, children were not present in the classrooms at that time, otherwise, the death toll would have been much higher. This earthquake led to the passage of the Field and Riley Acts by the State legislature. The Field Act regulates school construction, and gives the Division of the State Architect authority and responsibility for approving the design and supervising the construction of public schools. The Riley Act regulates the construction of buildings larger than two-family dwellings.

Torrance-Gardena Earthquakes of 1941

In 1941, two small earthquakes struck the southern Los Angeles basin, affecting surrounding communities. Although these earthquakes were relatively minor, they occurred close to the surface and caused significant, although localized damage. The magnitude 4.8 Torrance earthquake occurred on October 21st at 10:57 P.M., Pacific Standard Time and was located east of Carson, near the present-day interchange of the 405 and 710 freeways. Shaking up to intensity level VII was reported in the communities of Wilmington, Gardena, Lynwood, Hynes and Signal Hill where walls were cracked and chimneys damaged. In some cases, houses that had not been adequately repaired after the 1933 Long Beach earthquake were damaged again. No injuries were reported and damage estimates totaled $100,000 (www.scecdc.scec.org/quakedex.html).

A second earthquake occurred less than a month later, on November 14 at 12:42 A.M. Pacific Standard Time, near Wilmington. Shaking during the second earthquake was reportedly stronger than the first, locally reaching intensity level VIII (Table 6-1) and felt as far away as Cabazon, Carpinteria, and San Diego. Gas and water mains burst near the epicenter and storefronts in the business districts of Torrance and Gardena collapsed, crushing parked cars. Damage to local oilfields was significant - well casings and equipment were damaged and a 55,000 gallon oil tank ruptured, flooding nearby streets with oil. Production of several wells was lowered or stopped. No injuries were reported, although damage attributed to the second event totaled one million dollars (www.scecdc.scec.org/quakedex.html).

San Fernando (Sylmar) Earthquake of 1971

This M_w 6.6 earthquake occurred on the San Fernando fault zone, the western-most segment of the Sierra Madre fault, on February 9, 1971, at 6:00 in the morning. The surface rupture caused by this earthquake was nearly 12 miles long, and occurred in the Sylmar-San Fernando area, approximately 55 miles (88 km) northwest of Newport Beach. The maximum slip measured at the surface was nearly 6 feet.

The earthquake caused over $500 million in property damage and 65 deaths. Most of the deaths occurred when the Veteran's Administration Hospital collapsed. Several other hospitals, including the Olive View Community Hospital in Sylmar suffered severe damage. Newly constructed freeway overpasses also collapsed, in damage scenes similar to those that occurred 23 years later during the 1994 Northridge earthquake. Loss of life could have been much greater had the earthquake struck at a busier time of day. As with the Long Beach earthquake, legislation was passed in response to the damage caused by the 1971 earthquake. In this case, the building codes were strengthened and the Alquist Priolo Special Studies (now Earthquake Fault Zone) Act was passed in 1972.

Oceanside Earthquake of 1986

This magnitude 5.4 earthquake occurred on the morning of July 13, 1986 at 6:47 A.M. Pacific Daylight Time. The epicenter was about 32 miles offshore Oceanside and occurred on an unidentified fault that may be related to the San Diego Trough or the Palos Verdes-Coronado Bank fault zones (www.scecdc.scec.org/quakedex.html). One death and at least 29 injuries are attributed to this relatively small earthquake, which was felt throughout the coastal communities of southern California. At least 50 buildings were damaged from Newport Beach to San Diego, with damage estimates totaling nearly one million dollars.

Whittier Narrows Earthquake of 1987

The Whittier Narrows earthquake occurred on October 1, 1987, at 7:42 in the morning, with its epicenter located approximately 27 miles (43 km) northwest of Newport Beach (Hauksson and Jones, 1989). This magnitude 5.9 earthquake occurred on a previously unknown, north-dipping concealed thrust fault (blind thrust) now called the Puente Hills fault (Shaw and Shearer, 1999). The earthquake caused eight fatalities, over 900 injured, and $358 million in property damage. Severe damage was confined mainly to communities east of Los Angeles and near the epicenter. Areas with high concentrations of unreinforced masonry (URM) buildings, such as the "uptown" district of Whittier, the old downtown section of Alhambra, and the "Old Town" section of Pasadena, were severely impacted. Several tilt-up buildings partially collapsed, including tilt-up buildings built after 1971, that were built to meet improved building standards, but were of irregular configuration, revealing seismic vulnerabilities not previously recognized. Residences that sustained damage usually were constructed of masonry, were not fully anchored to their foundations, or were houses built over garages with large openings. Many chimneys collapsed and in some cases, fell through roofs. Wood-frame residences, in contrast, sustained relatively little damage, and no severe structural damage to high-rise structures in downtown Los Angeles was reported.

Newport Beach Earthquake of 1989

A small, magnitude 4.7 earthquake struck the city of Newport Beach at 1:07 P.M. Pacific Daylight Time on April 7, 1989 (www.scecdc.scec.org/quakedex.html). The earthquake did not rupture the surface or cause any significant damage, but is notable because it occurred on the Newport-Inglewood fault system directly below the city of Newport Beach (see Map 6-3).

Landers and Big Bear Earthquakes of 1992

On the morning of June 28, 1992, most people in southern California were awakened at 4:57 by the largest earthquake to strike California in 40 years. Named "Landers" after a small desert community near its epicenter, the earthquake had a magnitude of 7.3. Centered in the Mojave Desert, approximately 120 miles from Los Angeles, the earthquake caused relatively little damage for its size (Brewer, 1992). It released about four times as much energy as the very destructive Loma Prieta earthquake of 1989, but fortunately, it did not claim as many lives (one child died when a chimney collapsed). The power of the earthquake was illustrated by the length of the ground rupture it left behind. More than 50 miles of surface rupture occurred as a result of this earthquake. The earthquake ruptured five separate faults: Johnson Valley, Landers, Homestead Valley, Emerson, and Camp Rock faults (Sieh et al., 1993). Other nearby faults also experienced triggered slip and minor surface rupture. The average right-lateral strike-slip displacement was about 10 to 15 feet, with a maximum of up to 18 feet observed. Modified Mercalli Intensities of III were reported in the Newport Beach area as a result of this earthquake (http://pasadena.wr.usgs.gov/shake/ca/).

The magnitude 6.4 Big Bear earthquake struck little more than 3 hours after the Landers earthquake on June 28, 1992 at 8:05:30 A.M. PDT. This earthquake is technically considered an aftershock of the Landers earthquake (indeed, the largest aftershock), although the Big Bear earthquake occurred over 20 miles west of the Landers rupture, on a fault with a different orientation and sense of slip than those involved in the main shock. From its aftershock, the causative fault was determined to be a northeast-trending left-lateral fault. This orientation and slip are considered "conjugate" to the faults that slipped in the Landers rupture. The Big Bear earthquake did not break the ground surface, and, in fact, no surface trace of a fault with the proper orientation has been found in the area. The Big Bear earthquake caused a substantial amount of damage in the Big Bear area, but fortunately, it claimed no lives. However, landslides were triggered by the quake blocked roads in the mountainous areas, aggravating the clean-up and rebuilding process (www.scecdc.scec.org/quakedex.html).

Northridge Earthquake of 1994

The Northridge Earthquake of January 17, 1994 woke up most of southern California at 4:30 in the morning. The earthquake's epicenter was located 20 miles to the west-northwest of downtown Los Angeles, on a previously unknown blind thrust fault now called the Northridge (or Pico) Thrust. Although moderate in size, this earthquake produced the strongest ground motions ever instrumentally recorded in North America. The M_w 6.7 earthquake is one of the most expensive natural disasters to have impacted the United States. Damage was widespread, sections of major freeways collapsed, parking structures and office buildings collapsed, and numerous apartment buildings suffered irreparable damage. Damage to wood-frame apartment houses was very widespread in the San Fernando Valley and Santa Monica areas, especially to structures with "soft" first floor or lower-level parking garages. The high accelerations, both vertical and horizontal, lifted structures off of their foundations and/or shifted walls laterally. The death toll was 57, and more than 1,500 people were seriously injured. Although most damage was focused in the northern Los Angeles area, intensities of V-VI (Table 6-1) were recorded in the Newport Beach area, causing scattered light to moderate damage. Despite the losses, gains made through earthquake hazard mitigation efforts of the last two decades were obvious. Retrofits of masonry building helped reduce the loss of life, hospitals suffered less structural damage than in 1971 San Fernando earthquake, and emergency response was exemplary.

Hector Mine Earthquake of 1999

Southern California's most recent large earthquake was a widely felt magnitude 7.1. It occurred on October 18, 1999, in a remote region of the Mojave Desert, 47 miles east-southeast of Barstow. Modified Mercalli Intensities of IV (Table 6-1) were reported in the Newport Beach area (http://pasadena.wr.usgs.gov/shake/ca/). The Hector Mine earthquake is not considered an aftershock of the M 7.3 Landers earthquake of 1992, although Hector Mine occurred on similar, north-northwest trending strike-slip faults within the Eastern Mojave Shear Zone. Geologists documented a 25-mile (40-km) long surface rupture and a maximum right-lateral strike-slip offset of about 16 feet on the Lavic Lake fault.

Chino Hills Earthquake of 2008

A magnitude 5.4 earthquake occurred in the Chino Hills area south of Diamond Bar on July 29, 2008 at 11:42 AM PDT. The characteristics of the shaking indicate that the earthquake was caused by oblique-reverse faulting, meaning that the motion had components of both thrust and strike-slip. The source of the earthquake, which originated approximately 9 miles (14.5 km) below the ground surface, was assigned to a structure referred to as the "Yorba Linda trend." The shaking was felt throughout the Los Angeles basin, and as far away as San Diego, Tijuana, and Las Vegas, Nevada. Minor structural damage was reported in some of the older buildings at the California State University, Fullerton, and at the Placentia public library.

Baja California Earthquake of 2010

A magnitude 7.2 earthquake that occurred just south of the U.S. - Mexico border on Easter Sunday, April 4, 2010, at 3:40:42 PM PDT, was felt throughout Mexico, southern California, Arizona, and Nevada. Analysis of the waveforms suggests that there were two sub-events, with the first one rupturing an 18-km section of the Pescadores fault, followed, six to 12 seconds later by a second, larger event on the Borrego fault. Both of these faults are part of the Laguna Salada fault system, which is the southern extension of the Elsinore fault. Surface rupture continued northward to just past the border into California. The main earthquake caused triggered slip of up to a few centimeters on several faults in the Salton Sea area, and as far north as in the Mecca Hills. Secondary effects, including liquefaction, rockfalls and shattering were reported along a wide area in the El Centro and Brawley region, and westward toward San Diego. More than 4,000 aftershocks had been recorded ten days after the main shock (http://www.scsn.org/2010sierraelmayor.html). A peak instrumental ground acceleration of 1.1g was recorded at the Salton Sea. Similar or stronger shaking may have occurred closer to the epicenter, but given the lack of instrumentation in that area, went unrecorded. Many of the aftershocks occurred along the Elsinore, San Jacinto, and the southern extension of the San Andreas fault through the Brawley area. Based on observations reported by many residents, shaking in the Newport Beach area a result of this earthquake was light, in the Modified Mercalli intensity III to IV range (http://earthquake.usgs.gov/earthquakes/dyfi/events/ci/14607652/us/index.html).

La Habra Earthquake of 2014

The magnitude 5.1 earthquake that occurred on Friday, March 28, 2014 at 9:09 PM local time was felt from the Mexican border to the San Joaquin Valley. In Newport Beach, the shaking as a result of this earthquake was reported as weak, consistent with a Modified Mercalli intensity of III. The earthquake, although only moderate in size, caused structural damage to several apartment buildings and a few houses near its epicenter. Water mains and gas lines ruptured in La Habra and Fullerton. As many as 2,000 residents were without power immediately following the earthquake, and approximately 100 customers were still without power almost 24 hours after the temblor. Minor injuries due to broken glass and people trying to leave their residences were reported. The source (fault) for this earthquake is still being investigated by the seismological community; some have suggested the Puente Hills thrust fault, but the northeast trend defined by the hundred plus aftershocks may suggest a previously unknown fault that is somehow related to the Puente Hills thrust fault or the Whittier fault. Additional information regarding the source of this earthquake is anticipated as the seismological community reviews the ground motion data generated by this event.

Earthquake Hazard Assessment

Choosing Earthquakes for Planning and Design

It is often useful to create a **design earthquake scenario** to study the effects of a particular earthquake on a building or a community. Typically, such scenarios have considered the largest earthquake believed possible to occur on a fault or fault segment, referred to as the **maximum magnitude earthquake (M_{max})**. Building codes usually consider other scenarios for the design of structures, using the ground motion with a statistical probability of being exceeded in a given length of time, with different earthquake scenarios considered depending on the application, such as the planned use, lifetime, or importance of a facility. Traditionally, the more critical the structure, the longer the time period used between earthquakes and the larger the design earthquake that has been used. Seismic design parameters in the most recent version of the California Building Code (2013 edition) are based on the **risk-targeted maximum considered earthquake**, with a ground motion that has a 2 percent probability of being exceeded in 50 years and a recurrence interval of about 2,500 years, with an adjustment for risk. Risk is defined as the probability that damage will occur to the proposed structure. Buildings are designed to withstand a 1-percent probability of collapsing in 50 years.. **Seismic design parameters** define what kinds of earthquake effects a structure must be able to withstand. These include peak ground acceleration, duration of strong shaking, the periods of incoming strong motion waves, and the orientation of maximum response of the earthquake's motion.

Geologists, seismologists, engineers, emergency response personnel and urban planners typically have used maximum magnitude and maximum considered earthquakes to evaluate the seismic hazard of a site or area. The assumption is that if we plan for the worst-case scenario, we establish safety margins. As a result, smaller earthquakes, which are more likely to occur, can be dealt with effectively.

As is true for most earthquake-prone regions, many potential earthquake sources pose a threat to Newport Beach. Thus it is also important to consider the overall likelihood of damage from a plausible suite of earthquakes. This approach is called **probabilistic seismic hazard analysis (PSHA)**, and typically considers the likelihood of exceeding a certain level of damaging ground motion that could be produced by any or all faults within a given distance from the site, or city (typically, these analyses consider all seismic sources within 100 km, or 62-miles from the project site).

Regardless of which fault causes a damaging earthquake, there will always be **aftershocks**. By definition, these are smaller earthquakes that happen close to the **mainshock** (the biggest earthquake of the sequence) in time and space. These smaller earthquakes occur as the Earth adjusts to the regional stress changes created by the mainshock. The bigger the mainshock, the greater the number of aftershocks, the larger the aftershocks will be, and the wider the area in which they might occur. On average, the largest aftershock will be 1.2 magnitude units less than the mainshock. This is an average, and there are many cases where the biggest aftershock is larger than the average predicts. The key point is this: any major earthquake will produce aftershocks large enough to cause additional damage, especially to already weakened structures. Consequently, post-disaster response planning must take damaging aftershocks into account.

In California, many agencies are focused on seismic safety issues: the California Geological Survey (CGS), the State's Seismic Safety Commission (SSC), the United States Geological Survey (USGS), the Governor's Office of Emergency Services (Cal OES), the Applied Technology Council (ATC), the California Institute of Technology (Cal Tech), as well as a number of other universities and private foundations. These organizations, in partnership with other State and Federal agencies, have undertaken a rigorous program in California to identify seismic hazards and risks, including active fault identification, ground shaking, ground motion amplification, liquefaction, earthquake induced landslides, and for coastal areas, tsunami inundation zones. Seismic hazard maps have been published and are available for many communities in California through the California Geological Survey. Some of the most significant earthquake-induced hazards with the potential to impact the city of Newport Beach are described below.

Seismic Shaking

Seismic shaking is the seismic hazard that has the greatest potential to severely impact Newport Beach given the City's proximity to several active seismic sources (faults). To give the City a better understanding of the hazard posed by these faults, we performed a deterministic seismic hazard analysis to estimate the Peak Horizontal Ground Accelerations (PHGA) that can be expected at Newport Beach's new City Hall, and at the old City Hall location on Lido Island due to earthquakes occurring on any of the known active or potentially active faults within about 100 km (62 miles) of the City. We also ran the California Geological Survey's interactive probabilistic ground motion analysis to obtain a generalized value of the peak ground motion that could be expected at both of these locations. The difference between these two approaches is that, whereas a deterministic hazard assessment addresses individual sources or scenario events, probabilistic assessments combine all seismic sources and consider the likelihood (or probability) of each source to generate an earthquake. In a probabilistic analysis, a mathematical equation is used to estimate the combined risk posed by all known faults within 62 miles (100 km), and for each fault, a suite of possible damaging earthquakes is considered, each weighed according to its likelihood of occurring in any particular year.

The fault database (including fault locations and earthquake magnitudes of the maximum magnitude earthquakes for each fault) used to conduct these seismic shaking analyses is that used by the California Geological Survey (CGS) and the U.S. Geological Survey (USGS) (Peterson and others, 1996; Cao and others, 2003). Peak ground acceleration (ground shaking) depends on the size of the earthquake, the proximity of the rupturing fault, and local soil conditions. Effects of soil conditions are estimated by use of an attenuation relationship. To develop these relationships, scientists analyze recordings of earthquake shaking on similar soils during earthquakes of various sizes and distances. The peak ground acceleration estimates obtained from these analyses can be then used to provide a general indication of relative earthquake risk at a given site. For individual projects however, site-specific analyses that consider the precise distance from a given site to the various faults in the region, as well as the local near-surface soil types, should be conducted.

The underlying geologic units do make a difference in the ground motions expected in the city. Lido Island, the location of the old Newport Beach City Hall is underlain by soft, unconsolidated estuarine deposits, which can greatly amplify earthquake shaking. The new City Hall location is underlain by older marine sediments that have more shear strength than the estuarine sediments. To quantify the degree of amplification, velocity measurements of earthquake shear-waves and other site-specific sub-surface analyses would be needed. A generalized estimate, however, can be obtained by using any of several attenuation relations that have been developed for soft soils in the western United States. For the purposes of this report, we used deterministic analysis software by Blake (2000), and the attenuation relationships of Boore and others (1997) for a soil with a near-surface shear-wave velocity of 520 meters per second (m/s) for the new City Hall location, and 250 m/s for the old City Hall location. The deterministic analysis yielded a mean peak horizontal ground acceleration (PHGA) value of 0.46g for the new location, and 0.65g for the previous City Hall location. These values show that the new City Hall location is anticipated to experience significantly lower seismic shaking than the older location, although both ground acceleration values are in the moderate to high range (see Table 6-1 and Map 6-2B). The level of shaking calculated for the Lido Island location can be applied to other similar areas in the City, such as Balboa Island and the Newport Bay area, with even higher shaking levels anticipated as a result of an earthquake on the section of the Newport-Inglewood fault that extends through the western portion of the City. Shaking at these levels can cause damage even to newer buildings that are constructed in accordance with more stringent building standards; older structures can be damaged extensively.

Using the level of shaking required for the design of new structures in the most recent building code, the risk-targeted peak ground acceleration for the new City Hall location is 0.615g. This probabilistic ground motion value is in the moderate to high range for southern California (see Maps 6-2A and 6-2B), and reflects the fact that the City is located near several major fault systems with moderate to high earthquake recurrence rates. These levels of shaking can be expected to cause damage, particularly to older and poorly constructed buildings.

Table 6-3 shows:

- The closest approximate distance, in kilometers and miles, between Newport Beach's City Hall (new and prior locations) and each of the main faults considered in the analysis;
- the maximum magnitude earthquake (M_{max}) each fault is estimated capable of generating;
- the intensity of ground motion, expressed as a fraction of the acceleration of gravity (g), that could be experienced in the Newport Beach area if the M_{max} occurs on one of these faults (values given range from the median to median plus 1 sigma standard deviation); and
- the Modified Mercalli seismic Intensity (MMI) values estimated to be felt in the City as a result of the M_{max} on each one of these faults.

In general, peak ground accelerations and seismic intensity values decrease with increasing distance away from the causative fault. However, local site conditions, such as soft soils or the top of ridges, can amplify the seismic waves generated by an earthquake, resulting in localized higher accelerations than those listed here. The strong ground motion values presented here should therefore be considered as average values; higher values may occur locally in response to site-specific conditions.

Those faults that can cause peak horizontal ground accelerations of about 0.1g or greater (Modified Mercalli Intensities greater than VII) in the Newport Beach area are listed in Table 6-3. For a map showing most of these faults, refer to Map 6-1. Those faults included in Table 6-3 that would have the greatest impact on the Newport Beach area, or that are thought to have a higher probability of causing an earthquake, are described in more detail in the following pages.

Table 6-3: Estimated Horizontal Peak Ground Accelerations and Seismic Intensities in the Newport Beach Area (Deterministic Analysis)

Fault Name	Distance to City Hall (km) New, Prior	Distance to City Hall (mi) New, Prior	Magnitude of M_{max} *	PGA (g) from M_{max}	MMI from M_{max}
Newport-Inglewood (LA Basin)	4.8, 0.4	3.0, 0.3	7.1	0.40-1.1	X-XI
San Joaquin Hills Thrust	0 – 5.4	0 – 3.4	6.6	0.46-1.0	X-XI
Newport-Inglewood (Offshore)	5.0, 3.1	3.1, 1.9	7.1	0.42-0.98	X-XI
Compton Thrust	19.4, 14.3	12.1, 9.0	6.8	0.19-0.62	VIII-X
Palos Verdes	23.4, 19.3	14.5, 12.0	7.3	0.18-0.45	VIII-X
Puente Hills Blind Thrust	35.4, 34.7	22.0, 21.6	7.1	0.15-0.32	VIII-IX
Coronado Bank	38.2, 38.7	23.7, 24.0	7.6	0.15-0.32	VIII-IX
Chino-Central Ave. (Elsinore)	30.3, 33.6	18.8, 20.9	6.7	0.10-0.26	VII-IX
Whittier (Elsinore)	33.6, 34.5	20.9, 21.4	6.8	0.10-0.22	VII-VIII
Sierra Madre	58.4, 58.3	36.3, 36.2	7.2	0.06-0.22	VII-IX
San Andreas – Whole Southern	82.6, 84.6	51.3, 52.6	8.0	0.08-0.21	VII-VIII
Anacapa-Dume	86.8, 81.9	53.9, 50.9	7.5	0.04-0.22	VI-VIII
Elsinore-Glen Ivy	34.9, 37.8	21.7, 23.5	6.8	0.10-0.21	VII-VIII
San Andreas – 1857 Rupture	82.6, 84.8	51.3, 52.7	7.8	0.07-0.19	VI-VIII
Rose Canyon	68.2, 72.2	42.4, 44.2	7.2	0.05-0.16	VI-VII
Santa Monica	71.3, 67.1	44.3, 41.7	6.6	0.03-0.15	V-VIII
Malibu Coast	77.0, 72.4	47.8, 45.0	6.7	0.03-0.15	V-VIII
Hollywood	65.7, 62.5	40.8, 38.8	6.4	0.03-0.14	V-VIII

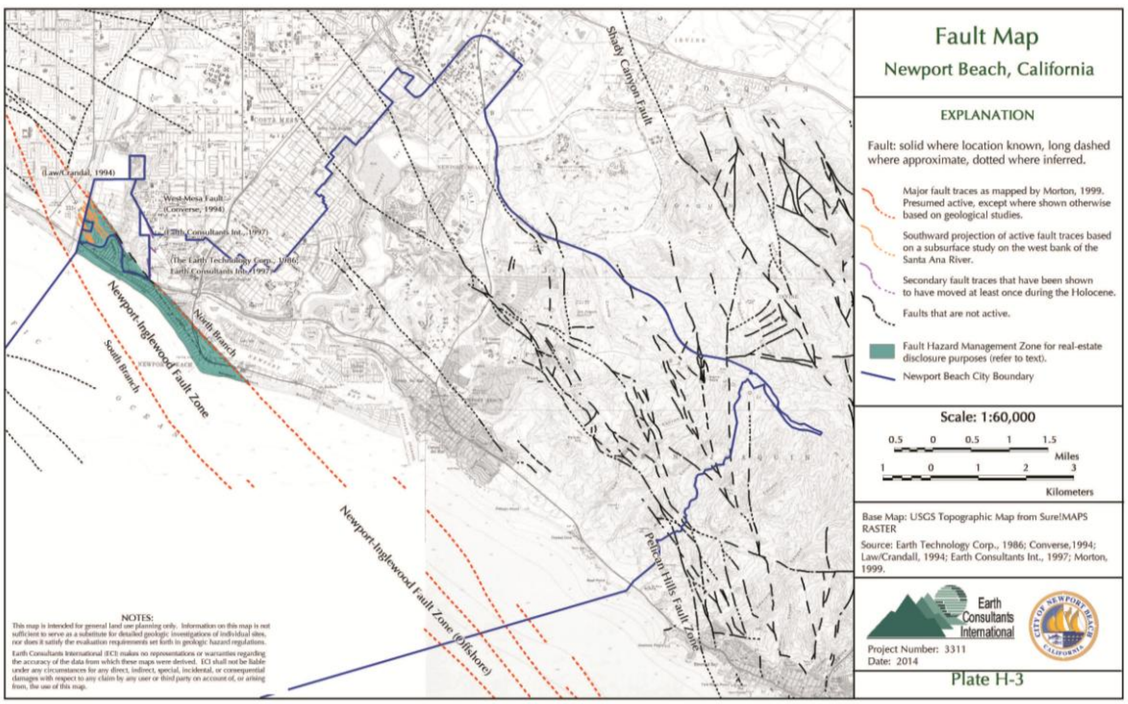
Abbreviations used in Table 6-3:
mi – miles; **km** – kilometer; $\mathbf{M_{max}}$ – maximum magnitude earthquake; **PGA** – peak ground acceleration as a percentage of g, the acceleration of gravity; **MMI** – Modified Mercalli Intensity.
* The M_{max} reported herein are based on the fault parameters published by the CGS (Cao et al., 2003; CDMG, 1996). However, as described further below in the text, recent paleoseismic studies suggest that some of these faults, like the Whittier and Sierra Madre faults, can generate even larger earthquakes than those listed above. In general, areas closer to a given fault will generally experience higher accelerations than areas farther away, therefore, as an example, the northern portion of the city, closer to the Whittier fault, would experience higher accelerations than those reported herein.
Notes: For each of the two locations summarized in Table 6-3, we ran a total of six deterministic analyses using three different attenuation relations, where each attenuation relation was in turn run for the median value, and for an uncertainty equal to the median plus one sigma standard deviation. The attenuation relations used include Boore et al.'s (1997) horizontal PGA relation, Bozorgnia, Campbell and Niazi's (1999) horizontal PGA relation, and Campbell and Bozorgnia (1997 revised) relation. The peak ground accelerations provided encompass the range in ground motions calculated in these runs.
There are several additional faults that could generate low to moderate shaking at the City that are not included in the table above. These include the Raymond, Verdugo, Clamshell-Sawpit, the various segments of the San Jacinto fault, other segments of the San Andreas and Elsinore faults, and the San Gabriel fault.

Newport-Inglewood Fault Zone

The northwest-trending Newport-Inglewood fault zone (NIFZ) is 145 miles long and extends onshore from Santa Monica south to Newport Beach. At Newport Beach, the fault continues offshore and lines up with a deep submarine canyon (Fischer and Mills, 1991) known as the Newport Submarine Canyon. The offshore segment of the fault joins the Rose Canyon fault, which extends southeasterly through San Diego to the international border. The Newport-Inglewood fault zone is discontinuous, consisting of a series of left-stepping en echelon fault strands, each up to 4 miles long. Onshore, the fault zone is marked by a series of uplifts and anticlines including Newport Mesa, Huntington Mesa, Bolsa Chica Mesa, Alamitos Heights and Landing Hill, Signal Hill and Reservoir Hill, Dominguez Hills, Rosecrans Hills, and Baldwin Hills (Barrows, 1974). These anticlines are traps for oil and have been drilled successfully since the beginning of the last century.

The NIFZ extends across the westernmost portion of Newport Beach (see Maps 6-1 and 6-4). In this area, the fault zone is over 1.5 miles wide and consists of many discontinuous primary fault stands and several short secondary fault traces. Several studies in the Newport Beach area and adjacent regions have identified multiple strands of the NIFZ that have displaced Holocene-age terraces and sediments (Converse Consultants, 1994; Shlemon et al., 1995; Grant et al., 1997; Earth Consultants International, 1997).

Map 6-4: Faults Mapped in the Newport Beach Area
(for a larger scale of this map, refer to Plate H-3 in Appendix H)



The slip rate for the NIFZ is poorly constrained at between 0.3 to 3.5 mm/yr. A study by Woodward-Clyde Consultants in 1979 calculated a slip rate of 0.5 mm/yr for the southern onshore segment of the NIFZ. This is consistent with long-term slip rates of 0.31 – 0.52 mm/yr calculated by Freeman et al. (1992) by correlating sediment layers on one side of the fault to a best match on the opposite side of the fault. Paleoseismic studies by Grant et al. (1997) also suggest a slip rate of between 0.34 to 0.55 mm/yr for the onshore segment. Fischer and Mills (1991) estimated a slightly higher slip rate of between 1.3 and 3.5 mm/yr for the offshore segment of the NIFZ between San

Mateo Point and Newport Beach with an earthquake recurrence interval of between 200 and 800 years. Lindvall and Rockwell (1995) calculated a maximum slip rate of 2 mm/yr for the Rose Canyon fault, the southern continuation of the NIFZ.

Paleoseismic studies by Grant et al. (1997) and Shlemon et al. (1995) have shown that the onshore segment of the NIFZ has had three to five ground rupturing earthquakes in the past 11,700 (+/-700 years). This is consistent with the recurrence interval calculated by Fischer and Mills (1991) for the offshore segment of the NIFZ. The last significant earthquake on the NIFZ was the magnitude 6.3 Long Beach earthquake. This earthquake did not break the ground surface. A maximum earthquake of magnitude 7.1 on the onshore segment of the NIFZ has the potential to generate strong ground motions in the Newport Beach area, with peak horizontal ground accelerations of between 0.4g and 1.1g (see Table 6-3). Similarly, a 7.1 earthquake on the offshore segment of the NIFZ could generate peak horizontal ground acceleration in the Newport Beach area of between 0.42g and 0.98g.

San Joaquin Hills Fault

Uplifted marine terraces between Huntington Beach and San Juan Capistrano suggest the presence of a southwest-dipping blind thrust beneath the San Joaquin Hills (see Map 6-1), adjacent to the Newport-Inglewood fault zone (Grant et al., 1999). Based on structural modeling of dated marine terraces, Grant et al. (1999) calculated a slip rate of about 0.42-0.79 mm/yr and a minimum average recurrence interval of about 1,600 to 3,100 years for moderate size earthquakes on this fault. Uplift of late Holocene shorelines and marsh deposits above the active shoreline are attributed to a relatively recent earthquake larger than magnitude 7 on the San Joaquin Hills fault (Grant et al., 2002). Radiocarbon dating and pollen analyses suggest this earthquake occurred between A.D. 1635 and A.D. 1855. Rivero et al. (2000) and Rivero and Shaw (2011) consider this fault to be part of a larger structure that extends offshore to the south. New studies being conducted on this fault zone as of the writing of this report are likely to provide additional information about the activity and seismic hazard posed by these structures.

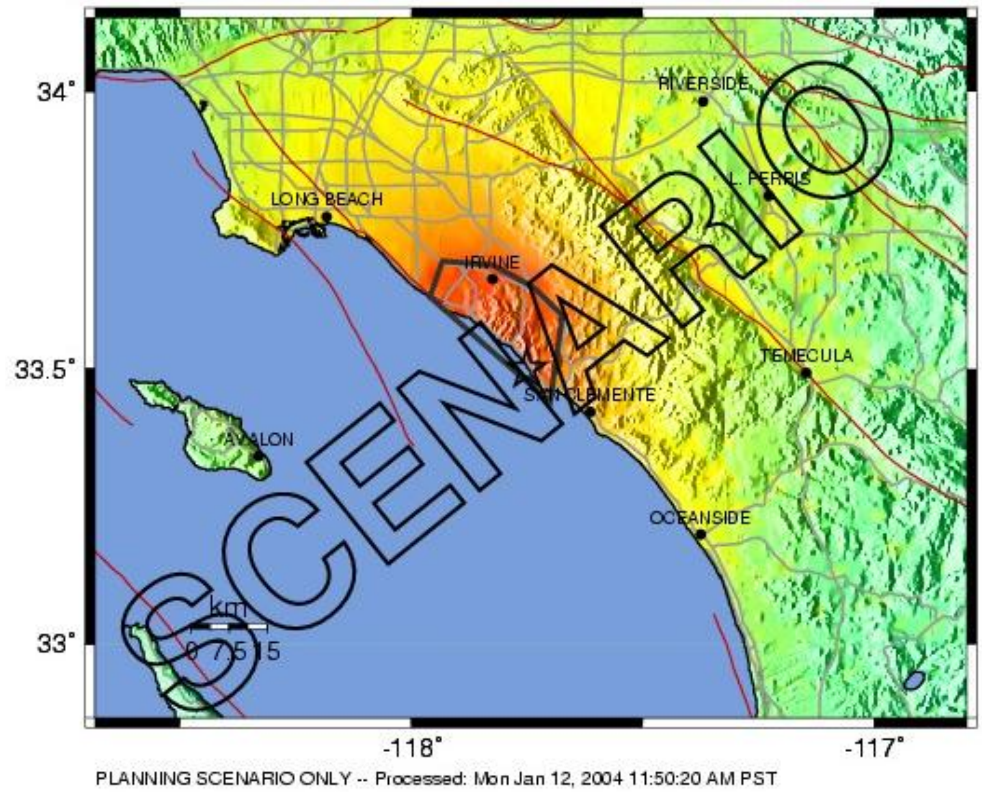
The deterministic analysis conducted for this study indicates that a magnitude 6.6 earthquake on the San Joaquin Hills thrust fault could generate peak horizontal ground accelerations in Newport Beach of between about 0.46g and 1.0g. Modified Mercalli intensities of about X-XI could be expected in the City, as illustrated in Map 6-5, below, and on Table 6-3. A larger, magnitude 7 earthquake on this fault would generate even stronger ground shaking in Newport Beach.

Compton Thrust Fault

The Compton Thrust fault is a blind structure in the southwestern portion of the Los Angeles basin. The fault is part of the Compton-Los Alamitos fault system, postulated to extend over 50 miles from western Santa Monica Bay southeast into northwestern Orange County. Little is known about this fault because it does not break the surface. However, Shaw and Suppe (1996) calculated a slip rate of 1.4 +/- 0.4 mm/yr based on modeling of deep seismic data. In 1997, Mueller reported that geologic structures and units overlying the fault are not deformed, including a 1,900 year-old peat deposit and a 15,000 to 20,000 year-old aquifer, suggesting that the fault is not active. As a result of Mueller's (1997) work, the Compton fault was taken off the CGS active fault database. More recent work, however, suggests that the Compton fault has generated several large-magnitude earthquakes in the Holocene, with a minimum slip rate of about 1.5 mm/yr (Leon et al., 2007; 2009). Oil-well records and seismic lines reviewed by Yeats and Verdugo (2010) show that the Compton-Los Alamitos fault is associated at depth with the Newport-Inglewood fault. In fact, survey records indicate that uplift occurred along the Compton-Los Alamitos trend during the 1933 Long Beach earthquake (Barrows, 1974), indicating that this structure accommodated some of the strain released during that earthquake.

Although associated with the Newport-Inglewood fault, the Compton-Los Alamitos fault is thought capable of generating a thrust-type earthquake on its own. For the purposes of this study, we assumed that the Compton fault has the potential to generate at a minimum a magnitude 6.8 earthquake that would cause peak horizontal ground accelerations of between 0.19g and 0.62g in the City of Newport Beach. Larger magnitude earthquakes (M>7) would generate higher peak accelerations.

Map 6-5: Intensity Map for a Magnitude 6.6 Earthquake Scenario on the San Joaquin Hills Fault



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+

Source: http://earthquake.usgs.gov/eqcenter/shakemap/sc/shake/San_Joaquin_Hills_se/

Palos Verdes Fault Zone

The 80- to 115 km-long Palos Verdes fault zone is located primarily offshore and extends in a southeasterly direction from Santa Monica Harbor to the southern San Pedro Channel (Map 6-1). The short onshore segment of the fault extends for 9 miles (15 km) from Redondo Beach to San Pedro and follows the northeastern flank of the Palos Verdes Hills. Offshore, to the southeast, the fault trends across Los Angeles Harbor, and onto the continental shelf where it splays into two discontinuous sub-parallel strands and continues southeast as the Coronado Bank fault zone. Northwest of Redondo Beach, the fault is thought to end in a horsetail splay in Santa Monica Bay, although some scientists suggest the fault continues northwesterly and joins the Dume fault (Stephenson et al., 1995). The fault is located about 12 miles west-southwest of Newport Beach at its nearest point.

Davis and others (1989) and Shaw and Suppe (1994) modeled the Palos Verdes fault as a southwest-dipping back thrust above a blind thrust. Calculated vertical rates of deformation for the fault based on uplifted marine terraces range from 0.2 to 0.7 mm/yr (Clarke et al., 1985) to 3 mm/yr (Ward and Valensise, 1994). Recent geomorphic studies, however, indicate the fault has a significant right-lateral component. McNeilan et al. (1996) used an offset channel in the Los Angeles Harbor to derive a right-lateral slip rate of 3 mm/yr.

Based on its length and uplift rate, the Palos Verdes fault could produce an earthquake of magnitude 7.3. Given its location relative to the City of Newport Beach, an earthquake of that size could generate ground shaking in the city of about 0.18g to 0.45g, with Modified Mercalli intensities of VIII to X.

Coronado Bank Fault

The 55-mile- (90-km-) long offshore Coronado Bank fault zone is the principal southern continuation of the Palos Verdes fault, extending from the southeast flank of the Lausen Knoll in the southern San Pedro Channel (about 12 miles at its closest approach from Newport Beach) to the La Jolla submarine channel. Bathymetric data show that the fault is well defined by alternating pop-up structures and broad transtensional sags (Legg, 1985; Legg and Kennedy; 1991; Legg and Goldfinger, 2001). Right-lateral motion has been inferred from uplift at left bends in the fault trace and sags at right bends. Little is known about the slip rate or return time of large events on the fault, although a roughly estimated slip rate of 2-3 mm/yr for the Coronado Bank fault zone is based on rates derived on the offshore segment of the Palos Verdes fault. If the Coronado Bank fault zone ruptures producing a maximum magnitude 7.6 earthquake, it could generate peak ground accelerations in Newport Beach of between about 0.15g and 0.32g.

Puente Hills Thrust Fault

In 1999, Shaw and others announced the discovery of a blind thrust fault that extends from northern Orange County to the Los Angeles metropolitan area. The fault does not extend upward to the surface, which is why it is called blind, although it is expressed at the surface by a series of low hills, including the Puente Hills on its eastern end. These hills have risen over the surrounding landscape in response to movement on the underlying fault; Dolan and others (2003) believe that the hills rise 1 to 2 meters (3 to 6 feet) every time the Puente Hills thrust fault breaks in a large magnitude earthquake of M_w 7.2 to 7.5.

Dolan and others' (2003) studies suggest that the fault has experienced four large earthquakes in the past about 11,000 years. Smaller earthquakes that rupture only a section of the fault are also possible, as evidenced by the Whittier Narrows earthquake of 1987, which is now attributed to rupture of a small, deep patch of the Santa Fe Springs segment of the Puente Hills thrust. Thrust faults typically generate stronger ground shaking than strike-slip faults, as the ground above the plane of the fault is moved up and over the underlying plane. Ground shaking from earthquakes on these types of faults is also felt over a broader area, tends to last longer, and has more of the lower frequency seismic waves. All of these characteristics are especially damaging to high-rise buildings and large structures, like freeway overpasses. In fact, a 2005 study on the impact that an earthquake on the Puente Hills fault would have on Los Angeles estimates between 3,000 and 18,000 fatalities, and more than $250 billion in total losses (Field et al., 2005), making this fault "The Big One" for the Los Angeles area. A magnitude 7.1 earthquake on the Puente Hills thrust fault is estimated to generate ground accelerations in the Newport Beach area of between 0.15g and 0.32g; stronger shaking could be experienced if the fault breaks in a larger magnitude earthquake, as indicated above. According to Dolan et al. (2003), this fault last ruptured several thousand years ago, although when exactly is unknown. Therefore, there is the possibility that this fault could rupture again in the not-too-distant future.

Elsinore – Chino - Whittier Fault Zone

The 125-mile (200-km) long Elsinore fault is part of the San Andreas fault system in southern California and accommodates about ten percent of the motion between the Pacific and North American plates (WGCEP, 1995). The fault extends northwesterly from the US-Mexico border to north of the Santa Ana Mountains and is divided, from south to north, into the Coyote Mountain, Julian, Temecula, and Glen Ivy segments. North of the Santa Ana Mountains the fault splits into the Whittier and Chino faults. The fault has historically produced a ~M 6 earthquake on the Glen Ivy segment (Toppozada and Parke, 1982; Rockwell et al., 1986), and a M>6.9 event on the Laguna Salada fault, the southern extension of the Elsinore fault in Mexico (Rockwell, 1989; Mueller and Rockwell, 1995). The Pescadores and Borrego faults, which are considered southern extensions of the Laguna Salada fault, ruptured in 2010, causing the Easter Sunday earthquakes in northern Mexico that were felt over a broad area of southern California. All of these events indicate that the Elsinore fault system is active and capable of producing destructive earthquakes. The 2007 Working Group on California Earthquake Probabilities (WGCEP, 2008) assigned the Elsinore fault an 11 percent probability of rupturing in a M>6.7 earthquake in the next 30 years.

Studies of the Wildomar strand of the Temecula segment yielded minimum late Holocene slip rates of about 4.2 mm/yr (Bergmann et al., 1993). This is roughly consistent with slip rates of about 5 mm/yr derived from dated offset alluvial fan deposits on the Glen Ivy segment to the north (Millman and Rockwell, 1986), and the Julian segment to the south (Vaughan and Rockwell, 1986). Although no individual earthquakes have been directly dated on the Wildomar fault, paleoseismic studies on the Murrieta Creek fault, an oblique-slip fault secondary to the Temecula segment, suggest an average recurrence interval of 300 to 700 years for the Elsinore fault in the Murrieta area. Paleoseismic studies on the southeastern end of the Temecula segment, near Agua Tibia Mountain, however, suggest a longer average recurrence interval of 550 to 600 years for the segment (Vaughan et al., 1999).

The Chino fault bounds the eastern flank of the Chino Hills and extends from the Los Serranos area of Chino Hills southwestward to Corona, for a distance of approximately 13 miles (21 km). For decades, the Chino fault was considered primarily a reverse, potentially active fault, but recent studies have shown that it is primarily a right-lateral strike-slip fault (with a minor reverse component), and that it has moved at least once in the Holocene (the past about 11,000 years) (Treiman, 2002a; Walls and Gath, 2001). Given these findings, the fault was upgraded to active, and zoned under the guidelines of the Alquist-Priolo Earthquake Fault Zone Act (Treiman, 2002a). The Central Avenue fault is to the east of the Chino fault, buried under sediments of the Chino Basin. This fault forms a barrier to ground water but at this time is not thought to be an active structure (Treiman, 2002a).

The rate of slip on the Chino fault is still being resolved. Fault experts believe that the Elsinore fault, which has a slip rate of 5 to 6 mm/yr, is transferring that strain northward onto the Whittier and Chino faults. As discussed further below, studies of the Whittier fault suggest that it has a slip rate of 2 to 3 mm/yr, suggesting that the Chino fault could be carrying a similar amount of strain. However, a paleoseismic study of the Chino fault conducted by Walls and Gath (2001) yielded a late Quaternary slip rate for this fault of only 0.36 to 0.51 mm/yr. If the Chino fault is indeed now slipping at a rate of less then 1 mm/yr, then some of the strain from the Elsinore fault may be responsible for aseismic (not earthquake-induced) folding and uplifting of the Chino (Puente) Hills, and other structures, such as the East Coyote anticline (Bjorklund and Burke, 2002; Myers et al., 2003; Madden and Yeats, 2008). Future studies of the Chino fault are expected to better define its slip rate and potential seismic hazard to the region.

Even with a relatively low rate of slip, the Whittier fault zone is considered one of the most prominent structural features of the Los Angeles basin. The fault zone extends from the Santa River northwestward to the Whittier Narrows area, a distance of approximately 24 miles (38 km). Southeast of the Santa Ana River, the Whittier fault merges with the Elsinore fault. Much of the movement of the Whittier fault is late Pleistocene and younger, as indicated by tilted, locally overturned and faulted bedrock less than 2 million years old, and faulted alluvium.

No major historical earthquakes have been attributed to the Whittier fault. However, trenching studies have documented recurrent movement of this fault in the past 17,000 years (Gath et al., 1992; Patterson and Rockwell, 1993). Based on radiocarbon dating of faulted and unfaulted alluvium exposed in trenches, the two most recent surface rupturing earthquakes on this fault occurred between 1,400 and 2,200 years ago, and 3,000 and 3,100 years ago, respectively (Patterson and Rockwell, 1993). These values give a minimum recurrence interval of 760 (+640, -274) years (WGCEP, 1995). Since a minimum of at least 1,400 years has passed since the last surface-rupturing event occurred on the Whittier fault, the fault is thought to be at or near the end of its cycle and is therefore likely to generate an earthquake in the not too distant future. Based on these trenching studies, the Whittier fault is thought to be moving at a rate of about 2.5 +/- 1 mm/yr.

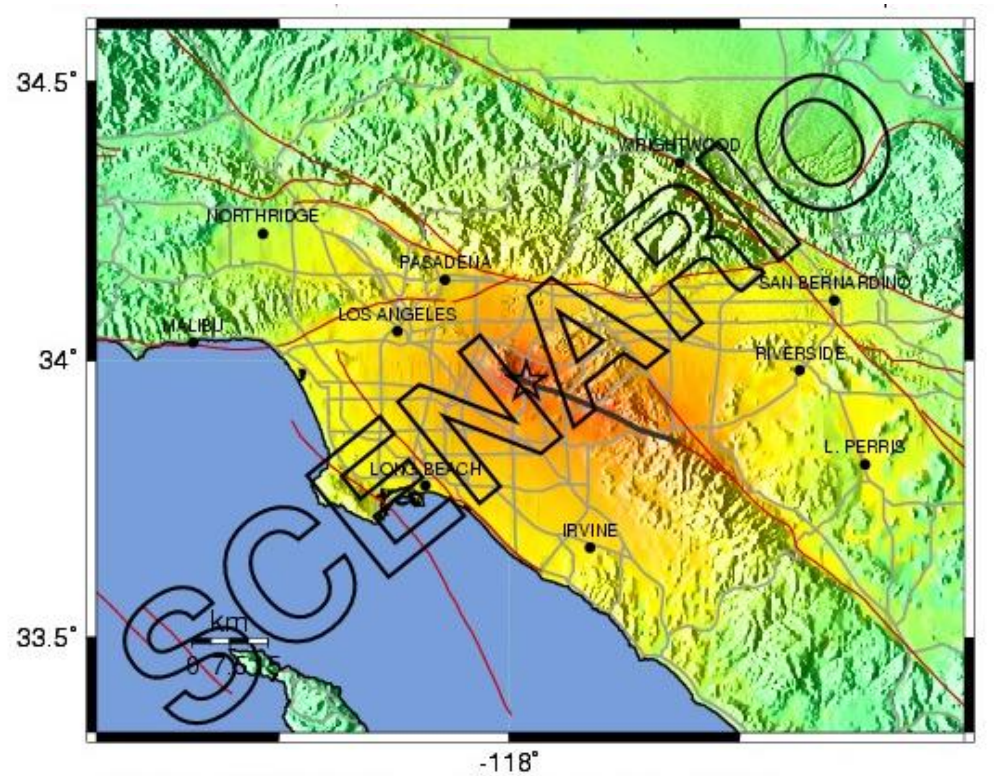
The deterministic analysis for Newport Beach estimates peak ground accelerations of about 0.10g to 0.26g for a magnitude 6.7 earthquake on the Chino segment, 0.10g to 0.22g for a magnitude 6.8 earthquake on the Whittier segment, and about 0.10g to 0.21g based on a magnitude 6.8 earthquake on the Glen Ivy segment of the Elsinore fault. Some geologists believe that the Whittier fault is capable of generating a 7.1 magnitude earthquake. Such an earthquake would result in stronger ground shaking in the Newport Beach area than the values reported herein (see the Modified Mercalli intensities estimated from a magnitude 6.8 earthquake scenario on the Whittier fault shown on Map 6-6 below).

Sierra Madre Fault Zone

The Sierra Madre fault zone is a north-dipping reverse fault zone approximately 47 miles (75 km) long that extends along the southern flank of the San Gabriel Mountains from San Fernando to San Antonio Canyon, where it continues southeastward as the Cucamonga fault. The Sierra Madre fault has been divided into five segments, each with a different rate of activity.

The northwestern-most segment of the Sierra Madre fault (the San Fernando segment) ruptured in 1971, causing the M_w 6.7 San Fernando (or Sylmar) earthquake. As a result of this earthquake, the Sierra Madre fault has been known to be active. In the 1980s, Crook and others (1987) studied the Transverse Ranges using general geologic and geomorphic mapping, coupled with a few trenching locations. Based on this work, they suggested that segments of the Sierra Madre fault east of the San Fernando segment have not generated major earthquakes in several thousands of years, and possibly as long as 11,000 years. By California's definitions of active faulting, most of the Sierra Madre fault would therefore be classified as not active. Then, in the mid-1990s, Rubin et al. (1998) trenched a section of the Sierra Madre fault in Altadena and determined that this segment had ruptured at least twice in the last 15,000 years, causing magnitude 7.2 to 7.6 earthquakes. This suggests that the Los Angeles area is susceptible to infrequent, but large earthquakes on the Sierra Madre fault. Rubin et al.'s (1998) trenching data show that during the last earthquake, the ground was displaced along the fault as much as 13 feet (4 meters) at the surface, and that total displacement in the last two events adds up to more than 34 feet (10.5 meters)! Similar results were reported by Tucker and Dolan (2001) from a trenching study they conducted in San Dimas, at the eastern end of the Sierra Madre fault. Their findings indicate that the eastern section of the fault last ruptured more than 8,000 years ago, and that the fault slipped more than 14 meters (46 feet) between about 24,000 and 8,000 years ago, for a slip rate of between 0.6 and 0.9 mm/yr.

Map 6-6: Intensity Map for a Magnitude 6.8 Earthquake Scenario on the Whittier Fault



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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+

Source: http://earthquake.usgs.gov/eqcenter/shakemap/sc/shake/Whittier6.8_se/

Although the Sierra Madre fault apparently slips at a slow rate of between 0.5 and 1 mm/yr (Walls et al., 1998; Tucker and Dolan, 2001), over time, it can accumulate a significant amount of strain. The paleoseismic data obtained at the Altadena site were insufficient to estimate the recurrence interval and the age of the last surface-rupturing event on this segment of the fault. At Horsethief Canyon in San Dimas, Tucker and Dolan (2001) calculated a recurrence interval of about 8,000 years using a slip rate of 0.6 mm/yr and a slip per event of 15 feet (5 meters). Therefore, if the last event occurred about 8,000 years ago, it is possible that these segments of the Sierra Madre fault are near the end of their cycle, and are likely to generate an earthquake in the not-too-distant future.

The deterministic analysis for the Newport Beach City Hall area estimates peak ground accelerations of about 0.06g to 0.22g, based on a magnitude 7.2 earthquake on the central segment of the Sierra Madre fault. A larger earthquake on this fault could generate stronger peak ground accelerations.

San Andreas Fault Zone

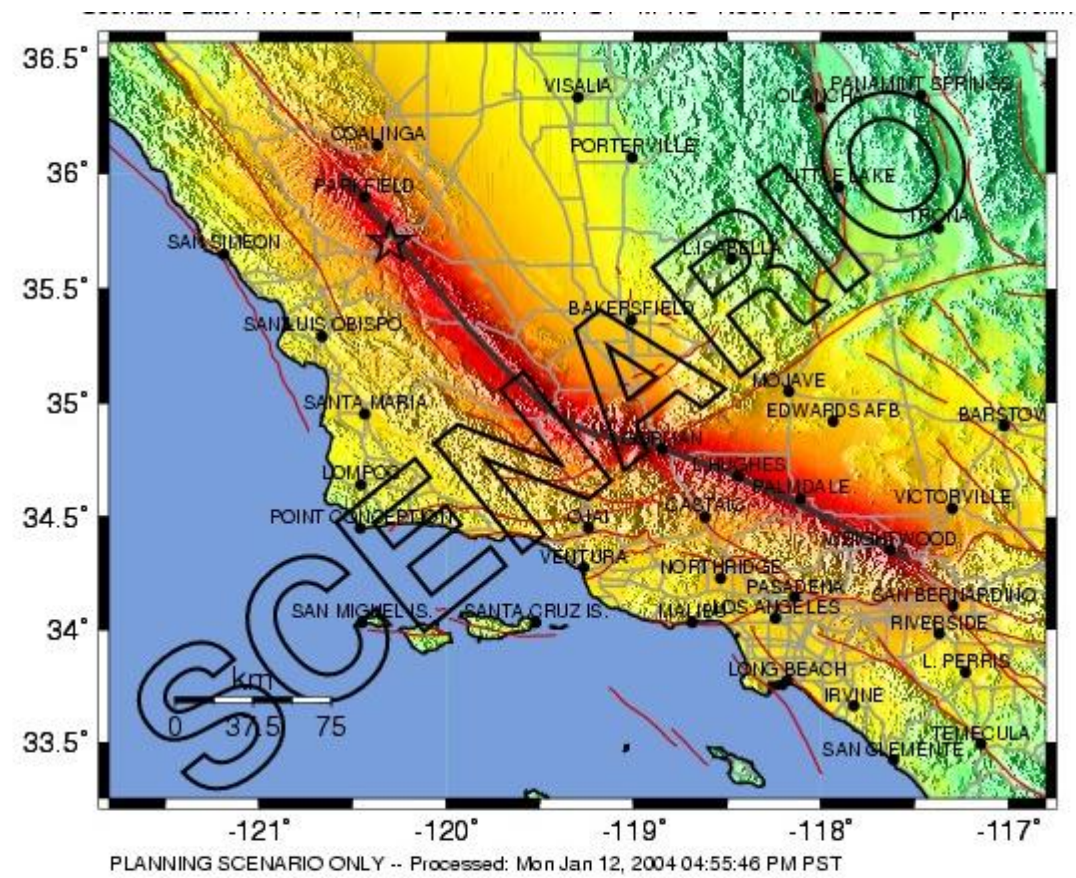
The San Andreas fault is the principal boundary between the Pacific and North American plates, and as such, it is considered the "Master Fault" because it has frequent (geologically speaking), large earthquakes, and it controls the seismic hazard in southern California. The fault extends over 750 miles (1,200 kilometers), from near Cape Mendocino in northern California to the Salton Sea region in southern California. At its closest approach, the San Andreas fault is approximately 51 miles (82 km) north-northeast of Newport Beach. Many refer to an earthquake on the San Andreas fault as "The Big One," and for many parts of southern California, this designation is indeed true. Other areas, including Newport Beach, are actually at greater risk from other faults. Nevertheless, the San Andreas fault should be considered in all seismic hazard assessment studies in southern California given its high probability of causing an earthquake in the near future. In 2007-2008, a group of scientists referred to as the 2007 Working Group on California Earthquake Probabilities (WGCEP, 2008) calculated that the southern San Andreas fault had a 59% probability of causing an earthquake of at least magnitude 6.7 in the next 30 years. That probability increases with each passing year without an earthquake.

Large faults, such as the San Andreas fault, are generally divided into segments in order to evaluate their future earthquake potential. The segments are generally defined at discontinuities along the fault that may affect the rupture length. Each segment is assumed to have a characteristic slip rate (rate of movement averaged over time), recurrence interval (time between moderate to large earthquakes), and displacement (amount of offset during an earthquake). While this methodology has some value in predicting earthquakes, historical records and studies of prehistoric earthquakes show that it is possible for more than one segment to rupture during a large quake or for ruptures to overlap into adjacent segments. For example, the last major earthquake on the southern portion of the San Andreas fault (and the largest earthquake reported in California) was the 1857 Fort Tejon (magnitude 8) event. The 1857 earthquake ruptured the Cholame, Carrizo, Big Bend, and Mojave North and Mojave South sections of the fault, resulting in displacements of as much as 27 feet (9 meters) along the rupture zone. The central and southern San Andreas fault is divided into ten sections named, from north to south, Parkfield, Cholame, Carrizo, Big Bend, Mojave North, Mojave South, San Bernardino North, San Bernardino South, San Gorgonio-Garnet Hill, and Coachella (WGCEP, 2008).

Peak ground accelerations in the Newport Beach area as a result of the 1857 earthquake are estimated to have been between about 0.07 and 0.19g. Rupture of these fault segments as a group, during a single earthquake, is thought to occur with a recurrence interval of between 104 and 296 years. Map 6-7 shows the seismic intensities that would be expected in the southern California areas if a repeat of the 1857 earthquake occurred.

If the entire southern section of the San Andreas ruptured in a magnitude 8 earthquake, peak horizontal ground accelerations in Newport Beach are estimated at between 0.08 and 0.21g. This earthquake would generate Modified Mercalli intensities in the VII to VIII range. Given its distance from the City, the shaking associated with this event would feel like rolling waves, with the duration of shaking lasting minutes, rather than seconds.

Map 6-7: Intensity Map for a Magnitude 7.8 Earthquake Scenario on the San Andreas Fault (Repeat of the 1857 Fort Tejon Earthquake)



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+

Source: http://earthquake.usgs.gov/eqcenter/shakemap/sc/shake/1857_se/

Fault Rupture

Primary fault rupture refers to fissuring and offset of the ground surface along a rupturing fault during an earthquake. Primary ground rupture typically results in a relatively small percentage of the total damage in an earthquake, but straddling a rupturing fault can cause severe damage to structures. Development constraints within active fault zones were implemented in 1972 with passage of the California Alquist-Priolo Earthquake Fault Zoning Act. This law prohibits the construction of new habitable structures astride an active fault and requires special geologic studies to locate, and evaluate whether a fault has ruptured the ground surface in the last about 11,000 years. If an active fault is encountered, structural setbacks from the fault are defined.

The Newport-Inglewood fault is the only known fault with the potential to generate primary surface rupture in the City of Newport Beach. The North Branch of the Newport-Inglewood fault as mapped by Morton (1999) comes on shore (from the south) near the intersection of Balboa

Boulevard and 15th Street, then crosses the Newport Channel and continues through the Coast Highway-Balboa Boulevard intersection (Map 6-4). The fault trace then continues through the foot of the bluffs, across the old Newport-Banning oil field, and into the city of Huntington Beach. The South Branch comes on shore in Huntington Beach, just up the coast from the Santa Ana River (Map 6-4). In Newport Beach, the North Branch is not considered sufficiently active and well defined by the CGS, and as a result, the fault in the Newport Beach area has not been zoned under the guidelines of the Alquist-Priolo Earthquake Fault Zoning Act. Farther north, the fault is better defined, which is why Alquist-Priolo Earthquake Fault Zones have been defined for the North Branch in Huntington Beach.

The lowland area of West Newport that is thought to be underlain by the North Branch of the fault (see Map 6-4) was developed extensively prior to recognition of the Newport-Inglewood fault as a surface rupture hazard. Therefore, there are no studies of the fault zone in the West Newport and Balboa Peninsula areas. Furthermore, the sediments in these areas are too young, and ground water is too close to the ground surface for trenching to be used as a successful fault study method. Subsurface studies using other techniques such as cone penetrometer testing (CPTs, see Grant et al., 1997) or geophysics could be used along the beach, but, to our knowledge, this has not been tried in this area. On the elevated terrace of Newport Mesa, however, several fault studies have been conducted looking for the active strands of the fault. The first studies to identify faults at or near the surface in the Newport Banning area were reportedly conducted jointly by Woodward-Clyde Consultants and the West Newport Oil Company in 1981 and 1985. Additional studies have been conducted by The Earth Technology Corporation (1986) and by Earth Consultants International (1997). The results of the 1981 study were published (Guptil and Heath, 1981) because one of the exposures reviewed – located approximately 600 feet northwest of the intersection of Pacific Coast Highway and Superior Avenue – suggested that the 1933 earthquake had actually ruptured the ground surface. This finding was not confirmed by The Earth Technology Corporation (1986) study who reported that the fault does not offset a well-developed soil profile estimated to be about 100,000 years old (Bryant, 1988).

The 1985 study (summarized by The Earth Technology Corporation, 1986) exposed a broad area of faulting in the western central and southeastern portion of the mesa. The faults in the western portion of the mesa are roughly coincident with the mapped trace of the North Branch of the fault (see Map 6-4). However, the 1985 study did not resolve the length, width or age of the faults. Then in 1986, The Earth Technology Corporation found that the faults encountered were not active under the criteria of the Alquist-Priolo Act. With one exception in the southeastern portion of the mesa discussed further below, this finding was confirmed locally by Earth Consultants International in 1997. These studies combined suggest that the North Branch of the Newport-Inglewood fault, as mapped, is not active, at least not in this area of Newport Beach.

Converse Consultants (1994) found a small fault, the West Mesa fault, near the western terminus of West 16th Street, while conducting a geologic study and grading for a filtration water plant (Map 6-4). The West Mesa fault trends between 5 and 30 degrees west of north, and is interpreted to have moved in the past 11,000 years, making it active. Earth Consultants International (1997) then trenched south of the Converse (1994) exposure in an attempt to find the southern continuation of this fault, but the fault was not found, suggesting that the fault is not laterally extensive. However, Earth Consultants International (1997) did find another small active fault about 600 feet to the south of the Converse study that strikes 50 degrees west of north, roughly parallel to the regional trend of the Newport-Inglewood fault. In the exposure, the fault had 12 to 18 inches of vertical separation, extended upward into the soil, and was therefore interpreted to have ruptured at least once in the past 11,000 years, probably co-seismically with movement on the main Newport-Inglewood fault.

Further, in reviewing previous work in the Newport Mesa area, Earth Consultants International (1997) concluded that a narrow fault zone mapped by The Earth Technology Corporation (1986) was not conclusively shown to be inactive. This fault zone trends 5 to 12 degrees west of north, similar to the orientation of the fault exposed by Converse (1994). All of these faults in the eastern portion of the mesa are not considered seismogenic (earthquake-producing) because of their small separations, narrow width, and non-ideal orientations. The offset seen on these faults probably resulted from co-seismic slip during an earthquake on a strand of the Newport-Inglewood fault farther to the south. Nevertheless, several inches of ground offset could cause severe damage to overlying structures. Consequently, although the hazard from primary surface rupture on these small faults is possibly low, building setbacks from these faults are appropriate. Alternatively, engineering strengthening of the foundations straddling the faults could be considered.

Finally, two paleoseismic investigations, one near Bolsa Chica (Grant et al., 1997) and the other on the west bank of the Santa Ana River (Law/Crandall, Inc., 1994; Shlemon et al., 1995) found evidence for five surface rupturing earthquakes in the past ~11,000 years on the North Branch of the Newport-Inglewood fault. The Law/Crandall (1994) study identified several fault traces south of the mapped trace of the North Branch of the Newport-Inglewood that appear to have moved in the Holocene. In Map 6-4, these fault traces are projected as straight lines from the west bank of the Santa Ana River southward into the Newport Beach area. This shows that the active faults appear to be located south of the North Branch, with active faulting spread over a broad area that most likely spans the area between the North and South branches. However, the location of these faults should be considered approximate at best, until further studies in this area are conducted.

The activity and location of the North Branch, and the faults south of the North Branch farther southeast, along West Newport and the Balboa Peninsula are unknown. Ideally, geologic studies similar in scope to those required by the CGS in Alquist-Priolo Earthquake Fault Zones should be conducted if new development or redevelopment is proposed in these areas. In reality, such investigations are not likely to be successful due to the small lot sizes and very high building density in these portions of the City, combined with the underlying, geologically young beach and sand dune deposits and shallow ground water. Trenching in these areas could also negatively impact adjacent properties. It is herein recommended that a "fault disclosure zone" be placed along the area between the mapped alignments of the North and South branches of the Newport-Inglewood fault, in the area where recent studies suggest that the recently active traces of the fault are located. The purpose of this fault disclosure zone is to make the public aware of the potential hazard (Map 6-4). If detailed geological investigations are conducted, the location and activity status (some of the splays may be proven to have not moved within the last 11,000 years) of the faults shown on Map 6-4 may be refined or modified. The map should be amended as new data become available and are validated.

Although the San Joaquin Hills fault may generate very strong earthquakes, damage from primary surface rupture is low because this fault is "blind." By definition, a blind thrust is a reverse fault that does not break the surface during an earthquake. For example, the 1994 Northridge earthquake ruptured on the blind Oakridge fault and was the most costly earthquake in U.S. history, but it did not break the surface. However, ground deformation resulting from uplifting of the landmass during a San Joaquin Hills fault quake could damage portions of Newport Beach.

Several other faults, such as the Pelican Hill fault, and the Shady Canyon fault (north of the city) have been mapped in the San Joaquin Hills (see Map 6-4). These faults appear to be confined to the older bedrock units, with no impact on the younger, Holocene terrace and alluvial deposits, and are therefore not considered active. Special geological studies for these faults are not considered warranted at this time.

Liquefaction and Related Ground Failure

Liquefaction is a geologic process that causes various types of ground failure. Liquefaction typically occurs in loose, saturated sediments primarily of sandy composition, in the presence of ground accelerations over 0.2g (Borchardt and Kennedy, 1979; Tinsley and Fumal, 1985). When liquefaction occurs, the sediments involved have a total or substantial loss of shear strength, and behave like a liquid or semi-viscous substance. Liquefaction can cause structural distress or failure due to ground settlement, a loss of bearing capacity in the foundation soils, and the buoyant rise of buried structures. The excess hydrostatic pressure generated by ground shaking can result in the formation of sand boils or mud spouts, and/or seepage of water through ground cracks.

As indicated above, there are three general conditions that need to be met for liquefaction to occur. The first of these – strong ground shaking of relatively long duration – can be expected to occur in the Newport Beach area as a result of an earthquake on any of several active faults in the region. The second condition – loose, unconsolidated sediments consisting primarily of silty sand and sand – occurs along the coastline from West Newport to the tip of Balboa Peninsula, as well as in and around Newport Bay. Young alluvial sediments also occur along the larger drainages (e.g., Bonita Canyon) within the City. The third condition – water-saturated sediments within about 50 feet of the surface – occurs along the coastline, in and around Newport Bay and Upper Newport Bay, in the lower reaches of major streams in Newport Beach, and in the floodplain of the Santa Ana River. Therefore, these are the areas with the potential to experience future liquefaction-induced ground displacements. The potentially liquefiable areas are shown in green on Map 6-8, and are discussed further below.

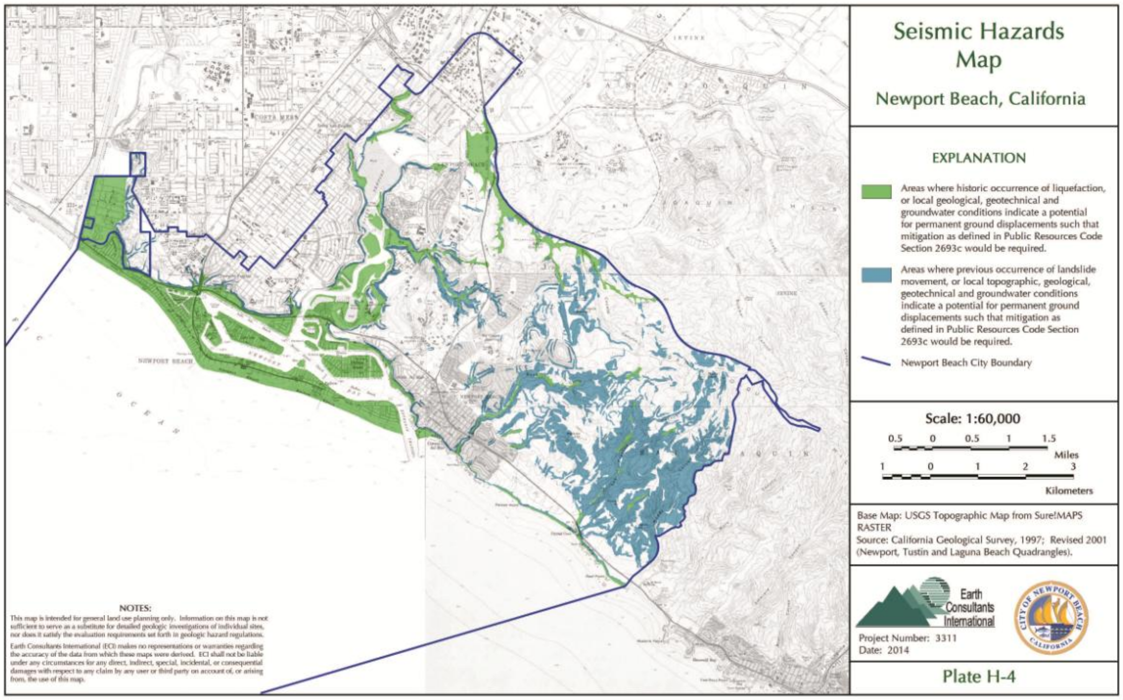
Structures built on the sand dune deposits lining the coast from the mouth of the Santa Ana River to the end of Balboa Peninsula are highly susceptible to liquefaction during an earthquake because depth to the water table is less than 15 feet. Likewise, buildings on the estuary deposits within and around Newport Bay are equally at risk from seismically induced liquefaction because of the shallow water table (Map 6-8). Areas along major stream channels, such as Bonita and Big Canyon, are also vulnerable to liquefaction, especially during wet climatic conditions/seasons. Liquefaction hazard is also mapped along Buck Gully, Los Trancos Canyon, Muddy Canyon, and the beach area from Corona del Mar to the eastern boundary of Newport Beach near Reef Point (Map 6-8).

Although not mapped, shallow groundwater conditions may occur locally in smaller drainages throughout central and eastern Newport Beach. Since the bedrock that forms the San Joaquin Hills weathers to sand-sized particles, some of the canyons may contain sediments susceptible to liquefaction. For example, sediments lining streams flowing southwest off Pelican Hill may be susceptible to liquefaction. The potential for these areas to liquefy should be evaluated on a case-by-case basis. Additionally, areas of artificial fill that have been placed on liquefiable soils may also be at risk.

It is likely that residential or commercial development will never occur in many of the liquefiable areas, such as Upper Newport Bay, the Newport Coast beaches, and the bottoms of stream channels. However, other structures (such as bridges, roadways, major utility lines, and park improvements) that occupy these areas are vulnerable to damage from liquefaction if mitigation measures have not been included in their design. Construction planned for these areas should include liquefaction mitigation measures, weighing the factors of public safety, the impact to the environment, and the risk of economic loss. For instance, a parking lot at the beach may not warrant ground modification measures, especially if the mitigation measures would be destructive to the environment, but a bridge abutment for a busy roadway would.

Map 6-8: Seismic Hazards in Newport Beach

(for a larger version of this map, refer to Plate H-4 in Appendix H)



A considerable part of the City's mapped liquefiable areas (West Newport, Balboa Peninsula, the harbor islands and vicinity) are already built upon, mostly with residential and commercial development. A portion of the City's active oil field is also built on liquefiable soils. It is likely that a nearby moderate to strong earthquake will cause extensive damage to buildings and infrastructure in these areas. Since retrofitting mitigation measures are generally not feasible, the City should be prepared to respond to damage and disruption in the event of an earthquake.

The types of ground failure typically associated with liquefaction are explained below.

Lateral Spreading

Lateral displacement of surficial blocks of soil as the result of liquefaction in a subsurface layer is called lateral spreading. Even a very thin liquefied layer can act as a hazardous slip plane if it is continuous over a large enough area. Once liquefaction transforms the subsurface layer into a fluid-like mass, gravity plus inertial forces caused by the earthquake may move the mass downslope towards a cut slope or free face (such as a river channel or a canal). Lateral spreading most commonly occurs on gentle slopes that range between 0.3° and 3°, and can displace the ground surface by several meters to tens of meters. Such movement damages pipelines, utilities, bridges, roads, and other structures. During the 1906 San Francisco earthquake, lateral spreads with displacements of only a few feet damaged every major pipeline. Thus, liquefaction compromised San Francisco's ability to fight the fires that caused about 85 percent of the damage (Tinsley et al., 1985).

Flow Failure

The most catastrophic mode of ground failure caused by liquefaction is flow failure. Flow failure usually occurs on slopes greater than 3 degrees. Flows are principally liquefied soil or blocks of intact material riding on a liquefied subsurface. Displacements are often in the tens of meters, but in favorable circumstances, soils can be displaced for tens of miles, at velocities of tens of miles per hour. For example, the extensive damage to Seward and Valdez, Alaska, during the 1964 Great Alaskan earthquake was caused by submarine flow failures (Tinsley et al., 1985).

Ground Oscillation

When liquefaction occurs at depth but the slope is too gentle to permit lateral displacement, the soil blocks that are not liquefied may separate from one another and oscillate on the liquefied zone. The resulting ground oscillation may be accompanied by the opening and closing of fissures (cracks) and sand boils, potentially damaging structures and underground utilities (Tinsley et al., 1985).

Loss of Bearing Strength

When a soil liquefies, loss of bearing strength may occur beneath a structure, possibly causing the building to settle and tip. If the structure is buoyant, it may float upward. During the 1964 Niigata, Japan earthquake, buried septic tanks rose as much as 3 feet, and structures in the Kwangishicho apartment complex tilted as much as 60 degrees (Tinsley et al., 1985).

Ground Lurching

Soft, saturated soils have been observed to move in a wave-like manner in response to intense seismic ground shaking, forming ridges or cracks on the ground surface. At present, the potential for ground lurching to occur at a given site can be predicted only generally. Areas underlain by thick accumulation of colluvium and alluvium appear to be the most susceptible to ground lurching. Under strong ground motion conditions, lurching can be expected in loose, cohesionless soils, or in clay-rich soils with high moisture content. In some cases, the deformation remains after the shaking stops (Barrows et al., 1994).

Seismically Induced Slope Failure

Strong ground motions can worsen existing unstable slope conditions, particularly if coupled with saturated ground conditions. Seismically induced landslides can overrun structures, people or property, sever utility lines, and block roads, thereby hindering rescue operations after an earthquake. Over 11,000 landslides were mapped shortly after the Northridge earthquake, all within a 45-mile radius of the epicenter (Harp and Jibson, 1996). Although numerous types of earthquake-induced landslides have been identified, the most widespread type generally consists of shallow failures involving surficial soils and the uppermost weathered bedrock in moderate to steep hillside terrain (these are also called disrupted soil slides). Rock falls and rockslides on very steep slopes are also common. The 1989 Loma Prieta and Northridge earthquakes showed that reactivation of existing deep-seated landslides also occurs (Spittler et al., 1990; Barrows et al., 1995).

A combination of geologic conditions leads to landslide vulnerability. These include high seismic potential; rapid uplift and erosion resulting in steep slopes and deeply incised canyons; highly fractured and folded rock; and rock with inherently weak components, such as silt or clay layers. The orientation of the slope with respect to the direction of the seismic waves (which can affect the shaking intensity) can also control the occurrence of landslides.

Much of the area in eastern Newport Beach has been identified as vulnerable to seismically induced slope failure. Approximately 90 percent of the land from Los Trancos Canyon to the State Park boundary is mapped as susceptible to landsliding by the California Geologic Survey (areas in blue on Map 6-8). The occurrence of numerous Holocene to latest Pleistocene (recent to about 20,000 years old) landslides indicate that slope failures have been common over a relatively short geologic time period and thus, without mitigation, pose a significant hazard to developments in these areas.

Additionally, the sedimentary bedrock that crops out in the San Joaquin Hills is locally highly weathered. In steep areas, strong ground shaking can cause slides or rockfalls in this material. Rupture along the Newport-Inglewood Fault Zone and other faults in southern California could reactivate existing landslides and cause new slope failures throughout the San Joaquin Hills. Slope failures can also be expected to occur along stream banks and coastal bluffs, such as Big Canyon, around San Joaquin Reservoir, Newport and Upper Newport Bays, and Corona del Mar.

Groundwater conditions at the time of the earthquake play an important role in the development of seismically induced slope failures. For instance, the 1906 San Francisco earthquake occurred in April, after a winter of exceptionally heavy rainfall, and produced many large landslides and mudflows, some of which were responsible for several deaths. The 1987 Loma Prieta earthquake however, occurred in October during the third year of a drought, and slope failures were limited primarily to rock falls and reactivation of older landslides that was manifested as ground cracking in the scarp areas but with very little movement (Griggs et al., 1991).

Ridgetop Fissuring and Shattering

Linear, fault-like fissures occurred on ridge crests in a relatively concentrated area of rugged terrain in the Santa Cruz Mountains during the Loma Prieta earthquake. Shattering of the surface soils on the crests of steep, narrow ridgelines occurred locally in the 1971 San Fernando earthquake, but was widespread in the 1994 Northridge earthquake. Ridgetop shattering (which leaves the surface looking as if it was plowed) by the Northridge earthquake was observed as far as 22 miles away from the epicenter. In the Sherman Oaks area, severe damage occurred locally to structures located at the tops of relatively high (greater than 100 feet), narrow (typically less than 300 feet wide) ridges flanked by slopes steeper than about 2.5:1 (horizontal:vertical). It is generally accepted that ridgetop fissuring and shattering is a result of intense amplification or focusing of seismic energy due to local topographic effects (Barrows et al., 1995).

Ridgetop shattering can be expected to occur in the topographically steep portions of the San Joaquin Hills. These areas are rapidly being developed so the hazard associated with ridgetop shattering is increasing. In addition, above ground storage tanks, reservoirs and utility towers are often located on top of ridges, and during strong ground shaking, these can fail or topple over, with the potential to cause widespread damage to development downslope (storage tanks and reservoirs), or disruptions to the lifeline systems (utility towers).

Vulnerability Assessment

The effects of earthquakes span a large area, and large earthquakes occurring in the southern California area would be felt throughout the region. However, the degree to which earthquakes are felt, and the damages associated with them may vary. At risk from earthquake damage are large stocks of old buildings and bridges; many hazardous materials facilities; extensive sewer, water, and natural gas pipelines; earthen dams; petroleum pipelines; and other critical facilities, not to mention private property and businesses. Secondary earthquake hazards, such as liquefaction and earthquake-induced landslides, can be just as devastating as the ground shaking.

Damage to the extensive building stock in the area is expected to vary. Older, pre-1945 steel frame structures may have unreinforced masonry such as bricks, clay tiles and terra cotta tiles as cladding or infilling. Cladding in newer buildings may be glass, infill panels or pre-cast panels that may fail and generate a band of debris around the building exterior (with considerable threat to pedestrians in the streets below). Structural damage may occur if the structural members are subject to plastic deformation that can cause permanent displacements. If some walls fail while others remain intact, torsion or soft-story problems may result. Overall, modern steel frame buildings have been expected to perform well in earthquakes, but the 1994 Northridge earthquake broke many welds in these buildings, a previously unanticipated problem.

Buildings are often a combination of steel, concrete, reinforced masonry and wood, with different structural systems on different floors or different sections of the building. Combination types that are potentially hazardous include: concrete frame buildings without special reinforcing, precast concrete and precast-composite buildings, steel frame or concrete frame buildings with unreinforced masonry walls, reinforced concrete wall buildings with no special detailing or reinforcement, large capacity buildings with long-span roof structures (such as theaters and auditoriums), large unengineered wood-frame buildings, buildings with inadequately anchored exterior cladding and glazing, and buildings with poorly anchored parapets and appendages (FEMA, 1985). Additional types of potentially hazardous buildings may be recognized after future earthquakes.

Mobile homes are prefabricated housing units that are placed on isolated piers, jackstands, or masonry block foundations (usually without any positive anchorage). Floors and roofs of mobile homes are usually plywood, and outside surfaces are covered with sheet metal. Mobile homes typically do not perform well in earthquakes. Severe damage occurs when they fall off their supports, severing utility lines and piercing the floor with jackstands.

In addition to building types, there are other factors associated with the design and construction of the buildings that also have an impact on the structures' vulnerability to strong ground shaking. Some of these conditions are discussed below:

- **Building Shape** – A building's vertical and/or horizontal shape can be important. Simple, symmetric buildings generally perform better than non-symmetric buildings. During an earthquake, non-symmetric buildings tend to twist as well as shake. Wings on a building tend to act independently during an earthquake, resulting in differential movements and cracking. The geometry of the lateral load-resisting systems also matters. For example, buildings with one or two walls made mostly of glass, while the remaining walls are made of concrete or brick, are at risk. Asymmetry in the placement of bracing systems that provide a building with earthquake resistance, can result in twisting or differential motions.

- **Pounding** – Site-related seismic hazards may include the potential for neighboring buildings to "pound," or for one building to collapse onto a neighbor. Pounding occurs when there is little clearance between adjacent buildings, and the buildings "pound" against each other as they deflect during an earthquake. The effects of pounding can be especially damaging if the floors of the buildings are at different elevations, so that, for example, the floor of one building hits a supporting column of the other. Damage to a supporting column can result in partial or total building collapse.

Damage to the region's critical facilities and infrastructure need to be considered and planned for. Critical facilities are those parts of a community's infrastructure that must remain operational after an earthquake. Critical facilities include schools, hospitals, fire and police stations, emergency operation centers, and communication centers. Plate H-1 shows the locations of the City's fire stations, police stations, schools, and other critical facilities. A vulnerability assessment for these facilities involves comparing the locations of these facilities to the hazardous areas identified in the City, including active and potentially active faults (Map 6-4), liquefaction-susceptible areas (Map 6-8; Plate H-4), unstable slope areas (Map 6-8, and Plates H-4 and H-19), potential dam failure inundation areas (Plate H-9), fire hazard zones (Plate H-13), and sites that generate hazardous materials.

High-risk facilities, if severely damaged, may result in a disaster far beyond the facilities themselves. Examples include power plants, dams and flood control structures, freeway interchanges, bridges, and industrial plants that use or store explosives, toxic materials or petroleum products.

High-occupancy facilities have the potential of resulting in a large number of casualties or crowd-control problems. This category includes high-rise buildings, large assembly facilities, and large multifamily residential complexes.

Dependent-care facilities, such as preschools and schools, rehabilitation centers, prisons, group care homes, and nursing homes, house populations with special evacuation considerations.

Economic facilities, such as banks, archiving and vital record-keeping facilities, airports, and large industrial or commercial centers, are those facilities that should remain operational to avoid severe economic impacts.

It is crucial that critical facilities have no structural weaknesses that can lead to collapse. For example, the Federal Emergency Management Agency (FEMA, 1985) has suggested the following seismic performance goals for **health care facilities**:

- The damage to the facilities should be limited to what might be reasonably expected after a destructive earthquake and should be repairable and not be life-threatening.
- Patients, visitors, and medical, nursing, technical and support staff within and immediately outside the facility should be protected during an earthquake.
- Emergency utility systems in the facility should remain operational after an earthquake.
- Occupants should be able to evacuate the facility safely after an earthquake.
- Rescue and emergency workers should be able to enter the facility immediately after an earthquake and should encounter only minimum interference and danger.
- The facility should be available for its planned disaster response role after an earthquake.

Lifelines are those services that are critical to the health, safety and functioning of the community. They are particularly essential for emergency response and recovery after an earthquake. Furthermore, certain critical facilities designed to remain functional during and immediately after an earthquake may be able to provide only limited services if the lifelines they depend on are disrupted. Lifeline systems include water, sewage, electrical power, communication, transportation (highways, bridges, railroads, and airports), natural gas, and liquid fuel systems. The improved performance of lifelines in the 1994 Northridge earthquake, relative to the 1971 San Fernando earthquake, shows that the seismic codes upgraded and implemented after 1971 have been effective. Nevertheless, the impact of the Northridge quake on lifeline systems was widespread and illustrates the continued need to study earthquake impacts, to upgrade substandard elements in the systems, to provide redundancy in systems, to improve emergency response plans, and to provide adequate planning, budgeting and financing for seismic safety.

Some of the observations and lessons learned from the Northridge earthquake are summarized below (from Savage, 1995; Lund, 1996).

- Several electrical transmission towers were damaged or totally collapsed. Collapse was generally due to foundation distress in towers that were located near ridge tops where amplification of ground motion may have occurred. One collapse was the result of a seismically induced slope failure at the base of the tower.

- Damage to above ground water tanks typically occurred where piping and joints were rigidly connected to the tank, due to differential movement between the tank and the piping. Older steel tanks not seismically designed under current standards buckled at the bottom (called “elephant’s foot”), in the shell, and on the roof. Modern steel and concrete tanks generally performed well.
- The most vulnerable components of pipeline distribution systems were older threaded joints, cast iron valves, cast iron pipes with rigid joints, and older steel pipes weakened by corrosion. In the case of broken water lines, the loss of fire suppression water forced fire departments to utilize water from swimming pools and tanker trucks.
- Significant damage occurred in water treatment plants due to sloshing in large water basins.
- A number of facilities did not have an emergency power supply or did not have enough power supply capacity to provide their essential services.
- Lifelines within critical structures, such as hospitals and fire stations, may be vulnerable. For instance, rooftop mechanical and electrical equipment is not generally designed for seismic forces. During the Northridge quake, rooftop equipment failed causing malfunctions in other systems.
- A 70-year old crude oil pipeline leaked from a cracked weld, spreading oil for 12 miles down the Santa Clara River.
- A freight train carrying sulfuric acid was derailed causing an 8,000-gallon acid spill and a 2,000-gallon diesel spill from the locomotive.

The above list is by no means a complete summary of the earthquake damage, but it does highlight some of the issues pertinent to the Newport Beach area. All lifeline providers should make an evaluation of the seismic vulnerability within their systems a priority. The evaluation should include a plan to fund and schedule the needed seismic mitigation. The 2014 La Habra earthquake caused several water mains to burst in the epicentral area and vicinity, showing that 20 years after the Northridge earthquake, many of the pipeline distribution systems in the Southern California area have not been upgraded, and are thus vulnerable to seismic shaking.

Risk Analysis

Risk analysis is the third phase of a hazard assessment. Risk analysis involves estimating the damage and costs likely to be experienced in a geographic area over a period of time. Factors included in assessing earthquake risk include population and property distribution in the hazard area, the frequency of earthquake events, landslide susceptibility, buildings, infrastructure, and disaster preparedness of the region. This type of analysis can generate estimates of the damages to the region due to an earthquake event in a specific location. FEMA's software program, HazUS, uses mathematical formulas and information about building stock, local geology and the location and size of potential earthquakes, economic data, and other information to estimate losses from a potential earthquake. A HazUS loss estimation was conducted for the City of Newport Beach as part of the 2008 study using data from the 2000 census with 2006 population numbers and other City-specific modifications to the data as described further below.

Updating the HazUS earthquake loss estimates was not part of the scope of work for the 2014 Plan. However, given that most growth in the City’s population is associated with new construction that is expected to perform well in an earthquake, the losses are anticipated to be similar to those presented here.

HazUS-MH™ is a standardized methodology for earthquake loss estimation based on a geographic information system (GIS). [HazUS-MH™ stands for Hazard US, Multi-Hazard version]. A project of the National Institute of Building Sciences, funded by the Federal Emergency Management Agency (FEMA), it is a powerful advance in mitigation strategies. The HazUS project developed guidelines and procedures to make standardized earthquake loss estimates at a regional scale. With standardization, estimates can be compared from region to region. HazUS is designed for use by state, regional and local governments in planning for earthquake loss mitigation, emergency preparedness, response and recovery. HazUS addresses nearly all aspects of the built environment, and many different types of losses. The methodology has been tested by comparing scenario results with actual losses generated by several past earthquakes. Subject to several limitations noted below, HazUS can produce results that are valid for the intended purposes.

Loss estimation is an invaluable tool, but it must be used with discretion. Loss estimation analyzes casualties, damage and economic loss in great detail. It produces seemingly precise numbers that can be easily misinterpreted. Loss estimation's results, for example, may cite 4,054 left homeless by a scenario earthquake. This is best interpreted by its magnitude. That is, an event that leaves 4,000 people homeless is clearly more manageable than an event causing 40,000 homeless people; and an event that leaves 400,000 homeless would overwhelm a region's resources. However, another loss estimation that predicts 7,000 people homeless should probably be considered equivalent to the 4,054 result. Because HazUS results make use of a great number of parameters and data of varying accuracy and completeness, it is not possible to assign quantitative error bars. Although the numbers should not be taken at face value, they are not rounded or edited because detailed evaluation of individual components of the disaster can help mitigation agencies ensure that they have considered all the important options.

The more community-specific the data that are input to HazUS, the more reliable the loss estimation. HazUS provides defaults for all required information. These are based on best-available scientific, engineering, census and economic knowledge. The loss estimations in this report have been tailored to Newport Beach by using a map of soil types for the City, topographic information provided by the City's GIS department for the flooding component, and updates to the HazUS database contained in the software's October 2006 version. Other modifications made to the data set before running the analyses included:

- updated the database of critical facilities, including the number and location of the fire and police stations in the City, and the number and location of schools in the City [note that since this analysis was conducted, City Hall, the main Fire Department, and the City's Emergency Operations Center have all been moved to a brand new building that is not located in a liquefaction-susceptible area],
- revised the number of beds available in the major hospital in Newport Beach to better represent its current patient capacity, and
- upgraded the construction level for all unreinforced masonry buildings in the City to better represent the City's retrofitting efforts of the last decade.

As useful as HazUS seems to be, the loss estimation methodology has some inherent uncertainties. These arise in part from incomplete scientific knowledge concerning earthquakes and their effect upon buildings and facilities, and in part from the approximations and simplifications necessary for comprehensive analyses.

Users should be aware of the following specific limitations:

- HazUS is driven by statistics, and thus is most accurate when applied to a region, or a class of buildings or facilities. It is least accurate when considering a particular site, building or facility.
- Losses estimated for lifelines may be less than losses estimated for the general building stock.
- Losses from smaller (less than M 6.0) damaging earthquakes may be overestimated.
- Pilot and calibration studies have not yet provided an adequate test concerning the possible extent and effects of landsliding; therefore, the earthquake scenarios do not include losses associated with earthquake-induced slope failure.
- The indirect economic loss module is still relatively new and experimental. While output from pilot studies has generally been credible, this module requires further testing.
- The databases that HazUS draws from to make its estimates are often incomplete or outdated (as discussed above, efforts were made to improve some of the datasets used for the analysis, but for some estimates, the software still relies on the year 2000 census tracts data). This is another reason the loss estimates should not be taken completely at face value.

Essential facilities and lifeline inventory are located by latitude and longitude. However, the HazUS inventory data for lifelines and utilities were developed at a national level and where specific data are lacking, statistical estimations are utilized. Specifics about the site-specific inventory data used in the models are discussed further in the paragraphs below. Other site-specific data used include soil types and liquefaction susceptible zones. The user then defines the earthquake scenario to be modeled, including the magnitude of the earthquake, and the location of the epicenter. Once all these data are input, the software calculates the loss estimates for each scenario.

The loss estimates include physical damage to buildings of different construction and occupancy types, damage to essential facilities and lifelines, number of after-earthquake fires and damage due to fire, and the amount of debris that is expected. The model also estimates the direct economic and social losses, including casualties and fatalities for three different times of the day, the number of people left homeless and number of people that will require shelter, number of hospital beds available, and the economic losses due to damage to the places of businesses, loss of inventory, and (to some degree) loss of jobs. The indirect economic losses component is still experimental; the software developers have checked the estimations against actual past earthquakes, such as the 1989 Loma Prieta, 1994 Northridge, and 2001 Nisqually, Washington earthquakes, but indirect losses are hard to measure, and it typically takes years before these monetary losses can be quantified with any degree of accuracy. Therefore, this component of HazUS is still considered experimental.

HazUS breaks **critical facilities** into two groups: essential facilities and high potential loss (HPL) facilities. Essential facilities provide services to the community and should be functional after an earthquake. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. The essential facility module in HazUS determines the expected loss of functionality for these facilities. The damage probabilities for essential facilities are determined on a site-specific basis (i.e., at each facility). Economic losses associated with these facilities are computed as part of the analysis of the general building stock. Data required for the analysis include occupancy classes (current building use) and building structural type, or a combination of essential facilities building type, design level and construction quality factor. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

HazUS divides the **lifeline** inventory into two systems: 1) transportation and 2) utility lifelines. The transportation system includes seven components: highways, railways, light rail, bus, ports, ferry and airports. The utility lifelines include potable water, wastewater, natural gas, crude and refined oil, electric power and communications. If site-specific lifeline utility data are not provided for these analyses, HazUS performs a statistical calculation based on the population served.

General Building Stock Type and Classification: HazUS provides damage data for buildings based on these structural types:

- Concrete
- Mobile home
- Precast concrete
- Reinforced-masonry bearing walls
- Steel
- Unreinforced-masonry bearing walls, and
- Wood frame

and based on these occupancy (usage) classifications:

- Residential (single-family and other residential)
- Commercial
- Industrial
- Agriculture
- Religion
- Government, and
- Education

Loss estimation for the general **building stock** is averaged for each census tract. Building damage classifications range from slight to complete. As an example, the building damage classification for wood frame buildings is provided below. Wood-frame structures comprise the most numerous building type in Newport Beach.

Wood, Light Frame:

- *Slight Structural Damage*: Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
- *Moderate Structural Damage*: Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
- *Extensive Structural Damage*: Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of "room-over-garage" or other "soft-story" configurations; small foundations cracks.
- *Complete Structural Damage*: Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or failure

of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Estimates of building damage are provided for "High", "Moderate" and "Low" seismic design criteria. Buildings of newer construction (e.g., post-1973) are best designated by "High." Buildings built after 1940, but before 1973, are best represented by "Moderate." If built before about 1940 (i.e., before significant seismic codes were implemented), "Low" is most appropriate. A large percentage of buildings in the City of Newport Beach fall in the "Moderate" and "High" seismic design criteria. [In 2006, when the HazUS analysis was conducted, less than 5 percent of the buildings in the City dated from before 1940; about 45 percent dated from between 1940 and 1969; and the rest were built on or after 1970.]

HazUS estimates two types of **debris**. The first is debris that falls in large pieces, such as steel members or reinforced concrete elements. These require special treatment to break into smaller pieces before they are hauled away. The second type of debris is smaller and more easily moved with bulldozers and other machinery and tools. This type includes brick, wood, glass, building contents and other materials.

Casualties are estimated based on the assumption that there is a strong correlation between building damage (both structural and non-structural) and the number and severity of casualties. In smaller earthquakes, non-structural damage will most likely control the casualty estimates. In severe earthquakes where there will be a large number of collapses and partial collapses, there will be a proportionately larger number of fatalities. Data regarding earthquake-related injuries are not of the best quality, nor are they available for all building types. Available data often have insufficient information about the type of structure in which the casualties occurred and the casualty-generating mechanism. HazUS casualty estimates are based on the injury classification scale described in Table 6-4.

Table 6-4: Injury Classification Scale

Injury Severity Level	Injury Description
Severity 1	Injuries requiring basic medical aid without requiring hospitalization.
Severity 2	Injuries requiring a greater degree of medical care and hospitalization, but not expected to progress to a life-threatening status.
Severity 3	Injuries which pose an immediate life-threatening condition if not treated adequately and expeditiously. The majority of these injuries are the result of structural collapse and subsequent entrapment or impairment of the occupants.
Severity 4	Instantaneously killed or mortally injured.

In addition, HazUS produces casualty estimates for **three times of day**:

- Earthquake striking at 2:00 a.m. (population at home)
- Earthquake striking at 2:00 p.m. (population at work/school)
- Earthquake striking at 5:00 p.m. (commute time).

Displaced Households/Shelter Requirements – Earthquakes can cause loss of function or habitability of buildings that contain housing. Displaced households may need alternative short-term shelter, provided by family, friends, temporary rentals, or public shelters established by the City, County or by relief organizations such as the Red Cross. Long-term alternative housing may require import of mobile homes, occupancy of vacant units, net emigration from the impacted area, or, eventually, the repair or reconstruction of new public and private housing. The number of people seeking short-term public shelter is of most concern to emergency response organizations. The longer-term impacts on the housing stock are of great concern to local governments, such as cities and counties.

Economic Losses – HazUS estimates structural and nonstructural repair costs caused by building damage and the associated loss of building contents and business inventory. Building damage can cause additional losses by restricting the building's ability to function properly. Thus, business interruption and rental income losses are estimated. HazUS divides building losses into two categories: (1) direct building losses and (2) business interruption losses. Direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. Business interruption losses are associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake. HazUS does not calculate business interruption losses due to failure of the lifeline systems (such as electric power outages).

Earthquakes may produce indirect economic losses in sectors that do not sustain direct damage. All businesses are forward-linked (if they rely on regional customers to purchase their output) or backward-linked (if they rely on regional suppliers to provide their inputs) and are thus potentially vulnerable to interruptions in their operation. Note that indirect losses are not confined to immediate customers or suppliers of damaged enterprises. All of the successive rounds of customers of customers and suppliers of suppliers are affected. In this way, even limited physical earthquake damage causes a chain reaction, or ripple effect, that is transmitted throughout the regional economy.

HazUS Scenario Earthquakes for the Newport Beach Area

Four specific scenario earthquakes were modeled using the HazUS loss estimation software available from FEMA: earthquakes on the San Joaquin Hills, Newport-Inglewood, Whittier, and San Andreas faults (see Table 6-5).

The four earthquake scenarios modeled for this study are discussed in the following sections. An earthquake on the San Andreas fault is discussed because it has the highest probability of occurring in the not too distant future, even though the loses expected from this earthquake are not the worst possible for Newport Beach. An earthquake on the San Andreas fault has traditionally been considered the "Big One," the implication being that an earthquake on this fault would be devastating to southern California. However, there are several other seismic sources that, given their location closer to coastal Orange County, would be more devastating to the region, even if the causative earthquake is smaller in magnitude than an earthquake on the San Andreas fault.

Table 6-5: HazUS Scenario Earthquakes for the City of Newport Beach

Fault Source	EQ Magnitude	Description
San Joaquin Hills	7.1	Potentially worst-case scenario for the City of Newport Beach because this fault's blind thrust geometry could produce greater vertical accelerations than a comparable strike-slip event and vertical motions are more damaging to structures. Note that the San Joaquin Hills fault properties are not well understood and the HazUS results should thus be interpreted with caution.
Newport-Inglewood	6.9	Potentially worst-case scenario for the City of Newport Beach because of the close proximity of this fault. The Newport-Inglewood fault parallels the coast only a few miles offshore of southern Newport Beach and comes onshore directly beneath West Newport.
Whittier	6.8	This fault lies about 22 miles north of the City and could cause significant damage in Newport Beach. The 6.8 magnitude earthquake modeled is in the middle of the size range of earthquakes that researchers now believe this fault is capable of generating.
San Andreas 1857 earthquake	7.8	A large earthquake that ruptures multiple segments of the San Andreas fault is modeled because of its high probability of occurrence, even though the epicenter would be relatively far from the City.

The San Joaquin Hills blind thrust was only discovered in the late 1990s and its geometry and behavior are not well constrained. However, an earthquake on this fault, due to its blind thrust geometry and location, has the potential to be as severe, or more damaging to Newport Beach than rupture of the Newport-Inglewood fault. Typically, earthquakes on thrust faults produce greater vertical accelerations than comparably sized strike-slip earthquakes (such as one on the Newport-Inglewood fault) and vertical motions are more damaging to structures. Scientists have suggested the San Joaquin Hills blind thrust fault could produce a magnitude 6.6 to 7.3 earthquake. We used a mid- to higher-end magnitude of 7.1 for our modeling based on Grant and others' (2002) study that suggests the last earthquake on this fault was greater than a magnitude 7. However, further research is needed to better understand the seismic character of the San Joaquin Hills fault.

Prior to the discovery of the San Joaquin Hills fault, the Newport-Inglewood fault was the only fault thought to pose a strong ground shaking threat to Newport Beach because of its close proximity to the City, its historic activity, and its recurrence interval. Map 6-4 shows that the northern trace of the Newport-Inglewood fault is 2 miles offshore of Reef Point, comes onshore about 1/2 mile southeast of Newport Pier, and crosses directly beneath downtown and West Newport. The Newport-Inglewood fault is also active; it generated the 1933 M_w 6.4 earthquake. The epicenter was located only a mile from Newport Beach, on the western side of the Santa Ana River. This earthquake did not rupture the surface, but substantial liquefaction-induced damage was reported from Long Beach to Huntington Beach. The earthquake caused 120 deaths, and over $50 million in property damage (Wood, 1933). The Newport-Inglewood fault is also thought to have generated as many as five surface rupturing earthquakes in the past about 11,700 years (Grant et al., 1997; Shlemon et al., 1995).

The Whittier fault is the northern extension of the Elsinore fault and is located approximately 22 miles north of the City of Newport Beach (Map 6-1). No major historical earthquakes have been attributed to the Whittier fault. However, trenching studies have documented recurrent movement of this fault in the past 17,000 years (Gath et al., 1992; Patterson and Rockwell, 1993). Based on these studies, the Whittier fault is thought to be moving at a rate of about 2.5 ± 1 mm/yr. The Southern California Earthquake Center (1995) proposed there is a 5 percent chance of an earthquake occurring on the Whittier fault by 2024. The Whittier fault is thought capable of producing a magnitude 6.8 maximum magnitude earthquake, although some investigators have proposed an even larger magnitude 7.1 quake. We used the more conservative magnitude 6.8 earthquake in the HazUS model.

We used data from the historic 1857 Fort Tejon earthquake to model the effects of a very large San Andreas earthquake on Newport Beach. Although the 1857 quake nucleated on the Carrizo segment, we place our modeled M 7.8 epicenter closest to Newport Beach (on the San Bernardino segment, the closest segment to Newport Beach) because this will yield the maximum possible damage caused by a San Andreas earthquake.

Inventory Data Used in the HazUS Loss Estimation Models for Newport Beach

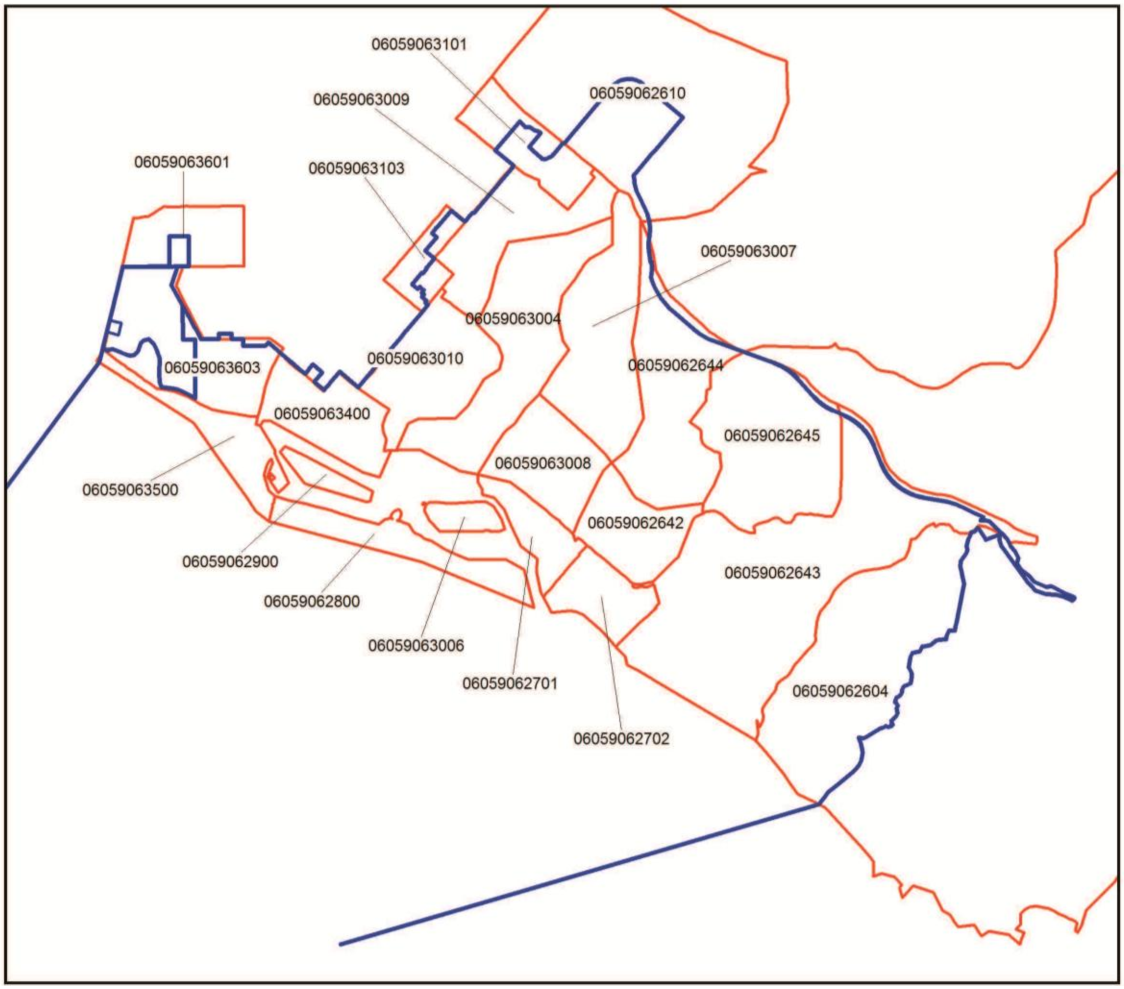
The population data used for the analyses were based on the 2006 American Community Survey data from the U.S. Census Bureau. The general building stock and population inventory data conform to census tract boundaries, and the census tract boundaries generally conform to City limits, with some exceptions. The region studied is about 50.8 square miles in area and contains 22 census tracts. The largest of these census tracts is nearly the same size as all the other census tracts combined, and extends well beyond the City boundary to the southeast and northeast, into an area sparsely populated (Map 6-9). According to the 2006 Census data, there were over 40,000 households in the region, with a total population of 87,955 (this figure includes those areas outside City limits that are part of the census tracts used in the study). The 2006-07 permanent population in Newport Beach was estimated at 84,000, but in the summer, it peaks at approximately 100,000 residents, plus 75,000 to 100,000 visitors. Therefore, although the population numbers used in the analysis are appropriate for the area, depending on the season, higher casualties could be expected for the earthquake scenarios considered. The City's 2012 population was estimated at 87,068 (see Section 2), so the numbers used in the HazUS analysis are still within acceptable range.

According to the HazUS database, in 2006, there were an estimated 38,900 buildings in the region with a total building replacement value (excluding contents) of $13.15 billion. [The 2010 Census data indicate 44,193 housing units in the City, of which 38,751 are occupied year round.] In terms of building construction types found in the region, wood-frame construction makes up 93 percent of the building inventory. Approximately 97 percent of the buildings (and 69 percent of the building value) are associated with residential housing (see Figure 6-2). The remaining percentage is distributed between the other general building types. The replacement value of the transportation and utility lifeline systems in the City of Newport Beach is estimated at nearly $609 million and $39 million, respectively (in 2006 dollars).

The HazUS inventory of unreinforced masonry (URM) buildings included 135 structures in the study area, whereas the 2006 Seismic Safety Commission data indicate there are 127 URMs in Newport Beach. These numbers are in close agreement; therefore we used the URM numbers that HazUS provides. However, we did change the seismic design criteria for all of the URMs in the City from low to moderate to reflect the retrofitting efforts that were accomplished in the late 1990s and early 2000s. It is important to note, however, that retrofitting is typically designed to keep buildings from collapsing, but that structural damage to the building is still possible and expected.

Map 6-9: Census Tracts Used in the HazUS Analysis (in red)
Compared to the City Boundaries (in blue)

(Note that the region used in the analysis includes parts of Costa Mesa and Irvine. The census tract farther south extends beyond the limits of the box)

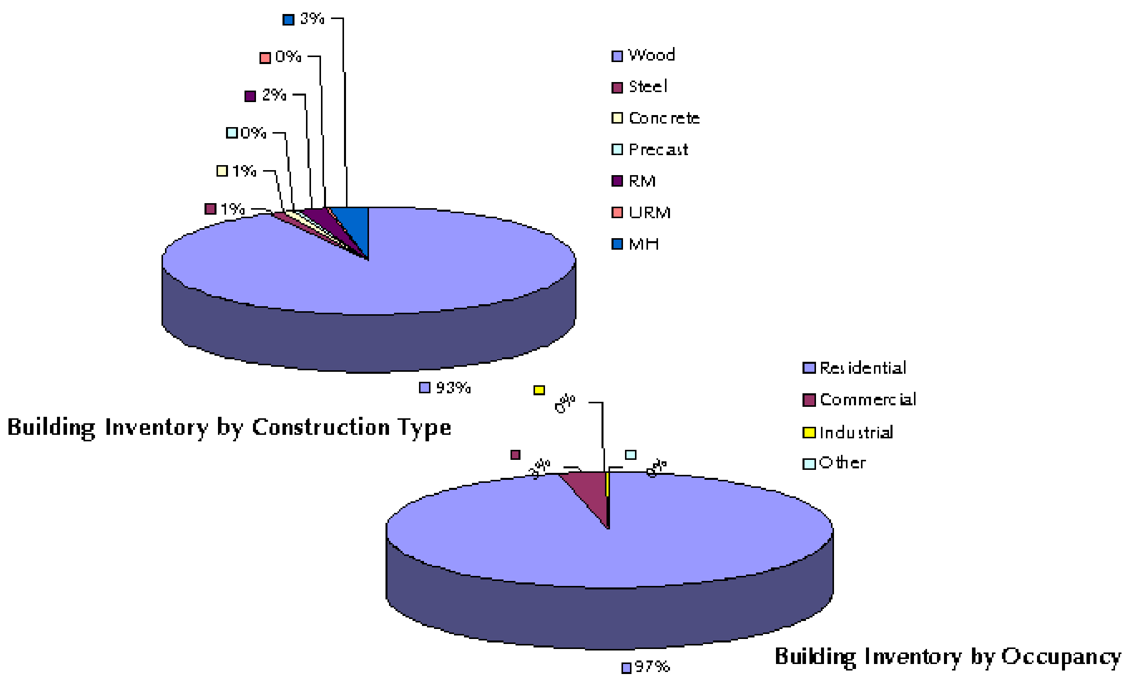


Regarding critical facilities, the HazUS database for the areas considered in the analysis included 28 school facilities (including public and private schools in Newport Beach and portions of Costa Mesa, pre-schools, and the Department of Education offices off of Red Hill Avenue), 8 fire stations, 2 police stations, and one emergency operations center (located in the auditorium of the main police station). [The City's new emergency operations center is located in the basement of the new City Hall.] In the discussion on losses below, however, we refer only to the schools within the City shown on Map 6-10. High potential loss facilities in the area identified in the HazUS database include 4 dams, 3 of which are considered high hazard, and 15 hazardous materials sites. The one hospital in the area, Hoag Memorial Hospital Presbyterian, was modeled with a total bed capacity of 511 beds, although the actual number of beds regularly available is less, as discussed further below.

Hoag Memorial Hospital Presbyterian is a not-for-profit, acute care hospital. Its campus consists of two hospital towers (West Tower and the Sue & Bill Gross Women's Pavilion), the Hoag Heart and Vascular Institute, the Hoag Cancer Center, an ambulatory surgery center (James Irvine Surgical Center), a childcare center and conference center. Fully accredited by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and designated as a Magnet hospital by the

American Nurses Credentialing Center (ANCC), Hoag offers a comprehensive mix of health care services, including Centers of Excellence in cancer, heart and vascular, neurosciences, orthopedics and women's health services.

Figure 6-2
Building Inventory, by Occupancy and Building Type, in the Newport Beach Area
(values shown are percentages)



Hoag has over 1,000 physicians on staff and has more than 4,000 employees. Hoag sees nearly 25,000 inpatients and 200,000 outpatients annually.

Although licensed for 511 beds, as of April 2007, the number of inpatient available beds was approximately 478 and the number of staffed beds was approximately 417. Inpatient available is an internal definition for beds that are physically available for inpatient use based on Hoag's operational use of bed. This excludes suspended beds and four Labor & Delivery Room (LDR) non-inpatient licensed beds, but includes all other physically available, 24-hour convertible and inpatient licensed beds in use. Staffed beds are defined as operationally available for inpatient use plus all LDR. This is based on Hoag's operational use of bed. Inpatient beds used exclusively for outpatient services or used temporarily for non-patient care (such as a lounge) are not counted in staffed bed numbers. These numbers more closely represent the hospital's daily capacity in being able to treat increased numbers of victims during a disaster.

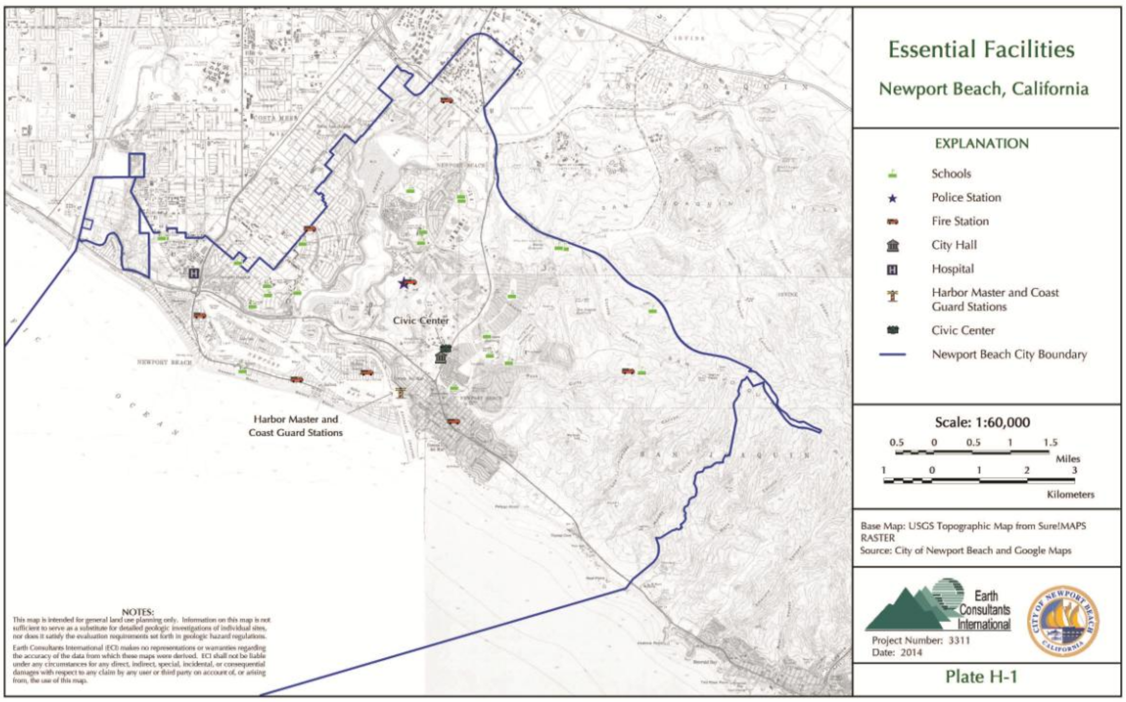
Hoag's emergency care unit has 30 licensed beds and has full victim decontamination capability, including equipment, supplies and trained first receivers. In 2007, the emergency care unit had started a total renovation and expansion that would increase the unit's bed capacity to 51 total licensed beds. The expected completion date for this renovation was mid-2010 and was the renovation was completed as planned.

The Hoag Hospital campus is supported by an extensive emergency power system. In addition to regular power supplied by Southern California Edison (SCE), the campus is supplemented by a natural-gas-fired cogeneration power plant. Also, a substantial emergency generator plant supports the critical load of the campus and is composed of five (5) 1750 kilowatt generators which is planned to provide power for up to 5 days on normal loads.

Map 6-10: Essential Facilities in Newport Beach (in 2014)

(for a larger version of this map, refer to Plate H-1 in Appendix H)

The HazUS analysis presented here used the location of the essential facilities as of 2006.



Estimated Losses Associated with the Earthquake Scenarios

HazUS loss estimations for Newport Beach based on the modeled earthquake scenarios are presented concurrently below. These scenarios include earthquakes on the San Joaquin Hills, Newport-Inglewood, Whittier, and San Andreas faults. Of the four earthquake scenarios modeled for the City, the results indicate that the San Andreas fault poses the least damage to the Newport Beach area, although this fault may have the highest probability of rupturing in the near-future.

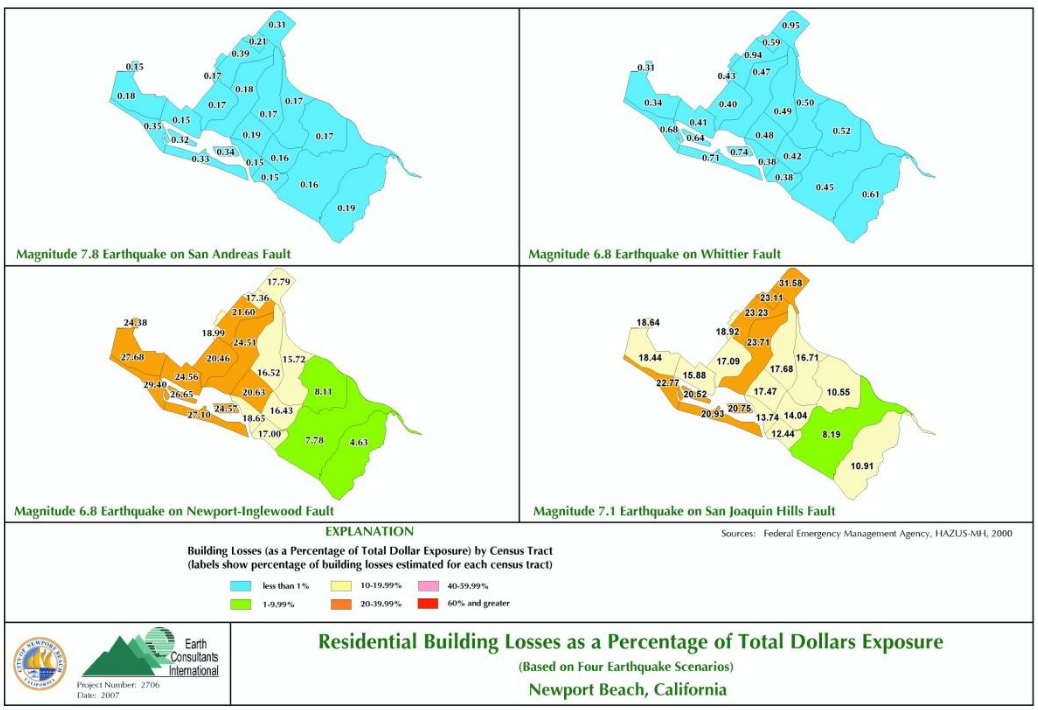
Given their proximity, fault type and magnitudes of their maximum earthquake, the San Joaquin Hills and Newport-Inglewood faults both have the potential to cause the worst-case scenario for Newport Beach. The San Joaquin Hills structure is a reverse fault that is thought to be responsible for uplift of the San Joaquin Hills. It may have caused the greater than magnitude 7 earthquake reported by the Portolá expedition in 1769 (Grant et al., 2002). In general, reverse earthquakes generate stronger ground accelerations that are distributed over broader geographic areas than similar-magnitude strike-slip earthquakes. The Newport-Inglewood fault also has the potential to cause significant damage in the City of Newport Beach. The losses anticipated as a result of the Whittier fault causing an earthquake are an order of magnitude lower than the two scenarios just discussed.

Building Damage

HazUS estimates that between approximately 190 and 15,900 buildings will be at least moderately damaged in response to the earthquake scenarios presented herein, with the lower number representative of damage as a result of an earthquake on the San Andreas fault, and the higher number representing damage as a result of an earthquake on the Newport-Inglewood fault. These figures represent about 0.5 to 41 percent of the total number of buildings in the study area. An estimated 1 to 2,910 buildings will be completely destroyed. Table 6-6 summarizes the expected damage to buildings by general occupancy type, whereas Table 6-7 summarizes the expected damage to buildings in the study area classified by construction type. The data presented in Tables 6-6 and 6-7 show that given the large percentage of residential structures, most of the buildings damaged will be residential, with wood-frame structures experiencing mostly slight to moderate damage.

Map 6-11: Damage Distribution to Residential Structures as a Result of Four Earthquake Scenarios

(for a larger version of this map, refer to Plate H-5 in Appendix H)



The San Joaquin Hills fault earthquake scenario has the potential to cause at least slight damage to more than 74 percent of the residential structures in Newport Beach, and moderate to complete damage to as much as 34 percent of the residential stock; whereas, the Newport-Inglewood scenario has the potential to cause at least slight damage to 78 percent of the residential structures in Newport Beach, and moderate to complete damage to approximately 40 percent of the residential stock. The distribution and severity of the damage caused by these earthquakes to the residential buildings in the City is illustrated in Map 6-11. The Whittier fault has the potential to cause some damage to the residential stock of Newport Beach, but the damage would not be as severe as that caused by either the San Joaquin Hills or Newport-Inglewood faults. The Whittier fault earthquake scenario is estimated to cause at least slight damage to nearly 10 percent of the residential stock. The San Andreas fault earthquake scenario is anticipated to cause at least slight damage to about 4 percent of the residential buildings in the City.

Table 6-6: Number of Buildings Damaged, by Occupancy Type

Scenario	Occupancy Type	Slight	Moderate	Extensive	Complete	Total
San Joaquin Hills	Residential	14,953	8,955	1,416	2,500	27,824
	Commercial	271	403	223	137	1,034
	Industrial	21	38	25	16	85
	Agriculture	0	0	0	0	0
	Religion	5	7	3	2	17
	Government	2	4	2	2	10
	Education	1	1	0	0	2
	Total	**15,253**	**9,408**	**1,669**	**2,567**	**28,972**
Newport-Inglewood	Residential	14,282	10,392	1,915	2,770	29,359
	Commercial	280	387	201	126	994
	Industrial	25	36	18	11	90
	Agriculture	0	0	0	0	0
	Religion	5	6	3	2	16
	Government	3	3	2	1	9
	Education	1	0	0	0	1
	Total	**14,596**	**10,824**	**2,139**	**2,910**	**30,469**
Whittier	Residential	3,156	396	22	3	3,577
	Commercial	101	41	5	0	147
	Industrial	11	5	1	0	17
	Agriculture	0	0	0	0	0
	Religion	2	1	0	0	3
	Government	1	0	0	0	1
	Education	0	0	0	0	0
	Total	**3,271**	**443**	**28**	**3**	**3,745**
San Andreas	Residential	1,447	159	9	1	1,616
	Commercial	53	18	2	0	73
	Industrial	6	2	0	0	8
	Agriculture	0	0	0	0	0
	Religion	1	0	0	0	1
	Government	1	0	0	0	1
	Education	0	0	0	0	0
	Total	**1,508**	**179**	**11**	**1**	**1,699**

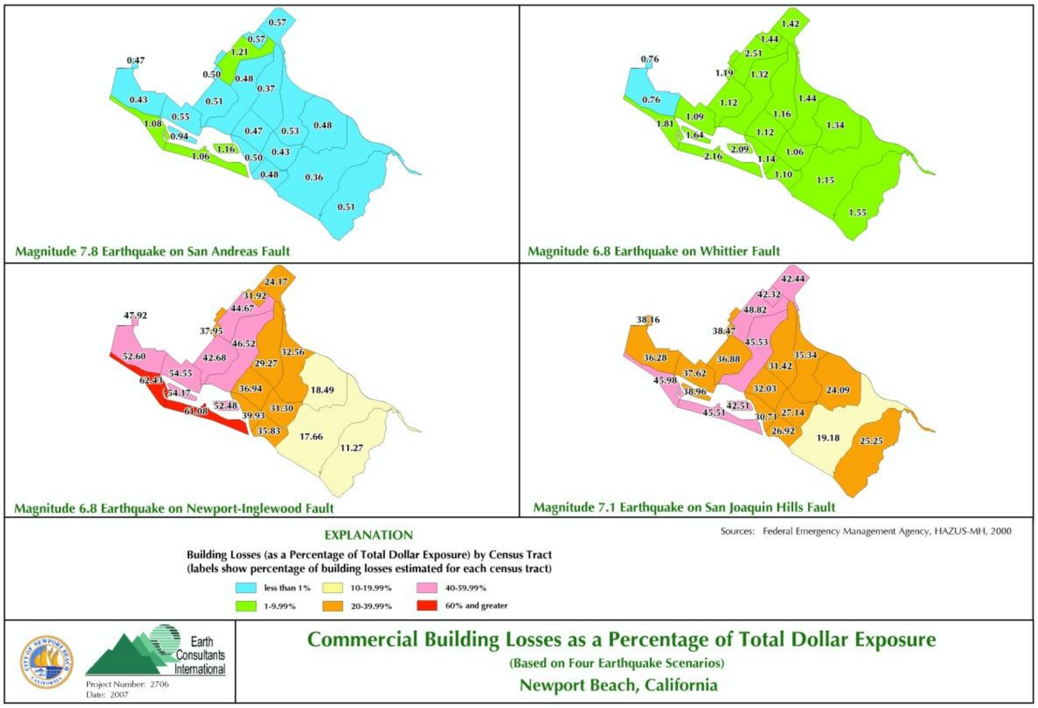
The commercial and industrial structures in Newport Beach will also be impacted (Table 6-6). The San Joaquin Hills and Newport-Inglewood earthquakes have the potential to cause at least moderate damage to about 63 and 59 percent, respectively, of the combined commercial and industrial buildings in the City. The distribution and severity of damage to the commercial structures in the City as a result of earthquakes on the San Joaquin Hills, Newport-Inglewood (NIFZ), Whittier and San Andreas faults is illustrated in Map 6-12. All four earthquakes shown on Map 6-12 are anticipated to cause at least some damage in the commercial district of the City, but an earthquake on the San Joaquin Hills fault would be the more regionally severe, given the fault's type and location beneath the heart of Newport Beach. An earthquake on the NIFZ would cause extensive damage to the commercial structures in the Balboa Peninsula and West Newport areas.

Table 6-7: Number of Buildings Damaged, by Construction Type

Scenario	Structure Type	Slight	Moderate	Extensive	Complete	Total
San Joaquin Hills	Concrete	100	120	68	46	334
	Mobile Homes	167	422	361	171	1,121
	Precast Concrete	32	68	47	27	174
	Reinforced Masonry	164	256	149	78	647
	Steel	77	150	95	57	379
	URM (Retrofitted)	20	46	33	28	127
	Wood	14,693	8,346	916	2,250	26,205
	Total	**15,253**	**9,408**	**1,669**	**2,657**	**28,987**
Newport-Inglewood	Concrete	96	120	69	50	335
	Mobile Homes	153	379	360	218	1,110
	Precast Concrete	36	65	40	22	163
	Reinforced Masonry	154	255	161	86	656
	Steel	76	145	94	59	374
	URM (Retrofitted)	19	43	33	31	126
	Wood	14,062	9,817	1,382	2,444	27,705
	Total	**14,596**	**10,824**	**2,139**	**2,910**	**30,469**
Whittier	Concrete	37	12	1	0	50
	Mobile Homes	180	111	14	0	305
	Precast Concrete	18	10	1	0	29
	Reinforced Masonry	48	24	3	0	75
	Steel	43	22	2	0	67
	URM (Retrofitted)	21	10	2	1	34
	Wood	2,924	254	5	2	3,184
	Total	**3,271**	**443**	**28**	**3**	**3,744**
San Andreas	Concrete	19	5	0	0	24
	Mobile Homes	118	64	7	0	189
	Precast Concrete	9	4	0	0	13
	Reinforced Masonry	25	10	1	0	36
	Steel	25	11	1	0	37
	URM (Retrofitted)	14	5	1	1	21
	Wood	1,298	80	1	0	1,379
	Total	**1,508**	**179**	**11**	**1**	**1,699**

The HazUS output shows that the retrofitted URMs in Newport Beach will suffer slight to complete damage, with up to 21 percent likely to be completely destroyed during an earthquake on the San Joaquin Hills fault, and up to 23 percent destroyed by an earthquake on the Newport-Inglewood fault. At first glance these numbers seems high, however, it is likely that most of the URMs would have collapsed during these scenarios if they had not been retrofitted. The numbers show that by retrofitting its URMs, Newport Beach has already reduced its vulnerability to seismic shaking, and as a result, its potential number of earthquake-induced casualties.

Map 6-12: Damage Distribution to Commercial Structures as a Result of Four Earthquake Scenarios



Significantly, reinforced masonry, concrete and steel structures are not expected to perform well, with hundreds of these buildings in Newport Beach experiencing at least moderate damage during an earthquake on the San Joaquin Hills or Newport-Inglewood faults. These types of structures are commonly used for commercial and industrial purposes, and failure of some of these structures explains the casualties anticipated during the middle of the day in the non-residential sector (see Table 6-8). These types of buildings also generate heavy debris that is difficult to cut through to extricate victims.

Casualties

Table 6-8 provides a summary of the casualties estimated for these scenarios. The analysis indicates that the worst time for an earthquake to occur in the City of Newport Beach is during maximum non-residential occupancy (at 2 o'clock in the afternoon, when most people are in their place of business and schools are in session). The San Joaquin Hills earthquake scenario is anticipated to cause the largest number of casualties, followed closely by an event on the Newport-Inglewood fault. Although still significant, given the number of estimated injuries and deaths, the model indicates that the safest time for an earthquake to occur in Newport Beach is during maximum residential occupancy at 2 o'clock in the morning, when most people are at home. These findings reflect the generally good performance of residential structures to strong ground shaking – houses may be damaged but for the most part are not expected to collapse. Both the Whittier and San Andreas fault scenarios are anticipated to result in only a few non-life threatening injuries.

Table 6-8: Estimated Casualties

Type and Time of Scenario			Level 1: Medical treatment without hospitalization	Level 2: Hospitalization but not life threatening	Level 3: Hospitalization and life threatening	Level 4: Fatalities due to scenario event
San Joaquin Hills	2A.M. (max. residential occupancy)	Residential	476	112	9	15
		Non-Residential	63	18	3	6
		Commute	0	0	0	0
		Total	**539**	**130**	**12**	**21**
	2 P.M. (max educational, industrial, and commercial)	Residential	85	20	2	2
		Non-Residential	1,620	469	76	151
		Commute	1	1	1	0
		Total	**1,706**	**490**	**79**	**153**
	5 P.M. (peak commute time)	Residential	188	44	4	6
		Non-Residential	957	276	45	87
		Commute	69	87	155	29
		Total	**1,214**	**407**	**202**	**122**
Newport-Inglewood	2A.M. (max. residential occupancy)	Residential	533	125	10	18
		Non-Residential	48	13	2	4
		Commute	0	0	0	0
		Total	**581**	**138**	**12**	**22**
	2 P.M. (max educational, industrial, and commercial)	Residential	95	22	2	3
		Non-Residential	1,314	377	60	120
		Commute	1	1	2	0
		Total	**1,410**	**400**	**64**	**123**
	5 P.M. (peak commute time)	Residential	211	49	4	7
		Non-Residential	790	226	37	71
		Commute	41	51	91	17
		Total	**1,042**	**326**	**132**	**95**
Whittier	2A.M. (max. residential occupancy)	Residential	8	1	0	0
		Non-Residential	0	0	0	0
		Commute	0	0	0	0
		Total	**8**	**1**	**0**	**0**
	2 P.M. (max educational, industrial, and commercial)	Residential	1	0	0	0
		Non-Residential	25	3	0	0
		Commute	0	0	0	0
		Total	**26**	**3**	**0**	**0**
	5 P.M. (peak commute time)	Residential	2	0	0	0
		Non-Residential	16	2	0	0
		Commute	0	1	0	0
		Total	**18**	**2**	**1**	**0**
San Andreas	2A.M. (max. residential occupancy)	Residential	3	0	0	0
		Non-Residential	0	0	0	0
		Commute	0	0	0	0
		Total	**3**	**0**	**0**	**0**
	2 P.M. (max educational, industrial, and commercial)	Residential	0	0	0	0
		Non-Residential	11	1	0	0
		Commute	0	0	0	0
		Total	**11**	**1**	**0**	**0**
	5 P.M. (peak commute time)	Residential	1	0	0	0
		Non-Residential	7	1	0	0
		Commute	0	0	1	0
		Total	**8**	**1**	**1**	**0**

Essential Facility Damage

The loss estimation model calculates the percentage of hospital beds in Newport Beach that will be available after each earthquake scenario.

A maximum magnitude earthquake on the San Joaquin Hills fault is expected to impact Hoag Memorial Hospital such that 54 percent of the beds would be damaged and unavailable for relief efforts, leaving only 46 percent of the hospital beds available on the day of the earthquake for use by existing patients (those already in the hospital) and by injured persons requiring hospitalization. One week after the earthquake, about 86 percent of the beds are expected to be back in service. After one month, 95 percent of the beds are expected to be operational.

On the day of the Newport-Inglewood earthquake, the model estimates that only about 114 hospital beds (22 percent, using 511 beds for the calculation) will be available for use by patients already in the hospital and those injured by the earthquake. After one week, 73 percent of the beds will be back in service. After thirty days, 93 percent of the beds will be available for use.

An earthquake on the Whittier fault is significantly better regarding the availability of hospital beds. The model estimates that 99 percent of the hospital beds will be available on the day of the earthquake. After one week, 100 percent of the hospital beds are expected to be available for use. Similarly, an earthquake on the San Andreas fault is not expected to cause damage to Hoag Memorial Hospital. On the day of the earthquake, the model estimates that 99 percent of the beds will be available for use; after one week, 100 percent of the beds will be available for use.

Given that the models estimate that about 600 people in the Newport Beach area will require hospitalization after an earthquake on the San Joaquin Hills fault (see Table 6-8), Hoag Memorial Hospital is not expected to have enough beds to meet the demand for medical care (the model estimates about 236 beds will be available at this hospital after the scenario earthquake, and that number includes beds occupied by patients already at the hospital when the earthquake strikes). Similarly, the hospital is not expected to be able to provide medical attention to all the people needing medical assistance after an earthquake on the segment of the Newport-Inglewood fault within or adjacent to Newport Beach. However, nearby cities, such as Irvine, Santa Ana, Mission Viejo and Fountain Valley may sustain less damage and people requiring hospitalization could be treated at medical facilities in these cities. The model estimates that there would be sufficient beds available to treat patients injured during an earthquake on either the Whittier or San Andreas fault.

HazUS also estimates the damage to other critical facilities in the City, including schools, fire and police stations, and the emergency operations center. According to the model, earthquakes on the San Andreas and Whittier faults will cause only slight damage to the schools, fire and police stations, and the City's emergency operations center. All of these facilities are expected be more than 50 percent functional the day after the earthquake.

An earthquake on the San Joaquin Hills fault is anticipated to cause at least moderate damage to all schools in the City, and none of the schools and school district offices in the study area are expected to be more than 50 percent operational seven days after the earthquake. The model also indicates that Hoag Memorial Hospital, the police stations, the emergency operations center, and 7 of the 8 fire stations will experience more than slight damage, and that none of these facilities will be more than 50 percent operational the day after the earthquake. [Given that the City's emergency operations center is located at the new City Hall, its functionality after an earthquake is expected to be much better than what the HazUS analysis estimated.]

Similarly, an earthquake on the Newport-Inglewood fault is anticipated to cause at least moderate damage to all schools in the City. The model also shows that Hoag Memorial Hospital and one of the fire stations will experience more than slight damage, with the hospital, the emergency operations center, and the police and fire stations all less than 50 percent operational the day after the earthquake. [Again, the emergency operations center has been moved to a new, earthquake-resistant structure, so its functionality after an earthquake is expected to be much better than this, as the HazUS model is referring to the older location.] The modeled earthquakes on the Whittier and San Andreas faults will not damage or cause delays to any of the critical facilities in the City of Newport Beach.

Building-Related Losses

Total economic losses include building- and lifeline-related losses based on the region's available inventory. Direct building losses (or capital stock losses in Table 6-9) are the estimated costs to repair or replace the damage caused to the buildings and its contents. It includes structural and non-structural damage to the building itself, and damage to the contents, and in the case of businesses, damage to inventory. Income losses, or business interruption losses, are losses associated with the inability to operate a business because of the damage it sustained during the earthquake. Income loss estimates also include the temporary living expenses for those people displaced from their homes because of the earthquake. Income losses, however, do not include losses related to the inability to operate the business because of lifeline outages or damage to the transportation network limiting access to a business.

The model estimates that total building-related losses in the City of Newport Beach will range from less than $42 million for an earthquake on the San Andreas fault, to $3,120 million for an earthquake on the San Joaquin Hills fault. Approximately 13 percent of these estimated losses would be related to business interruption in the City. Damage to residential occupancies accounts for the largest loss, ranging from about 45 to 55 percent of the total building-related economic loss estimates. Table 6-9 below provides a summary of the estimated economic losses anticipated as a result of each of the earthquake scenarios considered herein. The total economic losses to the region include the costs of repairing or replacing the damaged lifeline systems. This is discussed further below.

Table 6-9: Building-Related Economic Loss Estimates (in Million $)

Scenario	Capital Stock Losses				Income Losses				Total
	Residential	Commercial	Industrial	Other	Residential	Commercial	Industrial	Other	
San Joaquin Hills	1,507.57	1,002.12	150.83	53.34	71.64	325.17	6.34	3.41	3,120.42
Newport-Inglewood	1,698.05	869.97	113.74	42.57	76.25	300.35	4.82	2.7	3,108.44
Whittier	45.69	33.59	5.94	1.89	1.38	10.89	0.27	0.11	99.76
San Andreas	18.55	14.44	2.58	0.76	0.49	4.85	0.11	0.04	41.81

Shelter Requirement

HazUS estimates that nearly 3,694 households in Newport Beach may be displaced due to the San Joaquin Hills earthquake modeled for this study. About 741 people will seek temporary shelter in public shelters. The rest of the displaced individuals are anticipated to seek shelter with family or friends. An earthquake on the Newport-Inglewood fault is anticipated to displace over 4,153 households, with approximately 835 people seeking temporary shelter. The San Andreas and Whittier earthquakes are expected to displace none to very few households.

Table 6-10: Estimated Shelter Requirements

Scenario	Displaced Households	People Needing Short-Term Shelter
San Joaquin Hills	3,694	741
Newport-Inglewood	4,153	835
Whittier	0	0
San Andreas	6	1

Transportation Damage

Damage to the transportation system in the City of Newport Beach is based on a generalized inventory of the region, which includes areas outside of the City since the transportation network extends beyond corporate boundaries. Road segments are assumed to be damaged by ground failure only; therefore, the numbers presented herein may be low given that, based on damage observed from the Northridge and San Fernando earthquakes, strong ground shaking can cause considerable damage to bridges.

The San Joaquin Hills fault earthquake scenario is the worst-case for the transportation system in the City. Economic losses to the region due to bridge damage are estimated at between $0.5 million (for an earthquake on either the San Andreas or Whittier fault) to $27.35 million for an earthquake on the San Joaquin Hills fault (see Table 6-11). The HazUS analysis suggests that as many as twelve bridges would be damaged by an earthquake on the San Joaquin Hills fault; ten of these would experience at least moderate damage, and one bridge would be completely damaged. An earthquake on the Newport-Inglewood fault would cause at least moderate damage to five bridges, and one of these would be completely damaged. Neither the Whittier nor the San Andreas fault earthquake scenarios are expected to cause more than slight damage to the bridges in the area, and all bridges are expected to be more than 50 percent functional the first day after the earthquake. Although the road segments that traverse the area are anticipated to experience some damage, none of them will be significantly impaired, as they are all expected to be more than 50 percent functional the next day.

These loss estimates are a substantial improvement over loss estimates performed in 2003 that indicated losses of between $3.1 million for an earthquake on the San Andreas fault, and $57.4 million for an earthquake on the San Joaquin Hills fault. These improvements reflect the recent seismic upgrades and retrofitting that the City and Caltrans have undertaken for bridges in the region. Nevertheless, there are still several bridges in the Newport Beach area that are included in both the Federal Highway Administration's National Bridge Inventory (http://www.fhwa.dot.gov/bridge/nbi.cfm) and Caltran's Local Highway Bridge Program (http://www.dot.ca.gov/hq/LocalPrograms/hbrr99/hbrr99a.htm) list classified as either structurally deficient or functionally obsolete. The structurally deficient bridge, as of May 2, 2013 when the State issued the latest list of bridges, is the north-bound Jamboree Bridge over San Diego Creek. The functionally obsolete bridges in Newport Beach, per the State list, include the Via Lido bridge over West Lido Channel, the Marine Avenue bridge over Balboa Island Channel, the Park Avenue bridge over the Grand Canal, the 38th Street bridge over Rivo Alto, and the Park Avenue bridge over Waters Way. A bridge classified as structurally deficient either has a significant defect such that a speed or weight limit must be applied to the bridge to ensure its safety, or its approaches flood regularly. A functionally obsolete bridge is one whose design is not suitable for its current use, such as lack of safety shoulders or the inability to handle current traffic volume, speed, size, or weight.

John Wayne Airport is expected to incur losses of between about $0.29 million (for an earthquake on the San Andreas fault) and $5.34 million (for an earthquake on the San Joaquin Hills fault). In all scenarios, however, airport functionality will not be greatly impaired.

Table 6-11: Damage to the Transportation System

EQ Scenario	System		Segments in Inventory	Replacement Value ($Million)	With at Least Moderate Damage	With Complete Damage	Economic Loss ($Million)	>50% Functional After Day 1
San Joaquin Hills	Highway	Segments	7	294.64	0	0	7.22	7
		Bridges	58	232.39	10	1	27.35	46
	Railway	Facilities	1	2.57	1	0	1.07	1
	Airport	Facilities	1	6.43	1	0	3.82	1
		Runway	2	73.35	0	0	1.52	2
Newport-Inglewood	Highway	Segments	7	294.64	0	0	5.57	7
		Bridges	58	232.39	4	1	18.84	54
	Railway	Facilities	1	2.57	0	0	1.18	1
	Airport	Facilities	1	6.43	1	0	2.35	1
		Runway	2	73.35	0	0	0.16	2
Whittier	Highway	Segments	7	294.64	0	0	0	7
		Bridges	58	232.39	0	0	0.45	58
	Railway	Facilities	1	2.57	0	0	0.11	1
	Airport	Facilities	1	6.43	0	0	0.5	1
		Runway	2	73.35	0	0	0	2
San Andreas	Highway	Segments	7	294.64	0	0	0	7
		Bridges	58	232.39	0	0	0.47	58
	Railway	Facilities	1	2.57	0	0	0.06	1
	Airport	Facilities	1	6.43	0	0	0.29	1
		Runway	2	73.35	0	0	0	2

Utility Systems Damage

The HazUS inventory for the Newport Beach area does not include specifics regarding the various lifeline systems in the City, therefore, the model estimated damage to the potable water and electric power using empirical relationships based on the number of households served in the area. The results of the analyses regarding the functionality of the potable water and electric power systems in the City for the four earthquakes discussed herein are presented in Table 6-12. According to the models, the San Joaquin Hills and Newport-Inglewood earthquake scenarios will severely impact the electric power systems; thousands of households in the City are expected to not have electric power even three days after an earthquake on either of these faults. An earthquake on the San Joaquin Hills fault is anticipated to leave more than 7,000 households without electricity for more than one week, whereas an earthquake on the Newport-Inglewood fault would leave about 9,000 without electricity for one week, and up to 2,000 without power for one month.

The potable water system is expected to do better, but both the San Joaquin Hills fault and Newport-Inglewood fault earthquake scenarios have the potential of leaving thousands without potable water for at least 3 days after the earthquake. These results suggest that the City will have to truck in water to some of the residential neighborhoods until the damages to the water system are repaired. Residents are advised to have drinking water stored as part of their earthquake emergency kits, enough to last all members of the household (including pets) at least 3 days, and preferably one week.

Table 6-12: Expected Performance of Potable Water and Electricity Services

Scenario	Utility	Number of Households without Service*				
		Day 1	Day 3	Day 7	Day 30	Day 90
San Joaquin Hills	Potable Water	22,986	6,360	0	0	0
	Electricity	28,742	17,485	7,176	1,488	41
Newport-Inglewood	Potable Water	26,219	12,315	0	0	0
	Electricity	29,394	19,327	8,986	2,137	39
Whittier	Potable Water	0	0	0	0	0
	Electricity	0	0	0	0	0
San Andreas	Potable Water	0	0	0	0	0
	Electricity	0	0	0	0	0

*Based on Total Number of Households = 40,706.

Table 6-13: Expected Utility Systems Pipeline Damage

Scenario	System	Total Pipelines Length (km)	Number of Leaks	Number of Breaks
San Joaquin Hills	Potable Water	690	179	104
	Waste Water	414	142	82
	Natural Gas	276	152	88
	Oil	0	0	0
Newport-Inglewood	Potable Water	690	192	119
	Waste Water	414	152	94
	Natural Gas	276	162	101
	Oil	0	0	0
Whittier	Potable Water	690	8	2
	Waste Water	414	7	2
	Natural Gas	276	7	2
	Oil	0	0	0
San Andreas	Potable Water	690	10	3
	Waste Water	414	8	2
	Natural Gas	276	8	2
	Oil	0	0	0

Fire Following Earthquake

History shows that earthquake-induced fires have the potential to be the worst-case fire-suppression scenarios for a community because an earthquake typically causes multiple ignitions distributed over a broad geographic area, with the potential to severely tax the local fire suppression agencies. Furthermore, if fire fighters are involved with search and rescue operations, they are less available to fight fires. Fire suppression efforts can also be limited by a water distribution system that has been impaired by the earthquake. Thus, many factors affect the severity of fires following an earthquake, including ignition sources, types and density of fuel, weather conditions, functionality of the water systems, and the ability of firefighters to suppress the fires. The principal causes of earthquake-related fires are open flames, electrical malfunctions, gas leaks, and chemical spills. Downed power lines may ignite fires if the lines do not automatically de-energize. Unanchored gas heaters and water heaters have in the past been common problems, as these readily tip over during strong ground shaking; State law requires new and replaced gas-fired water heaters to be attached to a wall or other support.

The major urban conflagrations of former times in major cities were often the result of closely built, congested areas of attached buildings with no fire sprinklers, no adequate fire separations, no Fire Code enforcement, and narrow streets. In the past, fire apparatus and water supplies were also inadequate in many large cities, and many fire departments were comprised of volunteers. Many of these conditions no longer apply to the cities of today. Nevertheless, major earthquakes can result in fires and the loss of water supply, as it occurred in San Francisco in 1906, and in Kobe, Japan in 1995. A large portion of the structural damage caused by the great San Francisco earthquake of 1906 was the result of fires rather than ground shaking.

The moderately sized, M6.7 Northridge earthquake of 1994 caused 15,021 natural gas leaks that resulted in three street fires, 51 structure fires (23 of these caused total ruin) and the destruction, by fire, of 172 mobile homes. The 51 structure fires were caused by overturned water heaters (20), other overturned or damaged gas appliances (8), broken interior gas lines (8), broken gas meter set assemblies (2), street fires due to breaks in gas mains (7), and other unknown causes (8). The mobile home fires were primarily the result of failure of the supports leading to breakage of the gas risers, and breakage of the interior gas lines due to overturned water heaters and other appliances (Savage, 1995). The Southern California Gas Company reported 35 breaks in its natural gas transmission lines and 717 breaks in its distribution lines. About 74 percent of the leaks were corrosion related. In one incident, the earthquake severed a 22-inch gas transmission line and a motorist ignited the gas while attempting to restart his stalled vehicle. Response to this fire was impeded by the earthquake's rupture of a water main; as a result, five nearby homes were destroyed. Elsewhere, one mobile home fire started when a ruptured transmission line was ignited by a downed power line. In many of the destroyed mobile homes, fires erupted when inadequate bracing allowed the houses to slip off their foundations, severing gas lines and igniting fires.

A regional earthquake scenario that involves rupture of the entire southern section of the San Andreas fault was conducted in 2008 for the ShakeOut Scenario (Jones and others, 2008; Scawthorn, 2008). The scenario estimates that as a result of a magnitude 7.8 earthquake on the southern San Andreas, a total of 206 ignitions would occur in Orange County. This estimate does not include ignitions that are suppressed by responding citizens. Of the estimated 206 ignitions that will require fire department response, 165 would develop into large fires, each requiring the response of more than one fire engine company. The estimated ultimate burnt area in the County would be equivalent to about 37,000 single-family dwellings (Scawthorn, 2008). Using the 1994 Northridge earthquake as proxy, about half of the ignitions are expected to be electric related, about a quarter would be gas related, and the rest would be the result of a variety of causes, including chemical reactions. Also based on the Northridge earthquake, about 70 percent of all ignitions will occur in residential structures. Although city-specific estimates were not computed as part of the ShakeOut scenario, the data clearly highlight the hazard associated with earthquake-induced fires. Response to these fires will be hindered by a damaged water distribution system, overwhelmed local fire department resources, overwhelmed 911 centers, and extremely delayed response from strike teams coming in from outlying areas due to damage to the transportation system and traffic disruption (Scawthorn, 2008).

HazUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area as a result of an earthquake. For the earthquake scenarios ran for Newport Beach, HazUS estimates between 16 and 2 ignitions immediately following an earthquake, with the San Andreas fault earthquake scenario triggering 2 ignitions, the Whittier fault causing 3 ignitions, the Newport-Inglewood causing 16 ignitions and the San Joaquin Hills faults triggering 15 ignitions (Table 6-14). The burnt area resulting from these ignitions will vary depending on wind conditions. Normal wind conditions of about 10 miles per hour (mph) are expected to result in burn areas of between 3 and 100 acres. If Santa Ana wind conditions are present at the time of the earthquake, the burnt areas can be expected to be significantly larger. Additional information regarding fires after earthquakes and the resultant losses estimated for the City of Newport Beach are provided in Section 8.

Table 6-14: Fires Following an Earthquake

EQ Scenario	No. of Ignitions	Approximate Burn Area (Acres)	No. of Displaced Individuals	Building Value Destroyed (Million $)
San Joaquin Hills	15	70	416	52.75
Newport-Inglewood	16	100	707	88.08
Whittier	3	3	40	4.52
San Andreas	2	6	99	11.31

Debris Generation

The model estimates that between 9 and 889 thousand tons of debris will be generated by the earthquake scenarios considered in this study (see Table 6-15). Of the total amount, brick and wood comprise between 32 and 44 percent of the total, with the remainder consisting of reinforced concrete and steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 360 to 35,560 truckloads (assuming 25 tons per truck) to remove the debris generated by the earthquakes modeled.

Table 6-15: Debris Generated by Earthquake Scenarios

EQ Scenario	Brick/Wood (1000s Tons)	% Total	Reinforced Concrete/Steel (1000s Tons)	% Total	Total	No. of Truckloads
San Joaquin Hills	284	31.95	605	68.05	889	35,560
Newport-Inglewood	289.5	34.55	548.5	65.45	838	33,520
Whittier	9.5	43.18	12.5	56.82	22	880
San Andreas	4	44.44	55.56	55.56	9	360

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, State, or Federal agencies or organizations.

California Earthquake Mitigation Legislation

California is painfully aware of the threats it faces from earthquakes. Since the 1800s, Californians have been killed, injured, and lost property as a result of earthquakes. As the State's population continues to grow, and urban areas become even more densely built up, the risk will continue to increase. In response to this concern, for decades now the Legislature has passed laws to strengthen the built environment and protect the citizens. Table 6-16 provides a sampling of some of the 200 plus laws in the State's codes.

Table 6-16: Partial List of the Over 200 California Laws on Earthquake Safety

CA-1 Field Act (Education Code §17281, et seq.)	Establishes regulation for the design and construction of K-12 and community colleges to ensure seismic safety in new public schools.
CA-2 Riley Act	Requires local governments to have building departments that issue permits for new construction and alterations to existing structures. Set minimum seismic safety requirements that have since been incorporated into all building codes.
CA-5 Seismic Safety General Plan Element (Government Code § 65302)	Requires cities and counties to include seismic safety elements in their general plans. The seismic safety element later became part of the safety element.
Government Code Section 8870-8870.95	Creates Seismic Safety Commission.
Government Code Section 8876.1-8876.10	Established the California Center for Earthquake Engineering Research.
Public Resources Code Section 2800-2804.6	Authorized a prototype earthquake prediction system along the central San Andreas fault near the city of Parkfield.
Public Resources Code Section 2810-2815	Continued the Southern California Earthquake Preparedness Project and the Bay Area Regional Earthquake Preparedness Project.
Health and Safety Code Section 16100-16110	The Seismic Safety Commission and State Architect will develop a state policy on acceptable levels of earthquake risk for new and existing state-owned buildings.
Government Code Section 8871-8871.5	Established the California Earthquake Hazards Reduction Act of 1986.
Health and Safety Code Section 130000-130025	Defined earthquake performance standards for hospitals.
Public Resources Code Section 2805-2808	Established the California Earthquake Education Project.
Government Code Section 8899.10-8899.16	Established the Earthquake Research Evaluation Conference.
Public Resources Code Section 2621-2630 2621.	Established the Alquist-Priolo Earthquake Fault Zoning Act.
Government Code Section 8878.50-8878.52 8878.50.	Created the Earthquake Safety and Public Buildings Rehabilitation Bond Act of 1990.
Education Code Section 35295-35297 35295.	Established emergency procedure systems in kindergarten through grade 12 in all the public or private schools.
Health and Safety Code Section 19160-19169	Established standards for seismic retrofitting of unreinforced masonry buildings.
Health and Safety Code Section 1596.80-1596.879	Required all child day care facilities to include an Earthquake Preparedness Checklist as an attachment to their disaster plan.

City of Newport Beach Codes

Implementation of earthquake mitigation policy most often takes place at the local government level. The City of Newport Beach Community Development Department, Building Division enforces building codes pertaining to earthquake hazards. The City has adopted the provisions of the 2013 California Building Code, a modification to the 2012 Uniform Building Code with more restrictive amendments based upon the local geographic, topographic and climatic conditions. The City of Newport Beach, along with dozens of other local jurisdictions, have worked together to make these amendments to the California Building Code consistent with the rest of southern California. Currently, Newport Beach's Building Division staff are very active in the code development process and all regional activities to improve the technical provisions of the building code and the understanding of the purpose of the building codes by the public.

The City of Newport Beach Planning Division enforces the zoning and land use regulations relating to earthquake hazards. Generally, these codes and regulations seek to discourage development in areas that could be prone to flooding, landslide, wildfire and/or seismic hazards; and where development is permitted, that the applicable construction standards are met. Developers in hazard-prone areas may be required to retain a qualified professional engineer to evaluate level of risk on the site and recommend appropriate mitigation measures.

Extensive information about the City's departments, codes and policies, forms and handouts, bulletins, forms required for permit applications, fees, etc., are available from the City's website at http://www.newportbeachca.gov/. Look for the link to the City's departments, and then refer to the Building Division section. Building Division staff is also available to help in person at City Hall.

Businesses/Private Sector

Natural hazards have a devastating impact on businesses. In fact, according to the Institute for Business and Home Safety (IBHS), approximately 25 percent of all businesses do not reopen following a major disaster. Business owners and homeowners alike can protect their investment by identifying the risks associated with the natural and man-made disasters that their area is susceptible to (which this plan covers), and then creating and implementing an action plan that defines the steps to take should a disaster strike. To help business owners with this effort, the IBHS has developed "Open for Business," a disaster planning toolkit to help guide businesses in preparing for and dealing with the adverse affects natural hazards (available from https://www.disastersafety.org/open-for-business/). The kit integrates protection from natural disasters into the company's risk reduction measures to safeguard employees, customers, and the investment itself. The guide helps businesses secure human and physical resources during disasters, and helps to develop strategies to maintain business continuity before, during, and after a disaster occurs. The U.S. Small Business Administration also provides helpful information and checklists that can be used for this purpose (http://www.sba.gov/content/disaster-planning).

Hospitals

The Alfred E. Alquist Hospital Seismic Safety Act ("Hospital Act") was enacted in 1973 in response to the moderate Magnitude 6.6 Sylmar Earthquake in 1971 when four major hospital campuses were severely damaged and evacuated. Two hospital buildings collapsed killing forty seven people. Three others were killed in another hospital that nearly collapsed.

In approving the Act, the Legislature noted that: "Hospitals, that house patients who have less than the capacity of normally healthy persons to protect themselves, and that must be reasonably capable of providing services to the public after a disaster, shall be designed and constructed to resist, insofar as practical, the forces generated by earthquakes, gravity and winds." (Health and Safety Code Section 129680).

When the Hospital Act was passed in 1973, the State anticipated that, based on the regular and timely replacement of aging hospital facilities, the majority of hospital buildings would be in compliance with the Act's standards within 25 years. However, hospital buildings were not, and are not, being replaced at that anticipated rate. In fact, the great majority of the State's urgent care facilities are now more than 40 years old.

The moderate magnitude 6.7 Northridge Earthquake in 1994 caused $3 billion in hospital-related damage and evacuations. Twelve hospital buildings constructed before the Act were cited (red tagged) as unsafe for occupancy after the earthquake. Those hospitals that had been built in accordance with the 1973 Hospital Act were successful in resisting structural damage. However, nonstructural damage (for example, plumbing and ceiling systems) was still extensive in those post-1973 buildings.

Senate Bill 1953 (SB 1953), enacted in 1994 after the Northridge earthquake, expanded the scope of the 1973 Hospital Act. Under SB 1953, all hospitals were required by January 1, 2008 to survive earthquakes without collapsing or posing the threat of significant loss of life (life safety level). Provisions were made to allow this deadline to be extended to January 1, 2013 if compliance by the 2008 deadline would result in diminished capacity of healthcare services to the community. Subsequent amendments have provided for additional extensions, with the final date by which all hospitals must comply with the provisions of the act being January 1, 2020. To grant an extension to a hospital, the Office of Statewide Health Planning and Development (OSHPD) must consider the structural integrity of the building, the loss of essential healthcare services to the community if the hospital closed, and the financial hardship that the hospital would experience in complying with the provisions of the Act. The 1994 Act further mandates that all existing hospitals be seismically evaluated, and retrofitted, if needed, by 2030, so that they are in substantial compliance with the Act (which requires that the hospital buildings be reasonably capable of providing services to the public after disasters). SB 1953 applies to all urgent care facilities (including those built prior to the 1973 Hospital Act) and affects approximately 2,500 buildings on 475 campuses statewide.

SB 1953 directed OSHPD, in consultation with the Hospital Building Safety Board, to develop emergency regulations including "…earthquake performance categories with subgradations for risk to life, structural soundness, building contents, and nonstructural systems that are critical to providing basic services to hospital inpatients and the public after a disaster." (Health and Safety Code Section 130005).

In 2001, recognizing the continuing need to assess the adequacy of policies and the application of advances in technical knowledge and understanding, the California Seismic Safety Commission created an Ad Hoc Committee to re-examine the compliance with the Alquist Hospital Seismic Safety Act. The formation of the Committee was prompted by the evaluations of hospital buildings reported to OSHPD that revealed that about 40 percent of California's operating hospitals are in the highest category of collapse risk."

Earthquake Education

Earthquake research and education activities are conducted at several major universities in the southern California region, including Cal Tech, University of Southern California (USC), University of California - Los Angeles (UCLA), University of California – Santa Barbara (UCSB), University of California – Irvine (UCI), and University of California – San Diego (UCSD), and San Diego State University (SDSU).

The local clearinghouse for earthquake information is the Southern California Earthquake Center (SCEC) located at the University of Southern California, Los Angeles, CA 90089. Administrative offices are located on the first floor of the Zumberge Hall of Science on Trousdale Parkway, Telephone: (213) 740-5843, Fax: (213) 740-0011, Email: SCECinfo@usc.edu, Website: http://www.scec.org. The Southern California Earthquake Center (SCEC) is a community of scientists and specialists who actively coordinate research on earthquake hazards at fifteen core institutions, and communicate earthquake information to the public. SCEC is a National Science Foundation (NSF) Science and Technology Center and is co-funded by the United States Geological Survey (USGS).

In addition, Los Angeles County, along with 15 other southern California counties, sponsors the Emergency Survival Program (ESP), an educational program for learning how to prepare for earthquakes and other disasters (http://lacoa.org/esp.htm). Many school districts have very active emergency preparedness programs that include earthquake drills and periodic disaster response team exercises.

Earthquake Resource Directory

Local and Regional Resources

Southern California Earthquake Center (SCEC)

Level: Regional Hazard: Earthquake www.scec.org
3651 Trousdale Parkway Suite 169
Los Angeles, CA 90089-0742 Ph: 213-740-5843 Fx: 213-740-0011

Notes: The Southern California Earthquake Center (SCEC) gathers new information about earthquakes in southern California, integrates this information into a comprehensive and predictive understanding of earthquake phenomena, and communicates this understanding to end-users and the general public in order to increase earthquake awareness, reduce economic losses, and save lives.

Western States Seismic Policy Council (WSSPC)

Level: Regional Hazard: Earthquake www.wsspc.org
801 K Street Suite 1236
Sacramento, CA 95814 Ph: 916-444-6816 Fx: 916-444-8077

Notes: The WSSPC develops seismic policies and share information to promote programs intended to reduce earthquake-related losses.

Earthquake Country Alliance (ECA)

Level: Regional Hazard: Earthquake www.wsspc.org
3651 Trousdale Parkway Suite 169
Los Angeles, CA 90089 Ph: 213-740-1560

Notes: The Earthquake Country Alliance is a public-private partnership of people, organizations and regional alliances that work together to improve preparedness, mitigation and resiliency.

State Resources

California Department of Transportation (CalTrans)

Level: State Hazard: Multi http://www.dot.ca.gov/
3347 Michelson Drive, Suite 100 District 12 Offices
Irvine, CA 92612-0611 Ph: 949-724-2000

Notes: CalTrans is responsible for the design, construction, maintenance, and operation of the California State Highway System, as well as that portion of the Interstate Highway System within the state's boundaries. Alone and in partnership with Amtrak, CalTrans is also involved in the support of intercity passenger rail service in California.

California Resources Agency

Level: State Hazard: Multi http://resources.ca.gov/

1416 Ninth Street | Suite 1311
Sacramento, CA 95814 | Ph: 916-653-5656 | Fx: 916-653-8102

Notes: The California Resources Agency restores, protects and manages the state's natural, historical and cultural resources for current and future generations using solutions based on science, collaboration and respect for all the communities and interests involved.

California Geological Survey

Level: State | Hazard: Multi | www.consrv.ca.gov/cgs/index.htm
801 K Street | MS 12-30
Sacramento, CA 95814 | Ph: 916-445-1825 | Fx: 916-445-5718

Notes: The California Geological Survey develops and disseminates technical information and advice on California's geology, geologic hazards, and mineral resources.

California Geological Survey: Southern California Regional Office

Junipero Serra Building | 320 W. 4th Street, Suite 850
Los Angeles, CA 90013 | Ph: 213-239-0877 | Fx: 213-239-0894

California Department of Conservation

Level: State | Hazard: Multi | www.consrv.ca.gov
801 K Street, MS-24-01
Sacramento, CA 95814 | Ph: 916-322-1080 | Fx: 916-445-0732

Notes: The Department of Conservation provides services and information that promote environmental health, economic vitality, informed land-use decisions and sound management of our state's natural resources.

California Seismic Safety Commission

Level: State | Hazard: Earthquake | www.seismic.ca.gov
1755 Creekside Oaks Drive | Suite 100
Sacramento, CA 95833-3637 | Ph: 916-263-5506

Notes: The Seismic Safety Commission investigates earthquakes, researches earthquake-related issues and reports, and recommends to the Governor and Legislature, policies and programs needed to reduce earthquake risk. Some of the duties of the Commission include managing California's Earthquake Hazards Reduction Program, reviewing seismic activities funded by the State, providing a consistent policy direction for earthquake-related programs for all agencies at all government levels, proposing and reviewing earthquake-related legislation, conducting public hearings on seismic safety issues, recommending earthquake safety programs to governmental agencies and the private sector, and investigating and evaluating earthquake damage and reconstruction efforts following earthquakes..

Governor's Office of Emergency Services (Cal OES)

Level: State | Hazard: Multi | www.oes.ca.gov
P.O. Box 419047
Rancho Cordova, CA 95741-9047 | Ph: 916-845- 8911 | Fx: 916 845- 8910

Notes: The Governor's Office of Emergency Services coordinates overall state agency response to major disasters in support of local government. The office is responsible for assuring the state's readiness to respond to and recover from natural, manmade, and war-caused emergencies, and for assisting local governments in their emergency preparedness, response and recovery efforts.

Federal and National Resources

Building Seismic Safety Council (BSSC)

Level: National Hazard: Earthquake www.bssconline.org
1090 Vermont Ave., NW Suite 700
Washington, DC 20005-4905 Ph: 202-289-7800 Fx: 202-289-1092

Notes: The Building Seismic Safety Council (BSSC) develops and promotes building earthquake risk mitigation regulatory provisions for the nation. Provides a forum that fosters improved seismic safety provisions for the use by the building community in the planning, design, construction, regulation and utilization of buildings.

Federal Emergency Management Agency, Region IX

Level: Federal Hazard: Multi www.fema.gov
1111 Broadway Suite 1200
Oakland, CA 94607-4052 Ph: 510-627-7100 Fx: 510-627-7112

Notes: The Federal Emergency Management Agency is tasked with responding to, planning for, recovering from and mitigating against disasters.

Federal Emergency Management Agency, Mitigation Division

Level: Federal Hazard: Multi http://www.fema.gov/what-mitigation/federal-insurance-mitigation-administration
500 C Street, S.W.
Washington, D.C. 20472 Ph: 202-566-1600 Fx:

Notes: The Mitigation Division manages the National Flood Insurance Program and oversees FEMA's mitigation programs. It has a number of programs and activities which provide citizens protection, with flood insurance; prevention, with mitigation measures and partnerships, with communities throughout the country.

United States Geological Survey

Level: Federal Hazard: Multi http://www.usgs.gov/
345 Middlefield Road
Menlo Park, CA 94025 Ph: 650-853-8300 Fx:

Notes: The USGS provides scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

Insurance Institute for Business and Home Safety

Level: National Hazard: Multi www.disastersafety.org
4775 E. Fowler Avenue
Tampa, FL 33617 Ph: 813-286-3400 Fx: 813-286-9960

The Institute for Business & Home Safety (IBHS) is a nonprofit association that engages in communication, education, engineering and research. The Institute works to reduce deaths, injuries, property damage, economic losses and human suffering caused by natural disasters.

Publications

"Land Use Planning for Earthquake Hazard Mitigation: Handbook for Planners" by Wolfe, Myer R. et. al., (1986) University of Colorado, Institute of Behavioral Science, National Science Foundation.

This handbook provides techniques that planners and others can utilize to help mitigate for seismic hazards. It provides information on the effects of earthquakes, sources on risk assessment, and effects of earthquakes on the built environment. The handbook also gives examples on application and implementation of planning techniques to be used by local communities.

Contact: Natural Hazards Research and Applications Information Center
Address: University of Colorado, 482 UCB, Boulder, CO 80309-0482
Phone: (303) 492-6818
Fax: (303) 492-2151
Website: http://www.colorado.edu/UCB/Research/IBS/hazards

"Public Assistance Debris Management Guide", FEMA (July 2000).

The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be compliant with local and county emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The "Public Assistance Debris Management Guide" is available in hard copy or on the FEMA website.

"A Safer, More Resilient California: The State Plan for Earthquake Research," California Seismic Safety Commission (2004).

This is a 5-year statewide earthquake research plan that contains identifies research activities, and provides strategies to receive federal funding to implement the plan. For additional information and to review many more publications issued by the CSSC, refer to their website at http://www.seismic.ca.gov/pub.html.

"Putting Down Roots in Earthquake Country," Southern California Earthquake Center, 2011 edition.

An updated version of a classic booklet that discusses the earthquake risk in California and provides homeowners with specific information on how to earthquake-proof their homes and be prepared for an earthquake. The document is available online from www.earthquakecountry.org/roots. A Spanish version of the pamphlet is also available from the same site.

"7 Steps to an Earthquake Resilient Business – A Supplemental Guide to Putting down Roots in Earthquake Country," Southern California Earthquake Center, 2008.

This booklet provides information helpful to business owners to earthquake-proof their place of business, keeping their employees safe, and prevent work stoppages or business closure. This document is also available from www.earthquakecountry.org/roots/.

Refer to the References section (Appendix I) for a listing of the reports referenced in this section and other resources.

SECTION 7: FLOODS

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SECTION 7: FLOODS

Why are Floods a Threat to the City of Newport Beach?

Under the *National Flood Insurance Program*, a flood is:

a) a general and temporary condition or partial or complete inundation of normally dry land areas from:
   (1) the overflow of inland or tidal waters,
   (2) the unusual and rapid accumulation or runoff of surface waters from any source, or
   (3) mudslides (i.e., mudflows) which are caused by flooding and are akin to a river of liquid and flowing mud on the surfaces of normally dry land areas, or

b) the collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood or abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding.

This very broad definition of flooding is used in this document to address the potential for partial or complete inundation of normally dry land areas in Newport Beach as a result of storms, catastrophic failure of reservoirs, rogue waves, and tsunamis. Mudslides are discussed in Section 9. Although not occurring suddenly, this document also discusses sea level rise as a result of global climate change, and the potential short-term and long-term effects associated with increases in sea level.

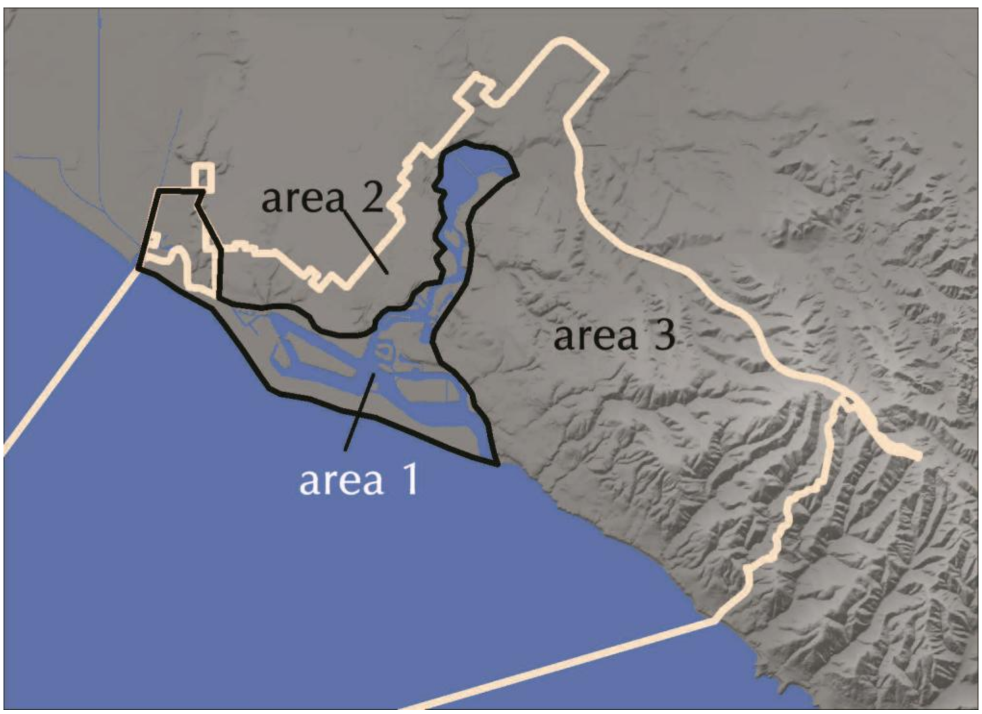
In a more specific sense, when most of us think of flooding, we think of rain, generally lots of it. In this context, floods are natural and recurring events that have traditionally been welcome: floods typically renew the landscape and increase the fertility of the floodplain soils. Floodplains also provide access to water supplies and have been used as transportation routes. For these reasons, floodplains have been alluring to populations for millennia, with many of the most important cities in history having been built adjacent to rivers. Unfortunately, these benefits come with a price – flooding is one of the most destructive natural hazards, responsible for more deaths per year than any other geologic hazard. Furthermore, average annual flood losses (in dollars) have increased steadily over the last decades as development in floodplains has increased. In short, flooding poses a threat to life and safety, and can cause severe damage to public and private property.

The City of Newport Beach and surrounding areas are, like most of Southern California, subject to unpredictable seasonal rainfall. Most years, the scant winter rains barely turn the hills green for a few weeks, but every few years the region is subjected to periods of intense and sustained precipitation that result in flooding. Flood events that occurred in 1969, 1978, 1980, 1983, 1992, 1995, 1998, 2005, and 2011 have caused an increased awareness of the potential for public and private losses as a result of this hazard, particularly in highly urbanized parts of floodplains and alluvial fans. As the population in Southern California increases, there is an increased pressure to build on flood-prone areas, and upstream of already developed areas. Increased development results in an increase in impervious surfaces, such as concrete, asphalt, and roofs. Water that used to be absorbed into the ground becomes runoff downstream. If the storm drain systems are not designed or improved to convey these increased flows, areas that may have not flooded in the past may be subject to flooding in the future. This is especially true for developments at the base of the mountains and hillsides, and downstream from canyons that have the potential to convey mudflows. Flooding hazards are a heightened concern in and downslope (and downstream) from areas burned by a wildfire.

The City of Newport Beach can be divided into three geographic areas: 1) a low elevation area comprised of West Newport, Balboa Peninsula, and Newport Bay, 2) elevated marine terraces that include Newport Mesa, Newport Heights and Westcliff, and 3) high relief terrain of the San Joaquin Hills in the eastern portion of the City (these geographic areas are shown on Map 7-1). The low elevation and terrace areas are generally drained by urbanized and relatively low relief streams that empty into Newport Bay. In contrast, rugged natural streams with steeper gradients drain the Newport Ridge and Newport Coast areas.

San Diego Creek is the main tributary to Newport Bay (see Map 7-2). Its headwaters lie about a mile east of the I-5 — I-405 intersection, at an elevation of about 500 feet. The creek flows westerly from its headwaters and empties into Newport Bay one mile west of the campus of the University of California at Irvine. Portions of San Diego Creek were channelized in 1968 for flood protection purposes.

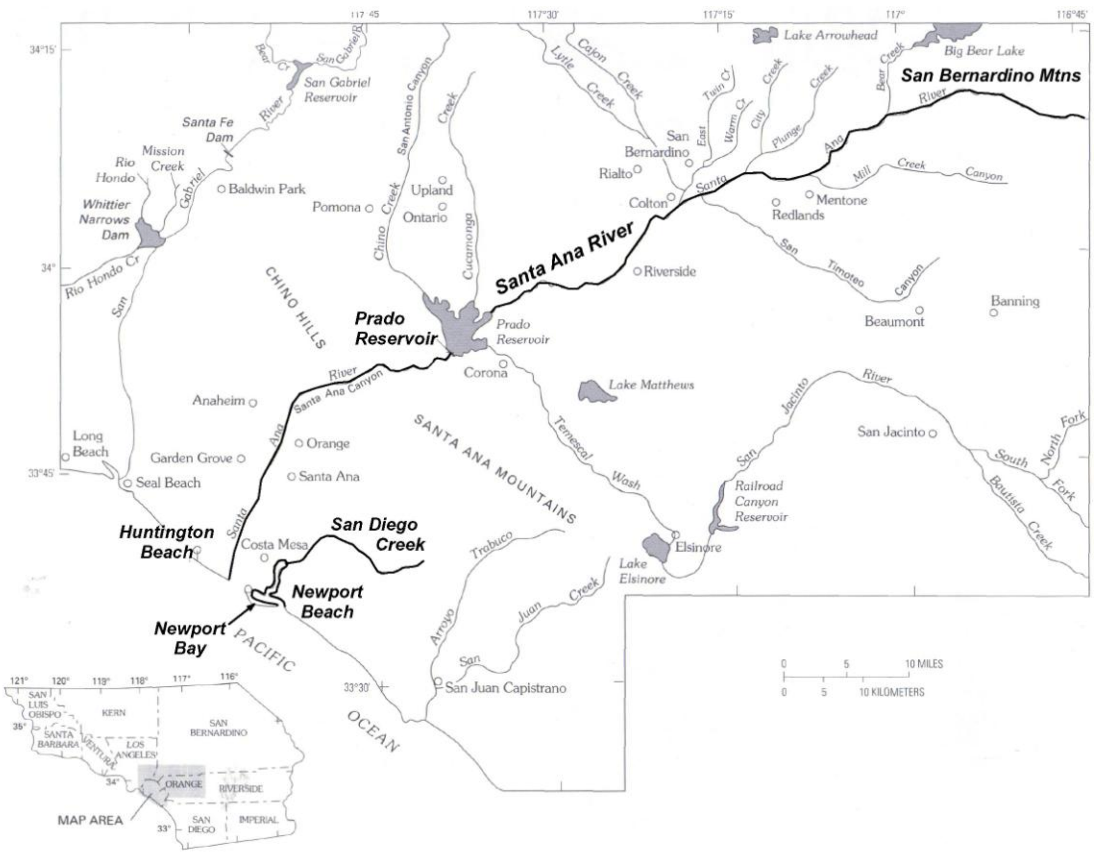
Map 7-1: Shaded Relief Map Showing General Drainage Areas Within the City of Newport Beach



The largest coastal river in Southern California, the Santa Ana River, empties into the Pacific Ocean near West Newport and forms the boundary between the cities of Huntington Beach and Newport Beach. It originates high in the San Bernardino Mountains and drains an area of about 2,470 square miles (Chin et al., 1991). Near the town of Corona, the Santa Ana River flows into Prado Reservoir (Map 7-2). Below Prado Dam, the river flows through Santa Ana Canyon, past highly urbanized cities in Orange County, and empties into the Pacific Ocean. Presently, 16.6 miles of the Santa Ana River, from its mouth to the city of Orange, are channelized for flood protection purposes. Prior to the extensive urbanization of Orange County (in the 1950s), the Santa Ana River was actively building a large alluvial fan with its apex located at the mouth of Santa Ana Canyon around the city of Anaheim. However, channelization of the river has limited any further alluvial deposition as the modern river deposits are now confined to a narrow corridor.

In addition to the Santa Ana River and San Diego Creek, the streams draining the San Joaquin Hills can also cause flooding potentially damaging to the City of Newport Beach. For example, flood hazards identified in Bonita Canyon, Big Canyon, Buck Gully, and Morning Canyon may impact residential development along these streams (these streams are shown on Plate H-7). Furthermore, a flood potential exists on smaller streams such as those draining Los Trancos Canyon and Muddy Canyon, albeit at a more localized scale. Flooding here is typically restricted to the narrow floodplains along the channel margins.

Map 7-2: Map Showing the Course of the Santa Ana River and Location of Newport Beach, Huntington Beach, Prado Dam, and the San Bernardino Mountains



(Figure adapted from Chin et al., 1991)

History of Flooding in the City of Newport Beach

Flood hazards in the City of Newport Beach can be classified into four general categories:

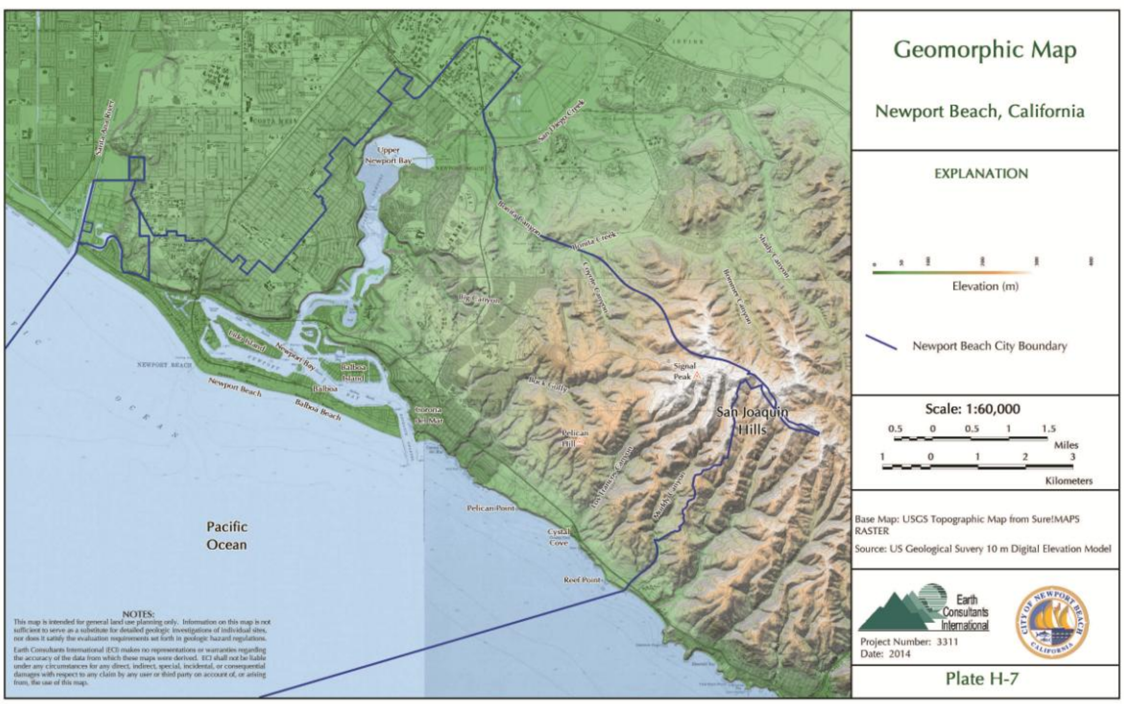
1) flooding of the low-lying coastal areas as a result of intense rain, often accompanied by high tides, storm surges and strong winds;
2) localized flash flooding from small, natural channels,
3) more moderate and sustained flooding from the Santa Ana River and San Diego Creek; and
4) low probability but high-impact flooding caused by tsunamis, rogue waves, and other coastal processes.

Storm-related floods and flash floods are often of short duration, but have high peak volumes and high velocities. This type of flooding occurs in response to the local geology and geography, and the built environment (human-made structures). The San Joaquin Hills in the eastern part of the City consist of sedimentary rock types that are fairly impervious to water so little precipitation infiltrates the ground; rainwater instead flows along the surface as runoff. When a major storm moves in, water collects rapidly and runs off quickly, making a steep, rapid descent from the hills into man-made and natural channels in the built environment and onto the marine terraces along the coast.

The major streams emanating from the San Joaquin Hills (Big Canyon, Coyote Canyon, Bonita Canyon, Buck Gully, Morning Canyon, Los Trancos Canyon, and Muddy Canyon) do not have stream gauges (Map 7-3 and Plate H-7). Therefore, peak discharge data are not available for these drainages. Additionally, the areas around these canyons became populated only relatively recently and there have been no significant storms in the past few years in this area, so historic accounts of flooding are unavailable. However, flooding on these streams likely occurs during major floods. For example, a flash flood in 1941 caused up to 6 feet of downcutting and undermined foundations in Laguna Canyon, approximately 3 miles southeast of Newport Beach. Although Laguna Canyon has a larger drainage area, channels in eastern Newport Beach probably experienced similar flooding in 1941, since both basins have similar characteristics and the storm intensity was comparable in both areas given their proximity.

Map 7-3: Geomorphic Map of Newport Beach Showing the Canyons Draining the San Joaquin Hills and the Low-Lying Areas in the City

(for a larger version of this map, refer to Plate H-7 in Appendix H)



Flooding on **San Diego Creek** has historically caused significant damage in Newport Beach because it is the biggest stream, with a drainage area of 118 square miles, to flow through the City (Map 7-4). Channelization of San Diego Creek also resulted in increased sediment flow into Upper Newport Bay, requiring extensive dredging projects to restore the ecosystem. The U.S. Geological Survey used to maintain three stream gauges along San Diego Creek. One of these, gauge No.

11048500 on Culver Drive, was operated continuously from 10/01/1949 to 09/30/1985 (its location is shown on Figure 7-1a). These data provide a relatively long-term record of mean daily discharge and peak flows that can be used to describe the flooding history and future flooding potential of the Newport Beach area. The Campus Drive gauge (gauge No. 11048555, see Figure 7-2) on San Diego Creek, which is closer to Newport Beach, unfortunately only operated sporadically between 10/01/1977 and 09/30/1985.

Map 7-4: Location Map Showing the San Diego Creek Watershed

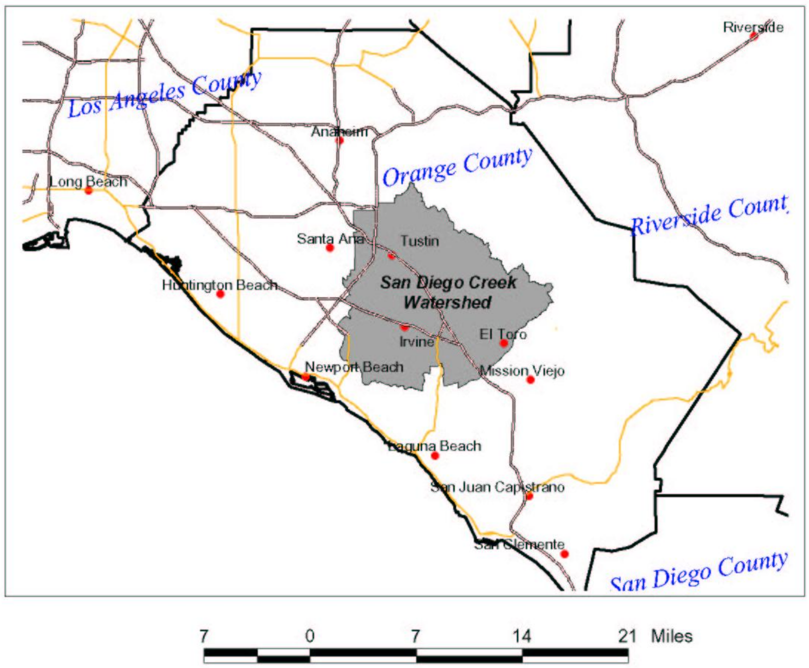


Figure 7-1a: Map Showing Location of Culver Drive Gauge

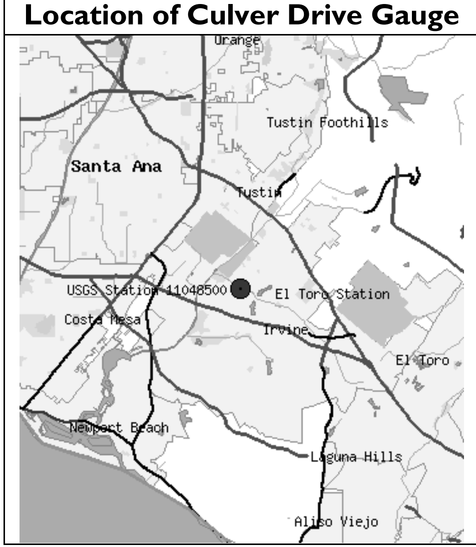
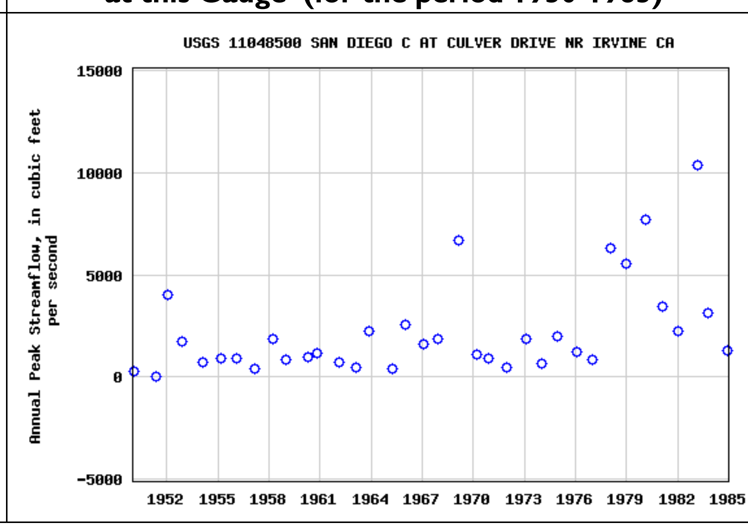
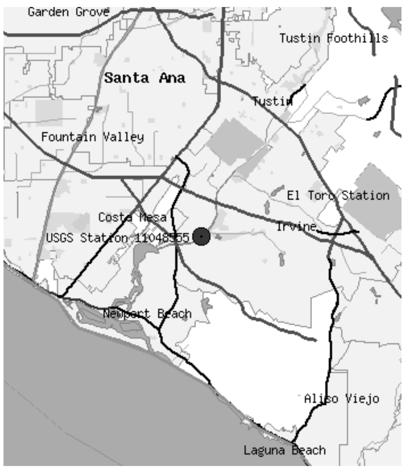
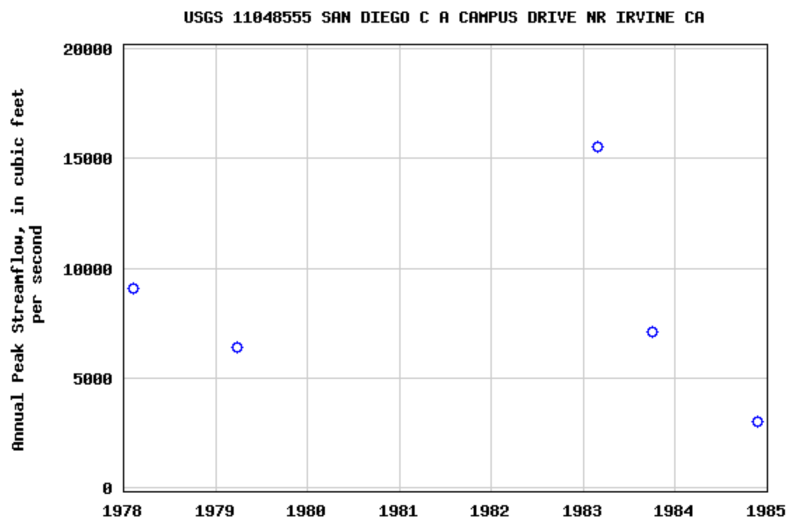


Figure 7-1b: Hydrograph Showing Peak Discharges at this Gauge (for the period 1950-1985)



Source: http://waterdata.usgs.gov

The largest flood measured during the 36-year period of record occurred in 1983, when the Campus Drive gauge measured a peak discharge of more than 15,000 cfs (Figure 7-2). A peak discharge of approximately 10,000 cfs was recorded 5 miles upstream at the Culver Drive gauge during the same flood event (Figure 7-1). The next highest peak flows measured in the area date from 1980 (see Figure 7-1b).

Figure 7-2a: Map Showing Location of the Campus Drive Gauge	**Figure 7-2b: Hydrograph Showing Peak Discharges at this Gauge** (for the periods 1978-1979 and 1983-1985)
	

Source: http://waterdata.usgs.gov

During the floods of February 24th, 1969 Orange County received more than 6 inches of rain (Orange County Register 1/13/95). The gauge on San Diego Creek at Culver Drive measured a peak flow of about 6,700 cfs (Figure 7-1b). Flooding in 1969 washed out MacArthur Boulevard when the existing storm drain at Jamboree Road was overwhelmed. High water also caused damage to Barranca Parkway near its intersection with Culver Road (Figure 7-3). Other roads and agricultural fields were also damaged by this event (Figure 7-4).

One of the largest and most intense El Niño events on record occurred during the winter of 1997-98. This was also one of the worst storm seasons reported in Southern California. Low-latitude Pacific storms, similar to those in 1938, again moved over Southern California resulting in periods of high-intensity cloudbursts on previously saturated ground. On Friday, February 6th, Newport Beach received 1.8 inches of rain over a 2-hour period, and more than 2.9 inches of rain for the day. A storm three days earlier had already saturated the ground and damaged the Balboa Pier. As a result of the second storm, the Newport Beach area experienced flooding, power outages, school evacuations, snarled traffic due to road closures, and several mudslides in the Upper Newport Bay area (between Jamboree Drive and Carnation Avenue). Serious flooding along Mariner's Mile due to water collecting along curbs and gutters led to the closure of a 2-mile stretch of Coast Highway between Dover Drive and Superior Avenue. Other areas that were flooded include 19th Street, Anaheim and Pomona Avenues, and Balboa Boulevard. Corona del Mar High School, Newport Elementary, Newport Harbor High School, and Andersen Elementary all experienced flooded classrooms (February 7, 1998 edition of the *Daily Pilot*). Damage from this storm was estimated at nearly $4.3 million. Newport Beach and Irvine suffered the most flooding damage.

Figure 7-3: Photograph Looking Upstream (northeast) at San Diego Creek at its Confluence with Barranca Parkway on February 25th, 1969

(Photograph used with permission from the Orange County Flood Control District's Library)

Figure 7-4: Photograph Looking Downstream at Flooding on Peters Canyon Wash (February 25, 1969)

(Photograph used with permission from the Orange County Flood Control District's Library)

During the storms of January 2005, several roadways, businesses and residential areas in Newport Beach were flooded when the storm surge coincided with a high tide of approximately 7 feet. It is not unusual for localized flooding of streets, businesses and residences to occur along the Balboa

Peninsula and other low-lying coastal areas of the City when storm surges, strong winds and high tides coincide (Figures 7-5a and 7-5b). No significant flooding was reported in Newport Beach between 2008 and the winter of 2012-2013, although significant flooding was reported in the Orange County area in December 2010. On December 19-22, 2010 there was heavy rain and periods of serious flooding in the region. Many areas reported flash flooding, debris flows and mudslides, and most rivers in the county reached flood stage. Damage in Orange County was estimated at $36 million, with $12 million in damages reported in Laguna Beach. The storms caused numerous traffic collisions, roadway flooding and road closures, swift water rescues, and damage to homes, businesses and infrastructure. Twelve miles of beaches in Orange County were closed due to massive amounts of debris and pollution brought about by the storm runoff (https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=272613).

Figures 7-5a and 7-5b: Flooding of Streets, Businesses and Residences in Newport Beach as a Result of the January 11, 2005 Storm

(Photos taken by Mr. Rick Greaney, General Services Department, City of Newport Beach.)

FEMA's records include 263 flood claims filed by residents of Newport Beach, including Balboa Island and Corona del Mar, between 1977 and 2010. The amounts paid by FEMA on these claims range from $0 to nearly $275,000.00, with an average of $6,040.00. Of the properties impacted, 12 have filed repetitive losses. As of the end of 2010, five of these properties had been mitigated. According to FEMA's records, of the remaining seven properties that have not been mitigated, only three are currently insured for flooding.

Historic Flooding in Orange County

The **Santa Ana River** is the largest drainage in Southern California. The river has flooded historically many times, and the course of the river has changed, at times significantly, in response to these flooding events. For example, the river currently outlets into the Pacific Ocean near West Newport; however, between 1769, when the Spanish first arrived in Southern California, and 1825, the Santa Ana River flowed out to sea through Alamitos Bay, near the present-day boundary between Los Angeles and Orange counties. In 1825, when severe storms caused extensive flooding in the area, the river resumed its ancient course through the Santa Ana Gap and around the toe of Newport Mesa to the ocean. Several other storms impacted the Southern California area between

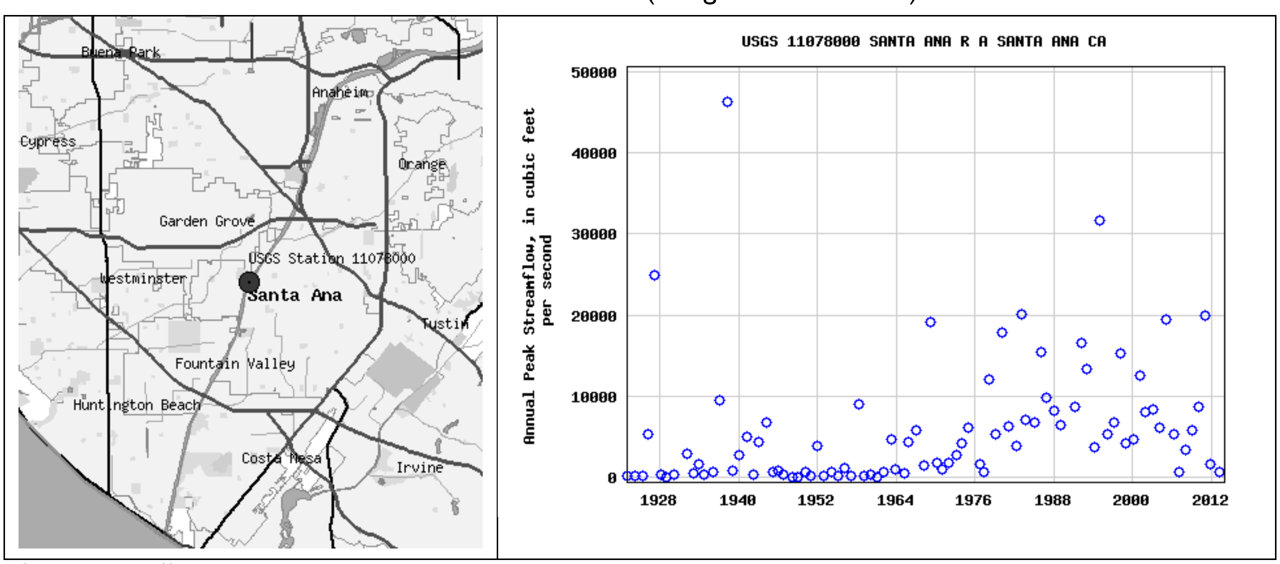
1770 and 1825 (in 1770, 1780, 1815, 1821, and 1822), but there are no records of flooding specific to the Santa Ana River.

The largest documented flood in the Santa Ana River valley occurred in the winter of 1861-1862 when it rained nearly continuously for a month. Based on an account by Crafts (1906, as reported in Troxell et al., 1942), "the fall of 1861 was sunny, dry and warm until Christmas, which proved to be a rainy day. All through the holidays there continued what we would call a nice, pleasant rain, as it often rains in this section for days at a time. This . . . lasted until the 18th of January, 1862, when there was a downpour for 24 hours or longer." This intense downpour destroyed settlements along the Santa Ana River from San Bernardino County to present-day Santa Ana and created an inland sea, up to 4 feet deep, in coastal Orange County. The river mouth swept as far to the southeast as the rock bluffs that today form the east side of the Newport Bay channel entrance. The peak discharge as a result of this storm was estimated at 320,000 cfs (City of Huntington Beach, 1974).

In 1867-1868, the area again experienced sustained precipitation, but of less intensity than that in 1862; therefore there was less damage. Then, in 1884, there were two floods. The first storm occurred in the latter part of February, saturating the ground. The second storm, which came six to eight days later, caused extensive damage. The Santa Ana River cut a new channel to the sea starting from near its confluence with Santiago Creek, cutting through farmlands east of the old channel, and discharging into the ocean about 3 miles southeast of its previous outlet. As much as 40 inches of rain were recorded in the area for that season (Troxell et al., 1942). Floods were also reported in the Los Angeles area in 1886, 1889, 1891, and in 1909. The 1909 floods caused significant damage in the upper reaches of the Santa Ana River, in San Bernardino and Riverside counties.

Until 1919, the river's outlet to the sea continued to migrate back and forth from the rock bluffs in Newport Bay (U.S. Corps of Engineers, 1993) to a point near the present day intersection of Beach Boulevard and Pacific Coast Highway in Huntington Beach. In 1919, a year after a local flood, local interests built a dam at Bitter Point (which appears to have been located near present-day 57th Street and Seashore Drive) to stop the flow into Newport Bay, and cut a new outlet for the Santa Ana River, where it has remained to date.

Figure 7-6: Location and Peak Discharge Hydrograph for the Santa Ana Gauge on the Santa Ana River (Gauge No. 11078000)



Source: http://waterdata.usgs.gov

The most destructive flood in Orange County occurred in 1938. Intense storms brought heavy rainfall to Orange County and Newport Harbor. In the Santa Ana River drainage, the 1938 storms caused 34 deaths (nearly 100 deaths were reported throughout California), 1,159,000 acres of flooded land, more than 2,000 people left homeless, and more than $14 million in damages (Feton, 1988; Troxell et al., 1942). Peak discharge in Santa Ana Canyon was estimated at 100,000 cfs. By the time floodwaters reached Santa Ana, the discharge had attenuated to ~46,000 cfs (Figure 7-6), which was still enough for the floodwaters to overtop the earthen levees and flood much of Huntington Beach and Newport Beach (Figure 7-7).

The damage caused by the 1938 flood reinforced the need for an upstream flood control facility. Prado Dam was constructed near Corona in 1941 to greatly reduce the flooding hazard in coastal Orange County. Operation of the dam during large rain events has effectively limited flow in the lower Santa Ana River channel. In 1969, when the second largest storm of the 20th century swept through Southern California, Prado Dam was used to manage the flow into the lower reaches of the river: During this event 77,000 cfs flowed into Prado Dam, but only 6,000 cfs were released downstream (City of Huntington Beach, 1974). When flow from downstream tributaries (e.g., Santiago Creek) was added to the dam release, discharge measured at the gauge in Santa Ana was limited to 20,000 cfs (Figure 7-6). This is a significant decrease compared to the ~46,000 cfs recorded at the same gauge during the 1938 flood.

Figure 7-7: Oblique Aerial Photograph Looking West at the Mouth of the Santa Ana River During the 1938 Flood

(Note the breaks in the levees at Verano Street and Adams Street and the inundation of West Newport and most of Huntington Beach.)

MOUTH OF SANTA ANA RIVER, MARCH 3, 1938.

Figures along channel represent distance in miles from Pacific Ocean. Courtesy of Fairchild Aerial Surveys, Inc.

(Photograph from Troxell et al., 1942)

In January and February 1980, California and Arizona were struck by several storm systems that brought much higher than normal precipitation to these areas. Between February 12 and February 20, the Prado Dam Flood Control Reservoir filled with approximately 100 acre-feet of water; between February 17 and February 26, daily mean discharges of more than 4,400 cfs were being measured at the Santa Ana gauge. These continuous high discharges scoured that portion of the riverbed between 17th Street and Harbor Avenue to depths of up to 20 feet, and undercut segments of the concrete lining along the banks (Chin et al., 1991). Six major bridges and numerous smaller bridges were impacted by severe scour. Extensive scour of the piles supporting the Fifth Street bridge necessitated closure of this bridge for nearly a year while repairs were made (see Figure 7-8). Even higher peak discharges were recorded at the Santa Ana gauge during the winters of 1983 and 1995 (see Figure 7-6). The historic maximum release from Prado Dam, of 10,100 cfs, occurred on 13 January 2005 (http://www.spl.usace.army.mil/resreg/htdocs/prdo.html).

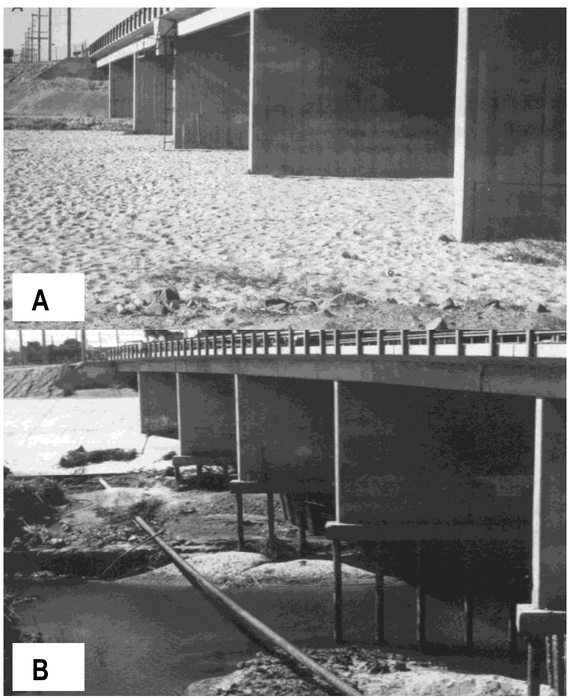


Figure 7-8: The Santa Ana River at the 5th Street Bridge in Santa Ana, showing the riverbed prior to the 1980 floods (A), and the channel after the 1980 floods (B). The channel was scoured 18 to 20 feet deep, exposing the piles supporting the bridge. The bridge was closed almost a year for repairs. (From Chin et al., 1991).

The 1997-1998 flooding discussed previously resulted in nearly $4.3million in property losses and $249 thousand in crop losses in Orange County. The $4.3 million in property losses may be significantly underestimated, given the widespread damage reported throughout the county, and given how a storm in 2010 is reported to have caused $12 million in damages in Laguna Beach alone.

Historic Flooding in Southern California

The main flooding events recorded in the Santa Ana River and San Diego Creek are described in the previous section. Given the settlement history of the area, however, to better understand the flooding patterns in Southern California, one has to look at the Los Angeles River (see Table 7-1). Records show that since 1811, the Los Angeles River has flooded more than 30 times, roughly about once every 6 years. But averages are deceiving, for the Los Angeles basin goes through periods of drought and then periods of above-average rainfall. For example, between 1868 and

1884, a period of 16 years, there were no major floods, but this was followed by a series of wet years with floods in 1885, 1886, 1889 and 1891. A similar cluster of wet years was recorded in the 1990s.

Table 7-1: Historical Floods in Los Angeles County

Year	Comments
1770-1771	Great flooding on the L.A. River recorded by Father Juan Crespi. River overflowed its channel.
1771-1772	Flooding recorded by Spanish Mission Fathers. San Gabriel Mission crops destroyed.
1775-1776	Due to heavy flooding, San Gabriel Mission was moved about 6 miles back from the river.
1779-1780	Flooding recorded by Spanish Mission Fathers. Flows filled riverbed and flooded the lowlands where wheat and barley had been planted.
1811	Flooding reported, although records are sparse.
1815	Flooding washes away the original Plaza in Los Angeles. River changes course at Alameda and 4th Street to cut west and join Ballona Creek. From there it emptied into Santa Monica Bay.
1822	A great flood on the Los Angeles River "covered all the lowlands and reached a greater height than was ever known before."
1824-25	The greatest of the earlier recorded floods. Los Angeles River changed its course back from the Ballona wetlands to San Pedro. Before this storm, the river would spread over the entire area, filling depressions at the surface and forming lakes, ponds and marshes, rarely discharging its waters into the sea. The 1825 floods cut a riverway to the ocean, draining the marshlands and causing the forests to disappear.
1832	Heavy flooding caused the drainage near Compton to change so that many lakes and ponds that "had been permanent, became dry a few years thereafter." Drainage of these ponds and lakes completed the destruction of the forests that used to cover a large part of southern L.A. County.
1849 – 1860	Floods of various magnitudes occurred in 1849-1850, 1851-1852, and 1859-1860.
1861-62	The "great flood" or the "Noachian deluge of California." Fifty inches of rain fell during December and January. The entire valley from Los Angeles to the ocean was a great lake. Part of the river split and drained into Ballona Creek. San Gabriel River also overflowed its banks and started a new channel.
1867-68	Floods spill over river channel and create a large, temporary lake out to Ballona Creek. San Gabriel River breaks out of its channel and washes thousands of acres of land.
1884	Two periods of intense rainstorms separated by 6 to 8 days. The first storms caused little damage. The second washed all but one of the bridges across the L.A. River, washed away many houses, and drowned several people. Parts of Los Angeles flooded 3 to 4 feet deep.
1886-87	A good part of Los Angeles was inundated. The levees were damaged and railway communication was impossible for 2 to 3 weeks.
1889	Flood on Christmas Day caused much damage; bridges and levees washed away; the old San Gabriel, new San Gabriel and L.A. Rivers joined near Downey and formed one body. Los Angeles River overtopped its channel.

Year	Comments
1914	Heavy flooding in January and February. Great damage to Los Angeles harbor.
1916-1938	Flooding in 1916. Minor floods causing damage in certain areas reported in 1918, 1921-1922, 1926, 1927, 1931, 1932, 1934, 1936, and 1937.
1934	Moderate to severe flooding starting January 1. Over 40 dead in La Cañada – Glendale area. Debris flow killed 12 people who had taken shelter in the Montrose Legion Hall.
1938	Series of storms beginning December 1937. March floods exceeded all previous floods for which records were available. Large tracts inundated; bridges, highways and railroads severely damaged. 87 people killed, over $78 Million (1938 dollars) in damage.
1941-1944	Los Angeles River floods five times.
1952	Moderate flooding.
1969	Recurrent precipitation during January and February nearly approached the largest total since 1884. Nearly 40 people died as direct result of the floods in Southern California, and more than 10,000 had to be evacuated.
1978	Two moderate floods.
1979	Los Angeles experiences severe flooding and mudslides.
1980	Flood tops banks of river in Long Beach. Sepulveda Basin spillway almost opened. Flooding killed 36, left 6,000 homeless, affected 100,000 and caused $350 million in damages.
1983	Flooding kills six people.
1992	15-year flood. Motorists trapped in Sepulveda basin. Six people dead.
1994-1995	Heavy flooding throughout the State. The total damages are estimated at $2 billion.
1997-98	The 1997 floods caused extensive damage in 48 California counties, including Los Angeles and Orange counties. Total damages were estimated at $1.8 billion. The 1998 El Niño storms also caused damage, but this was less than it could have been because many had taken measures to reduce their risk following the 1997 storms.
2003-2004	The rains followed the extensive fires of 2003; in many areas, canyons chocked with ashes and debris caused debris flows that did substantial damage downstream. Flash floods killed 18 in the Southern California area.
2004-05	The second-wettest year on record in the Los Angeles Basin; the rains caused extensive damage in some areas, triggering landslides and debris flows. Between Feb.17-23, flooding in Los Angeles County alone killed 9 people, affected 150, and caused $250 million in damages. In January, flooding and landsliding caused 28 deaths, 8 injuries, affected 500, and caused $200 million in damages.
2005-06	Flooding due to intense precipitation between Dec. 31 and Jan. 18 killed 3 people, affected 3,600, and caused $245 million in damages in northern and Southern California, and Nevada.
2010-2011	California winter storms caused flooding, debris flows and mudflows in several counties, including Orange County. Major Disaster Declaration issued on January 26, 2011.

Sources: http://www.em-dat.net/disasters/; htpp://www.fema.gov

What Factors Create Flood Risk?

Climate

Flooding occurs when climate, geology, and hydrology combine to create conditions where water flows outside of its usual course. As the historical record shows, in the City of Newport Beach, climate (storm-induced precipitation and storm-induced high waves), high tides, geography, and elevated sea levels can combine to create seasonal coastal flooding conditions resulting in beach erosion and property damage.

Average yearly precipitation in the Newport Beach area is about 12 inches (see Table 7-2), whereas 14 inches of precipitation fall annually in Santa Ana (Table 7-3). These tables show that areas closer to the coast receive a little less precipitation, on average, than inland areas.

Table 7-2: Average Annual Rainfall by Month for the Newport Beach Harbor Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	2.5	2.4	1.9	1.1	0.2	0.1	0.0	0.1	0.3	0.3	1.2	2.0	**11.9**

Data based on 59 complete years between 1931 and 1995.

Table 7-3: Average Annual Rainfall by Month for the Santa Ana Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	3.0	2.9	2.4	1.1	0.2	0.1	0.0	0.1	0.2	0.4	1.4	2.4	**14.1**

Data based on 64 complete years between 1931 and 1995.
Source: http://www.worldclimate.com/

Not only does rainfall vary from one location to the next, often within short distances, but rainfall in Southern California is extremely variable from year to year, ranging from one-third the normal amount to more than double the normal amount. "Averages" are not particularly representative of rainfall in the Southern California area, as illustrated with the following discussion about downtown Los Angeles: the average annual rainfall in Los Angeles for the last 135 years (between 1877 and 2012) is 14.98 inches, but rainfall during this time period has ranged from only 3.21 inches in 2006-2007 to 38.2 inches in 1883-1884 (www.laalmanac.com/weather/we13.htm). In fact, in only 24 of the past 135 years has the annual rainfall been within plus or minus 10 percent of the 14.98-inch average, and in only 42 years has the annual rainfall been within plus or minus 20 percent of the average value. This makes the Los Angeles basin a land of extremes in terms of annual precipitation.

Flood risk and water supply in the western United States, including Southern California, are closely tied to **atmospheric rivers** (ARs). Much research in the last decade has focused on the study of these meteorological phenomena, in great part due to the increased use of radar, satellite data, and other imaging techniques. ARs are narrow streams of water vapor transported in the lower atmosphere (Zhu and Newell, 1998) that are thought responsible for most of the very large storms on the west coast of the United States, and that account for 30 to 50 percent of the precipitation that falls in California. Typically packing high wind speeds, ARs are typically 400 to 500 kilometers wide, but are thousands of kilometers long, sometimes extending across whole ocean basins. When ARs traveling across the Pacific Ocean collide with the mountain ranges in the west coast, the vapor is forced upwards, where it condenses and rains out, leading to significant flooding (Ralph and Dettinger, 2011).

The U.S. Geological Survey's (USGS) Multi Hazards Demonstration Project (MHDP) has been combining various science disciplines to test and improve the resiliency of communities to natural disasters. By developing a disaster scenario (such as the 2008 ShakeOut Earthquake Scenario discussed in Section 6) scientists, engineers, and other experts are engaging emergency planners, first responders, businesses, universities, insurance companies, government agencies and the public in preparing for a major natural disaster. The second major project of the MHDP is a catastrophic winter storm scenario consisting of a hypothetical (but not unrealistic) Pacific storm striking the west coast of California, similar in intensity to the 1861-1862 series of storms that resulted in state-wide flooding that left the central coast impassible, the capital underwater for three months, and the State bankrupt.

The hypothetical **ARkStorm** (for Atmospheric River 1,000), if it occurred today, would overwhelm the State's flood protection system, which is normally designed to control the 100- to 200-year storm runoff. Property damage and business disruption from the ARkStorm are estimated to be on the order of $725 billion, nearly three times the loss expected for the hypothetical southern California ShakeOut earthquake (Porter et al., 2011). The USGS report indicates an ARkStorm is not only plausible, but probable, and may not be a worst case. The geological record suggests that six megastorms have occurred in California in the past 1,800 years – all more severe than the 1862 event. The products of the ARkStorm Scenario are intended to be used by emergency planners, policymakers and other to review disaster preparedness, conduct risk assessments and disaster drills, explore ways to adequately fund response and recovery, plan future hazards mapping, and educate the public.

Storms that bring precipitation to Southern California typically occur in the winter, or are associated with summer tropical storms (or monsoons). Each of these is described below.

- **Winter Rainfall:** Winter storms are characterized by heavy and sometimes prolonged precipitation over a large area, and are typically associated with atmospheric rivers. These storms usually occur between November and April and are responsible for most of the precipitation recorded in Southern California. The storms originate over the Pacific Ocean and move eastward (and inland). The mountains, such as the San Gabriel and San Bernardino Mountains, form a rain shadow, slowing down or stopping the eastward movement of this moisture. A significant portion of the moisture is dropped on the mountains as snow. If large storms are coupled with snowmelt from these highlands, large peak discharges can be expected in the main watersheds at the base of the mountains. Some of the severe winter storm seasons that have historically impacted the Southern California area have been related to El Niño events.

  El Niño is the name given to a phenomenon that starts every few years, typically in December or early January, in the southern Pacific, off the western coast of South America, but whose impacts are felt worldwide. Briefly, warmer than usual waters in the southern Pacific are statistically linked with increased rainfall in both the southeastern and southwestern United States; droughts in Australia, western Africa and Indonesia; reduced number of hurricanes in the Atlantic Ocean; and increased number of hurricanes in the Eastern Pacific. Two of the largest and most intense El Niño events on record occurred during the 1982-83 and 1997-98 water years. [A water year is the 12-month period from October 1 through September 30 of the next year. Often a water year is identified only by the calendar year in which it ends, rather than by giving the two years, as above.] These are also two of the worst storm seasons reported in Southern California.

  Some of the wetter winter storms have been attributed to a type of atmospheric river termed the "Pineapple Express," a term that has been used in California for many years. These are atmospheric rivers that draw in moisture from the tropics near Hawaii. For example, the severe storms of December 2004 and January 2005 have been blamed on a "Pineapple Express" jet stream that passed over the Hawaiian Islands and brought moisture-laden air directly from the tropics to the west coast of California. In December 2004, as this condition was developing, the northern jet stream shifted towards the California coast allowing storms from the north to tap into the deep tropical moisture brought by the sub-tropical jet stream, dramatically increasing the rainfall in southern California (NOAA, 2005a).

- **Summer Monsoons and Thunderstorms:** Another relatively regular source of heavy rainfall, particularly in the mountains and adjoining cities, is from summer tropical storms. Tropical rains or monsoons typically occur in the summer or early fall, between July and October. These storms originate as tropical cyclones in the warm waters off Baja California, in the eastern Pacific Ocean, and move northward into Southern California. By the time they move onshore over Baja California, the cyclones generally diminish to less-than-tropical-storm strength, but their remnants often bring significant precipitation to the Southern California mountains and deserts. Tropical storms that have dropped significant rainfall in the Southern California area in the last 150 years are listed in Table 7-4 below. Many of these storms are associated with El Niño or La Niña events. Thunderstorms can occur at any time, but are usually more prevalent in the higher mountains during the summer, and usually impact relatively small areas.

Table 7-4: Historical Tropical Storms that Affected Southern California

Month-Year	Date(s)	Source of Rain; Southern California	Rainfall
Oct. 1858	2nd & 3rd	The only known historical hurricane that made a landfall in Southern California; 75-mph winds estimated in San Diego; tropical storm winds along coastline north to Long Beach; intense rain reported from San Diego to Santa Barbara.	> 7"
July 1902	20th & 21st	Deserts and southern mountains. El Niño of 1901-02.	up to 2"
Aug. 1906	18th & 19th	Deserts and southern mountains. El Niño of 1905-06.	up to 5"
Sept. 1910	15th	Mountains of Santa Barbara County.	2"
Aug. 1915	26th	Deserts of Southern California, and into Riverside. El Niño of 1914-15.	1"
Aug. 1921	20th & 21st	Deserts and southern mountains. La Niña of 1920-21.	up to 2"
Sept. 1921	30th	Deserts. La Niña of 1920-21.	up to 4"
Sept. 1929	18th	Southern mountains and deserts.	up to 4"
Sept. 1932	28th - Oct 1st	Mountains and deserts, 15 fatalities in the Tehachapi area. El Niño of 1932-33.	up to 7"
Aug. 1935	25th	Southern valleys, mountains and deserts.	up to 2"
Aug. 1936	9th	Locally heavy rainfall in the mountains surrounding Los Angeles.	n/a

Month-Year	Date(s)	Source of Rain; Southern California	Rainfall
Sept. 1939 (during El Niño of 1938-39)	4th - 7th	Remnants of a hurricane; impacted the southern mountains, and the southern and eastern deserts.	up to 7"
	11th & 12th	Deserts, central and southern mountains.	up to 4"
	19th - 21st	Deserts, central and southern mountains.	up to 3"
	25th	Tropical cyclone that made a landfall in San Pedro, with sustained winds of 50 mph. Only known tropical cyclone to make a landfall in Southern California. 93 people died; 45 onshore and 48 offshore, at sea. Ten houses washed away in Belmont Shores.	5" in LA basin
		Surrounding mountains.	6 to 12"
Sept. 1941		Southern mountains and deserts. Strong El Niño of 1940-1941.	up to 1"
Sept. 1945	9th & 10th	Central and southern mountains	up to 2"
Sept. 1946	30th - Oct 1st	Southern mountains. El Niño of 1946-47.	up to 4"
Aug. 1951	27th - 29th	Southern mountains and deserts; many roads washed out in the Imperial Valley. El Niño of 1951-52.	2 to 5"
Sept. 1952	19th - 21st	Central and southern mountains. El Niño of 1951-52.	up to 2"
July 1954	17th - 19th	Deserts and southern mountains. El Niño of 1953-54.	up to 2"
July 1958	28th & 29th	Deserts and southern mountains. El Niño of 1957-58.	up to 2"
Sept. 1959	11th	Spotty rainfall in the deserts and mountains.	up to ½"
Sept. 1960	9th & 10th	Hurricane Estelle dissipated west of Central Baja California; southern mountains at and near Julian.	3.40"
Sept. 1963	17th - 19th	Tropical storm Katherine made landfall in northern Baja California; impacted central and southern mountains. El Niño of 1963-64.	up to 7"
Sept. 1967	1st - 3rd	Hurricane Katrina in Baja California; impacted southern mountains and deserts.	2"
Sept. – Oct. 1971	30th – Oct. 1st	Caribbean-Sea Hurricane Irene crossed Nicaragua; reformed in the eastern Pacific as Hurricane Olivia, which made landfall in Central Baja California; impacted southeast deserts. La Niña of 1970-71.	up to 1"
Sept. 1972	3rd	Remnants of Hurricane Hyacinth made landfall between Los Angeles and San Diego with 25-mph winds and rainfall in the central and southern mountains. El Niño of 1972-1973.	up to 1"
Oct. 1972	6th	Hurricane Joanne made landfall in northern Baja; maintained tropical storm strength into Arizona; rain in southeast deserts. El Niño of 1972-1973.	up to 2"

Month-Year	Date(s)	Source of Rain; Southern California	Rainfall
Sept. 1976	10th & 11th	As a result of the tropical storm Kathleen; impacted the central and southern mountains; sustained winds of 57 mph at Yuma. Killed 12 people in the U.S.; 70-80% of Ocotillo was destroyed; caused millions of dollars in damage. El Niño of 1976-1977.	6 to 12"
Aug. 1977	n/a	Hurricane Doreen dissipated over the Southern California coastal waters. Widespread flooding; extensive crop damage. In Los Angeles and south, up to 2" of rain.	2"
		Mountains. El Niño of 1977-78.	up to 8"
Oct. 1977	6th & 7th	Remnants of Hurricane Heather tracked into southern Arizona; impacted southern mountains and deserts.	up to 2
Sept. 1978	5th & 6th	Remnants of Hurricane Norman impacted the mountains. El Niño of 1977-78.	> 3"
June 1980	29th & 30th	Remnants of Hurricane Celia; scattered rainfall in Santa Barbara.	up to ½"
Sept. 1982	17th & 18th	Remnants of Hurricane Norman; with scattered rainfall in the southern mountains and deserts. Strong El Niño of 1982-83.	up to 1"
Sept. 1982	24th - 26th	Remnants of Hurricane Olivia; impacted the mountains. Strong El Niño of 1982-83.	up to 4"
Sept. 1983	20th & 21st	Hurricane Manuel dissipated off west coast of northern Baja California; impacted the southern mountains and deserts. Strong El Niño of 1982-83.	up to 3"
Oct. 1983	7th	Remnants of Hurricane Priscella scattered light rain across Southern California. Strong El Niño of 1982-83.	n/a
Sept. 1984	10th & 11th	Hurricane Marie dissipated off the west coast of northern Baja California; scattered rain in coastal areas.	n/a
Aug. 1997	17th – 19th	Tropical storm Ignacio dissipated near the south-central California coast with gale-force winds over coastal waters. Strong El Niño of 1997-1998.	n/a
Sept. 1997	N/a	Hurricane Linda, the strongest storm recorded in the eastern Pacific with 180-mph winds, threatened to come ashore in California as a subtropical storm. Storm turned away, but caused high surf, waves 18 ft. high, showers and thunderstorms. Strong El Niño of 1997-1998.	n/a
Sept. 1997	25th	Hurricane Nora crossed into Southern California and Arizona from Baja California. Brought heavy rain to parts of the region, causing millions of dollars in damage to agriculture.	

Month-Year	Date(s)	Source of Rain; Southern California	Rainfall
Sept. 2004	10th – 19th	Mid-level moisture from hurricane Javier spread over northern Mexico, and southwestern US.	n/a
July 2006	31st	Remnants of tropical storm Emilia brought rain to Southern California that helped extinguish the House Fire.	
Sept. 2007	20 – 22nd	Thunderstorms and showers; flooding watch in Santa Catalina Island; rain throughout the Southern California area.	n/a
July 2012	18th – 20th	Remnants of Hurricane Fabio generated scattered showers and thunderstorms in the Los Angeles basin.	na
August 2013	25th – 26th	Moisture from the remnants of tropical storm Ivo caused flash floods and mudslides in San Bernardino County and Arizona. One motorist drowned in Needles.	3-4"
http://www.fema.gov/nwz97/eln_scal.shtm; http://usatoday.com/weather/whhcalif.htm; http://www.nhc.noaa.gov; Chenoweth and Landsea, 2004 (on the 1858 Hurricane); http://www.nasa.gov/topics/earth/features/earth20121017.htm; http://en.wikipedia.org/wiki/List_of_California_hurricanes			

Tides

Tides are regular changes in the ocean water levels caused by the gravitational pull of the Moon and Sun acting on the oceans' surface. The changing tide at a given location results from the interaction between the changing positions of the Moon and Sun, the effects of the Earth's rotation, and the local bathymetry or shape of the ocean floor.

Tides are either semidiurnal (two high waters and two low waters every day), or diurnal (one high water and one low water per day). In the east coast of the United States, tides are semidiurnal, whereas on the west coast, significant tidal fluctuations occur once and twice daily, twice monthly, twice yearly, every 4.4 years, and every 18.6 years (Flick, 1998). In California, the two high tides and two low tides that occur daily are unequal in amplitude: The lower-low tide of the day generally follows the higher-high tide seven or eight hours later. These semi-diurnal differences in the height between the high and low water levels over about half a day vary in a two-week cycle. Around new and full moon, when the Sun, Moon and Earth are in line, the tidal forces due to the Sun reinforce those due to the Moon, creating a maximum in tidal range called "spring tides" or "springs" (meaning "to jump" or "to leap up"). When the Moon is at first or third quarter, and it is not in line with the Sun, the effects due to the gravitational pull from the Sun partially cancel those of the Moon, resulting in a minimum tide range. This is called the "neap tide" or "neaps." The distance between the Moon and the Earth also has an effect on tide heights; as a result one spring tide per month is usually higher than the other. In Southern California, the highest monthly tides are those in the winter and summer.

Given that tides affect the depth of the water in both the ocean and estuaries and create oscillating currents known as tidal streams that have an impact on navigation, recreation, and potential flooding of coastal areas, tidal tables that show the predicted tide heights at a given location are published for the benefit of a variety of users (see www.mobilegeographics.com or www.saltwatertides.com for examples). In Newport Beach, the Municipal Operations Department refers to tidal tables on a daily basis to assess whether or not they need to close some or all of the valves around the low-lying areas of the City to prevent flooding from high tides. If the tides are expected to be higher than 5.2 feet, City personnel close some of the valves; if the tides are expected to be more than 7 feet high, they close all of the 86 valves in the City (Jim Auger, personal communication, 2008). Since most of these gate valves are opened and closed manually, this takes some time. This function is especially important in the winter, when the extreme monthly higher-high tides generally occur in the early morning (Flick and Cayan, 1984; Flick, 1998; Flick, 2007). This means that preparations by City personnel to prevent flooding often need to be made at night. If the higher-high tides occur together with a winter storm, the resulting storm surge can overwhelm the storm drain and valves system in the City. Fortunately, this does not occur often.

In Southern California, peak storm surges associated with El Niño events occurred in January and March 1983, and in February 1998. The late January 1983 sea levels were the highest that had been recorded in the region until then, with gauges in San Diego and Los Angeles measuring levels at 9.6 and 12.2 inches, respectively, above the predicted high tide. The storm surge associated with the 1998 storms is a record high (1.8 feet in Los Angeles; 1.6 feet in Newport Beach); fortunately, the storm coincided with the neap tides in Southern California, greatly reducing coastal flooding and damage (Flick, 1998). The January 2005 storms, on the other hand, generated a slightly lower storm surge of 1 to 1.2 feet, but coincided with higher tides, resulting in flooding of many low-lying areas in the City, as discussed previously. More recently, on December 12-15, 2012, a winter storm coincided with unusually high tides of almost 8 feet, resulting in coastal flooding in Orange County, from Seal Beach south to Newport Harbor. On the 13th, tide levels peaked around 8.4 feet, which was about 3 to 6 inches higher than the predicted high tide, attributed to the approaching low pressure area. The high tide, combined with runoff from the rain caused flooding of Pacific Coast Highway in and near Huntington Beach, along Marcus Avenue in Newport Harbor, and near the intersection of Newport Boulevard and 26th Street. Some homes were flooded with nearly one foot of water. Similar flooding was observed on the morning of the 14th, with the tide reaching nearly 8 feet (https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=423426).

Geography and Geology

The local hills and mountains are very steep and consist of rock types that are fairly impervious to water. Consequently, little precipitation infiltrates the ground; rainwater instead flows across the surface as runoff, collecting in the major drainages that pass through the City. When a major storm moves in, water collects rapidly and runs off quickly, making a steep, rapid descent from the hills into man-made and natural channels within developed areas. Because of the steep terrain, scarcity of vegetation, and the constant shedding of debris from the hill slopes, flood flows often carry large amounts of mud, sand, and rock fragments. Sheet flow occurs when the capacities of the existing channels (either natural or man-made) are exceeded and water flows over and into the adjacent areas.

The Southern California area has been shaped by erosion and sedimentation for millennia. Most of the mountains that ring the valleys and coastal plain have and are being uplifted along movement on faults; this movement has fractured the bedrock, allowing for their brittle slopes to be readily eroded. Rivers and streams have then carried boulders, rocks, gravel, sand, and silt down these slopes to the valleys and coastal plain. Over time, these sediments have collected in the valley bottoms, so that locally these sediments are as much as twenty thousand feet thick. This sediment generally acts as a sponge, absorbing vast quantities of water received as precipitation in those years when heavy rains follow a dry period. But like a sponge that is near saturation, the same soil fills up rapidly when a heavy rain follows a period of relatively wet weather. So, in some years of heavy rain, flooding is minimal because the ground is relatively dry, whereas the same amount of rain following a wet period, when the ground is already saturated, can cause extensive flooding.

Built Environment

The northern two-thirds of Newport Beach, as a good portion of Orange County, are essentially built out. This leaves precious little open land to absorb rainfall. This lack of open ground forces water to remain on the surface and accumulate rapidly. If it were not for the massive flood control system that has been built over the years, with its concrete-lined rivers and stream beds, flooding in the Santa Ana River basin would be a much more common occurrence. And the tendency is towards even less and less open land. In-fill building is becoming a much more common practice in many areas: Developers tear down older homes, which typically cover up to 40 percent of the lots that they sit on, and replace each of them with three or four town homes or apartments, which may cover 90 to 95 percent of the lot. This increase in impervious surfaces (including concrete walkways, and roofs) results in a direct increase in runoff.

Another potential reason for recurrent storm flooding in developed areas is "asphalt creep." The street space between the curbs of a street is a part of the flood control system. Water leaves the adjacent properties and accumulates in the streets, where it is directed towards the underground portion of the flood control system. The carrying capacity of a given street is determined by the width of the street and the height of the curbs along the street. Often, when streets are being resurfaced, a one- to two-inch layer of asphalt is laid down over the existing asphalt. This added layer of asphalt subtracts from the rated capacity of the street to carry water. Thus the original engineered capacity of the entire storm drain system is marginally reduced over time. Subsequent re-paving of the street further reduces its engineered capacity.

When structures or fill are placed in the floodway or floodplain, water is displaced. Development raises the river levels by forcing the river to compensate for the flow space obstructed by the inserted structures and/or fill. When structures or materials are added to the floodway or floodplain and no fill is removed to compensate, serious problems can arise. Flood waters may be forced away from historic floodplain areas. As a result, other existing floodplain areas may experience floodwaters that rise above historic levels. Local governments must require engineer certification to ensure that proposed developments will not adversely affect the flood-carrying capacity of the Special Flood Hazard Area (SFHA). Displacement of only a few inches of water can mean the difference between no structural damage occurring in a given flood event, and the inundation of many homes, businesses, and other facilities. Careful attention should be given to development that occurs within the floodway to ensure that structures are prepared to withstand base flood events.

In highly urbanized areas, increased paving can lead to an increase in volume and velocity of runoff after a rainfall event, exacerbating the potential flood hazards. Care should be taken in the development and implementation of storm water management systems to ensure that these runoff waters are dealt with effectively.

How Are Flood-Prone Areas Identified?

The Federal Emergency Management Agency (FEMA) is mandated by the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 to evaluate flood hazards. To promote sound land use and floodplain development, FEMA provides Flood Insurance Rate Maps (FIRMs) for local and regional planners. Flood risk information presented on FIRMs is based on historic, meteorological, hydrologic, and hydraulic data, as well as topographic surveys, open-space conditions, flood control works, and existing development.

Rainfall-runoff and hydraulic models are utilized by the FIRM program to analyze flood potential, adequacy of flood protective measures, surface-water and groundwater interchange characteristics, and the variable efficiency of mobile (sand bed) flood channels. It is important to realize that FIRMs only identify potential flood areas based on the conditions at the time of the study, and do not consider the impacts of future development. To prepare FIRMs that illustrate the extent of flood hazards in a flood-prone community, FEMA conducts engineering studies referred to as Flood Insurance Studies (FISs). Using information gathered in these studies, FEMA engineers and cartographers delineate Special Flood Hazard Areas (SFHAs) on FIRMs. SFHAs are those areas subject to inundation by a "**base flood**" which FEMA sets as a 100-year flood (see definitions below).

Flood Insurance Rate Maps (FIRM) and Flood Insurance Studies (FIS) Floodplain maps are the basis for implementing floodplain regulations and for delineating flood insurance purchase requirements. A Flood Insurance Rate Map (FIRM) is the official map produced by FEMA which delineates SFHA in communities where NFIP regulations apply. FIRMs are also used by insurance agents and mortgage lenders to determine if flood insurance is required and what insurance rates should apply.

Water surface elevations are combined with topographic data to develop FIRMs. FIRMs illustrate areas that would be inundated during a 100-year flood, floodway areas, and elevations marking the 100-year-flood level. In some cases they also include base flood elevations (BFEs) and areas located within the 500-year floodplain. Flood Insurance Studies and FIRMs produced for the NFIP provide assessments of the probability of flooding at a given location. FEMA conducted many Flood Insurance Studies in the late 1970s and early 1980s. These studies and maps represent flood risk at the point in time when FEMA completed the studies. However, it is important to note that not all 100-year or 500-year floodplains have been mapped by FEMA.

FEMA flood maps are not entirely accurate. These studies and maps represent flood risk at the point in time when FEMA completed the studies, and does not incorporate planning for floodplain changes in the future due to new development. Although FEMA is considering changing that policy, it is optional for local communities.

Flood Mapping Methods and Techniques

Although many communities rely exclusively on FIRMs to characterize the risk of flooding in their area, there are some flood-prone areas that are not mapped but remain susceptible to flooding. These areas include locations next to small creeks, local drainage areas, and areas susceptible to man-made flooding.

In order to address this lack of data, jurisdictions can take efforts to develop more localized flood hazard maps. One method that has been employed includes using high-water marks from flood events or aerial photos, in conjunction with the FEMA maps, to better reflect the true flood risk. The use of GIS (Geographic Information System) is becoming an important tool for flood hazard mapping. FIRM maps can be imported directly into GIS, which allows for GIS analysis of flood hazard areas.

Communities find it particularly useful to overlay flood hazard areas on tax assessment parcel maps. This allows a community to evaluate the flood hazard risk for a specific parcel during review of a development request. Coordination between FEMA and local planning jurisdictions is the key to making a strong connection with GIS technology for the purpose of flood hazard mapping.

FEMA and the Environmental Systems Research Institute (ESRI), a private company, have formed a partnership to provide multi-hazard maps and information to the public via the Internet. ESRI produces GIS software, including ArcViewC9 and ArcInfoC9. The ESRI web site has information on GIS technology and downloadable maps. The hazards maps provided on the ESRI site are intended to assist communities in evaluating geographic information about natural hazards. Flood information for most communities is available on the ESRI web site. Visit www.esri.com for more information.

The NFIP also reduces flood losses through regulations that focus on building codes and sound floodplain management. In the City of Newport Beach, the NFIP and related building code regulations went into effect on September 1, 1978 (City ID No. 060227). NFIP regulations (44 Code of Federal Regulations (CFR) Chapter 1, Section 60, 3) require that all new construction in floodplains must be elevated at or above base flood level.

Flood Terminology

Floodplain

A floodplain is a land area adjacent to a river, stream, lake, estuary, or other water body that is subject to flooding. This area, if left undisturbed, acts to store excess floodwater. The floodplain is made up of two sections: the floodway and the flood fringe.

100-Year Flood

The 100-year flooding event is the flood having a one percent chance of being equaled or exceeded in magnitude in any given year. Contrary to popular belief, it is not a flood occurring once every 100 years. The 100-year floodplain is the area adjoining a river, stream, or watercourse covered by water in the event of a 100-year flood. A **100-year flood** is defined by looking at the long-term average period between floods of a certain size, and identifying the size of flood that has a 1 percent chance of occurring during any given year. This base flood has a 26 percent chance of occurring during a 30-year period, the length of most home mortgages. However, a recurrence interval such as "100 years" represents only the long-term average period between floods of a specific magnitude; rare floods can in fact occur at much shorter intervals or even within the same year.

Floodway

The floodway is one of two main sections that make up the floodplain. Floodways are defined for regulatory purposes. Unlike floodplains, floodways do not reflect a recognizable geologic feature. For National Flood Insurance Program (NFIP) purposes, floodways are defined as the channel of a river or stream, and the overbank areas adjacent to the channel. The floodway carries the bulk of the floodwaters downstream and is usually the area where water velocities and forces are the greatest. NFIP regulations require that the floodway be kept open and free from development or other structures that would obstruct or divert flood flows onto other properties.

In accordance with NFIP requirements, Newport Beach prohibits all development in the floodway, but this regulation is not retroactive, and as a result, there are older structures built therein. For example, all of Balboa Island is located in the floodway. The NFIP floodway definition is "the channel of a river or other watercourse and adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot." Floodways are not mapped for all rivers and streams but are generally mapped in developed areas.

Flood Fringe

The flood fringe refers to the outer portions of the floodplain, beginning at the edge of the floodway and continuing outward. Generally, the flood fringe is defined as "the land area which is outside of the stream flood way but is subject to periodic inundation by regular flooding." This is the area where development is most likely to occur, and where precautions to protect life and property need to be taken.

Development
For floodplain ordinance purposes, development is broadly defined as "any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations located within the area of special flood hazard." The definition of development for floodplain purposes is generally broader and includes more activities than the definition of development used in other sections of local land use ordinances.

Base Flood Elevation (BFE)
The term "Base Flood Elevation" refers to the elevation (normally measured in feet above sea level) that the base flood is expected to reach. Base flood elevations can be set at levels other than the 100-year flood. Some communities choose to use higher frequency flood events as their base flood elevation for certain activities, while using lower frequency events for others. For example, for the purpose of storm water management, a 25-year flood event might serve as the base flood elevation, whereas the 500-year flood event may serve as base flood elevation for the tie down of mobile homes. The regulations of the NFIP focus on development in the 100-year floodplain.

Storm Flooding Characteristics
Four primary types of storm-induced flooding have historically affected the coastal Southern California area, including the City of Newport Beach: riverine flooding, urban flooding, debris flows, and coastal flooding (see descriptions below). In Newport Beach, specifically, storm flooding hazards can be classified into three general categories: 1) flash flooding from small, natural channels, 2) more moderate and sustained flooding from the Santa Ana River and San Diego Creek, and 3) coastal flooding associated with storm surges.

Riverine Flooding
Riverine flooding is the overbank flooding of rivers and streams. This process in a natural environment adds sediment and nutrients to the flooded area, cyclically enhancing the fertility of the soils, which is why floodplains have been the breadbaskets of civilizations through the ages. However, large floods have the potential to cause significant damage to man-made structures and cause significant loss of life. Flooding in large river systems typically results from large-scale weather systems that generate prolonged rainfall over a wide geographic area, causing flooding in hundreds of smaller streams, which then drain into the major rivers.

Shallow-area flooding is a special type of riverine flooding. FEMA defines shallow flood hazards as areas that are inundated by the 100-year flood with flood depths of only one to three feet. These areas are generally flooded by low-velocity sheet flows of water.

Urban Flooding
As land is converted from agricultural fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization of a watershed changes the hydrologic systems of the basin. Heavy rainfall collects and flows faster on impervious concrete and asphalt surfaces. The water moves from the clouds, to the ground, and into streams at a much faster rate in urban areas. Adding these elements to the hydrological systems can result in floodwaters that rise very rapidly and peak with violent force. The flooding of developed areas often occurs when the amount of water generated from rainfall and runoff exceeds the storm water system's capability to remove it.

Newport Beach, like most cities, has a high concentration of impervious surfaces that either collect water, or concentrate the flow of water in channelized or man-improved channels. The San Joaquin

Hills in the eastern part of the City consist of sedimentary rock types that are fairly impervious to water so little precipitation infiltrates the ground; rainwater instead flows along the surface as runoff. When a major storm moves in, water collects rapidly and runs off quickly, making a steep, rapid descent from the hills into manmade and natural channels in the built environment and onto the marine terraces along the coast. During periods of urban flooding, streets can become swift moving rivers and basements and other low-lying areas can fill with water. Storm drains may also back up with vegetation and debris causing additional, localized flooding.

Debris Flows

Another flood related hazard that can affect certain parts of the Southern California region is debris flows. Debris flows most often occur in mountain canyons and at the foothills of the mountains that serve as backdrop to the area. However, any hilly or mountainous area with intense rainfall and the proper geologic conditions may experience one of these very sudden and devastating events.

Debris flows, sometimes referred to as mudslides, mudflows, or debris avalanches, are common types of fast-moving landslides that generally occur during periods of intense rainfall (or rapid snow melt). They usually start on steep hillsides as shallow landslides that liquefy and accelerate to speeds that are typically about 10 miles per hour, but can exceed 35 miles per hour. The consistency of debris flows ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars. Debris flows from many different sources can combine in channels, and their destructive power may be greatly increased. They continue flowing down hills and through channels, growing in volume with the addition of water, sand, mud, boulders, trees, and other materials. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc in developed areas.

Coastal Flooding

Flooding of coastal areas often occurs during periods of stormy weather, due to storm surges. A **storm surge** is an abnormal rise in sea water level associated with hurricanes and other storms at sea. Surges result from strong on-shore winds and/or intense low-pressure cells associated with ocean storms. Water level is controlled by wind, atmospheric pressure, existing astronomical tide, waves and swell, local coastal topography and bathymetry, and the storm's proximity to the coast. Flooding of deltas and other low-lying coastal areas is exacerbated by the influence of tidal action, localized storm waves, and frequent channel shifts.

Most often, destruction by storm surge is attributable to:

- Wave impact and the physical shock on objects associated with the *passing* of the wave front. The water may lift and carry objects to different locations.
- *Direct impact* of waves on fixed structures. This tends to cause most of the damage.
- Failure of private and public sea walls, resulting in significant flooding.
- *Indirect impacts,* such as flooding and the undermining of major infrastructure (such as highways and railroads).

For example, unusually severe storms in June, July and August of 1920 caused extensive damage to the west jetty in Newport Beach. Tidal currents swept the sand from beneath the toes of the jetty's slopes, and the rocks sank into the ocean floor, which lowered the crest of the jetty so that two large gaps appeared in it at times of high tide. Storm-generated swells, especially when combined with tidal action also have the potential to cause damage. In the Southern California area, including Newport Beach, localized flooding and accelerated rates of coastal erosion have occurred when storms are combined with high tides. This occurred during the 1977-1978, 1983, 1988, 2005 and

2010 storms, when the combination of high waves, local storm surges and high tides damaged several coastal structures in Southern California.

According to Walker et al. (1984), the 1977-78 storms did not damage the piers and jetties at Newport Beach. During the storms in 1988, however, the high water extended to the first row of houses behind the groin field at Newport Beach causing minor flood damage to these structures (Pipkin et al., 1992). Although the brunt of the February 1998 storms did not strike during high tide, the storm surge was such that the Newport pier was damaged. The winter storms of 2009-2010 caused extensive erosion up and down the Southern California coastline, in many areas touted as the "worst in a decade" (Los Angeles Times, 04/02/2010; http://articles.latimes.com/2010/apr/02/local/la-me-vanishing-beaches2-2010apr02).

Interestingly, recent studies (Ruggiero et al., 2010; Seymour, 2011) have shown that average wave heights along the west coast have gradually increased during the past several decades, based on an analysis of long-term wave data from buoys located off the coast. The data show that between 1996 and 2010, 75 storm events generating waves 16 feet high and higher occurred along the Southern California coastline, from Pt. Concepcion south to the Mexican border, whereas in the period between 1984 and 1995, there were only 11 storm events generating waves of that size (Russell and Griggs, 2012, based on data by Seymour, 2011). The reasons behind this sharp increase in wave height are poorly understood at this time; increases in ocean water temperature, changes in storm tracks, higher wind speeds, and more intense winter storms are all thought to be possible factors. Nevertheless, an increase in storms generating large waves off the coast of Newport Beach means an increase in coastal erosion rates, with the potential for significant damage to infrastructure and private property.

Tsunami and Rogue Wave Flooding

A **tsunami** is a sea wave caused by any large-scale disturbance of the ocean floor that occurs in a short period of time and causes a sudden displacement of water. Tsunamis can travel across the entire Pacific Ocean basin, or they can be local. For example, an earthquake off the coast of Japan can generate a tsunami that causes substantial damage in Hawaii and Northern California. These distantly generated tsunamis are also referred to as teletsunamis. This report addresses the potential for both teletsunamis and locally generated tsunamis impacting the Newport Beach coastline.

Large-scale tsunamis are not single waves, but rather a long train of waves. The most frequent causes of tsunamis are shallow underwater earthquakes and submarine landslides, but tsunamis can also be caused by underwater volcanic explosions, oceanic meteor impacts, and even underwater nuclear explosions. Tsunamis are characterized by their length, speed, low period, and low observable amplitude: the waves can be up to 200 km (125 mi) long from one crest to the next, they travel in the deep ocean at speeds of up to 950 km/hr (600 mi/hr), and have periods of between 5 minutes and up to a few hours (with most tsunami periods ranging between 10 and 60 minutes). Their height in the open ocean is very small, a few meters at most, so they pass under ships and boats undetected (Garrison, 2002), but may pile up to heights of 30 m (100 ft) or more on entering shallow water along an exposed coast, where they can cause substantial damage. The highest elevation that the water reaches as it runs up on the land is referred to as wave runup, uprush, or inundation height (McCulloch, 1985; Synolakis et al., 2002). Inundation refers to the horizontal distance that a tsunami wave penetrates inland (Synolakis et al., 2002).

Earthquake-generated tsunamis have been studied more extensively than any other type. Researchers have found that there is a correlation between the depth and size of the earthquake and the size of the associated tsunami: the larger the earthquake and the shallower its epicenter, the larger the resulting tsunami (Imamura, 1949; Iida, 1963, as reported in McCulloch, 1985). The size of the tsunami is also related to the volume of displaced sea floor (Iida, 1963). Given these correlations, several researchers in the last decades have modeled tsunami runups for various areas along the Pacific Ocean, including in the western United States (Houston, 1980; Brandsma et al., 1978; Synolakis, 1987; Titov and Synolakis, 1998; and many others – refer to www.usc.edu/dept/tsunamis/tsupubs and www.tsunamiresearchcenter.com/publications/).

Rogue waves are very high waves, as much as tens of meters high, but, compared to tsunamis, they are very short from one crest to the next, typically less than 2 km (1.25 mi) long. Rogue waves arise unexpectedly in the open ocean, and their generating mechanism is a source of controversy and active research. Rogue waves are unpredictable and therefore it is nearly impossible to plan for them. Some theories on rogue wave formation include:

- Strong currents that interact with existing swells making the swells much higher;
- A statistical aberration that occurs when a number of waves just happen to be in the same place at the same time, combining to make one big wave;
- The result of a storm in the ocean where the wind causes the water surface to be rough and choppy, creating very large waves.

Notable Tsunamis and Rogue Waves in the Newport Beach Area

In the Pacific Basin, most tsunamis originate in six principal regions, all of which have prominent submarine trenches. Of the six regions, only three have produced major tsunami damage along the California coastline in historical times. These are the Aleutian (Gulf of Alaska) region, the region off Chile, in South America (CDMG, 1976), and the region off eastern Japan, as evidenced by the March 2011 Tohoku-oki event. Southern California is generally protected from teletsunamis by the Channel Islands, which deflect east- and northeast-trending waves, and by Point Arguello, which deflects waves coming in from the continental area of Alaska (see Map 7-5). Tsunamis generated by local earthquakes or landslides have historically posed only a minor, localized risk to Southern California. However, the record also shows that the highest sea waves recorded in the Southern California area were caused by a locally generated tsunami, the 1812 Santa Barbara event.

Although the historical record for Southern California is short, to date approximately 55 tsunamis have been recorded in Southern California since the early 1800s (see Table 7-5). Given that instrumented tidal measurements in Southern California were first made in 1854, wave heights for pre-1854 events are estimated based on historical accounts.

Most records are for the San Diego and Los Angeles areas, with only a few events actually mentioned in the Orange County area. Most of the recorded tsunamis produced only small waves between 0.15 and 0.3 m (0.5 – 1 ft) high that did not cause any damage, but eight are known to have caused damage in the Southern California area. Those events are shown in bold in Table 7-5, and are described further in the paragraphs below.

Map 7-5: Wave Exposure Map for Newport Beach
(Source: U.S. Army Corps of Engineers, Los Angeles District, November 1993, Condition Survey for Entrance Jetties, Newport Bay Harbor, Orange County, California.)

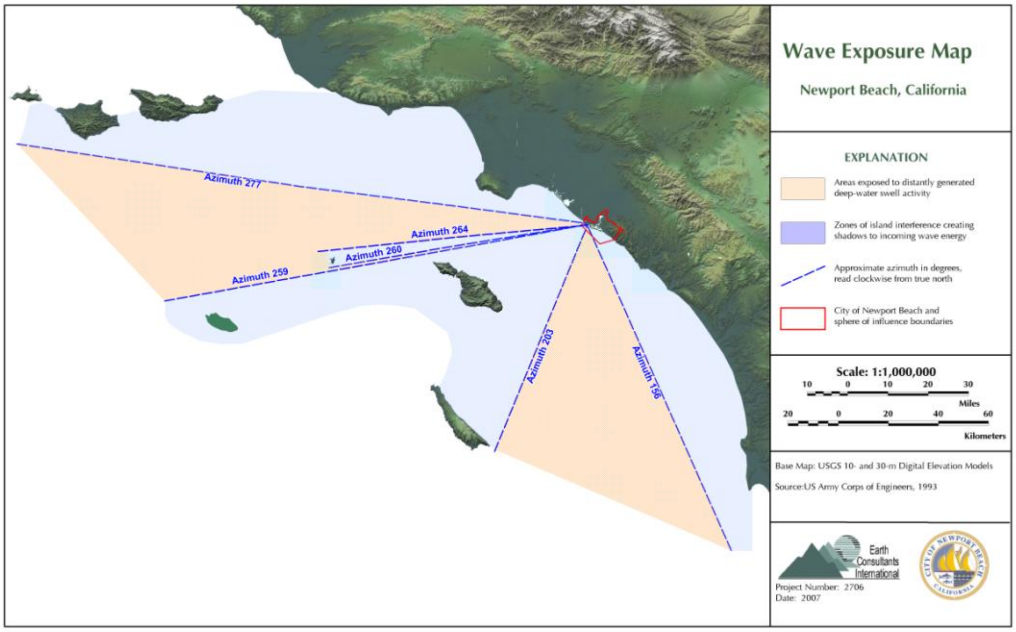


Table 7-5: Historical Tsunami Record for Southern California - 1812 to Present
(Tsunamis that caused damage in Southern California are in bold)

Date	Source	Wave Height
December, 1812	**Southern California; earthquake or landslide in Santa Barbara Channel?**	**Santa Barbara: ~2-3 m (6.6-9.8 ft); Ventura: ~2-3 m (6.6-9.8 ft)**
November, 1853	Kuril Islands	Unknown; possibly observed in San Diego
May, 1854	Southern California; possibly same as July or December events	Unknown; observed in San Diego
July, 1854	Unknown; possible meteorological origin	San Diego: ~0.3 m (~1 ft)
December 23, 1854	Japan	San Diego: < 0.1 m (0.3 ft)
December 24, 1854	Japan	San Diego: 0.1 m (0.3 ft)
July, 1855	Southern California; possible offshore landslide caused by earthquake in Los Angeles	Unknown; large waves reported at Point San Juan; 2 unusually heavy sea waves in San Juan Capistrano.
April, 1868	Hawaii	San Diego: 0.1 m (0.3 ft)
August, 1868	Chile	San Diego: 0.3 – 0.8 m (0.6-2.6 ft); San Pedro: 1.8 m (5.9 ft) Wilmington: 1.8 m (5.9 ft)
August, 1872	Aleutian Islands	San Diego: < 0.1 m (0.3 ft)
May, 1877	Chile	San Pedro: 1 m (3.3 ft); Wilmington: 1 m (3.3 ft); Gaviota: 3.7 m (12.1 ft)
August, 1879	Southern California; possible undersea landslide caused by earthquake in San Fernando area	Unknown; tsunami reported at Santa Monica

Date	Source	Wave Height
December, 1899	Southern California; Underwater landslide generated by earthquake in San Jacinto area?	Unknown; large wave reported along Southern California coast
February, 1902	El Salvador-Guatemala	Unknown; large wave reported in San Diego
January, 1906	Ecuador	Unknown; reported in San Diego
August, 1906	Chile	San Diego: 0.1 m (0.3 ft)
May, 1917	South Pacific	Unknown; large waves reported in La Jolla
June, 1917	South Pacific	Unknown; reported in San Diego
April, 1919	South Pacific	Unknown; reported in San Diego
November, 1922	Chile	San Diego: 0.2 m (0.7 ft)
February, 1923	Kamchatka	San Diego: 0.2 m (0.7 ft)
October, 1925	Unknown; possible meteorological origin or submarine volcanic event	Long Beach: 0.34 m (0.1 ft)
January, 1927	**Southern California; possible submarine landslide caused by earthquake in Imperial Valley**	**Unknown; large waves reported along Southern California coast: 1.8 m (5.9 ft) runup at Surf; 1.5 m (4.9 ft) runup at Port San Luis.**
November, 1927	Central and Southern California; offshore earthquake off Point Arguello, possibly on the Hosgri fault	La Jolla: 0.2 – 0.3 m (0.7 – 1 ft); Surf: 1.8 m (5.9 ft) Port San Luis: 1.5 m (4.9 ft)
June, 1928	Southern Mexico	La Jolla: < 0.1 m (0.3 ft)
August, 1930	Southern California; offshore earthquake in Santa Monica Bay	Santa Monica: 0.6 m (1.9 ft)
March, 1933	Japan	Los Angeles: 0.2 m (0.7 ft); Santa Monica < 2.0 m (6.6 ft)
March, 1933	Southern California; Long Beach Earthquake	Long Beach: 0.1 m? (0.3 ft)
August, 1934	**Unknown; possibly caused by earthquake or submarine landslide near Balboa, or of meteorological origin**	**Newport Beach: 3 m rise (9.8 ft); 9-12 m (30 –39 ft) waves**
April, 1943	Chile	San Diego: 0.1 m (0.3 ft)
December, 1944	Japan	San Diego: < 0.1 m (0.3 ft)
April, 1946	Aleutian Islands	Avila: 1.2 m (3.4 ft)
March, 1957	**Aleutian Islands**	**San Diego: 0.2 – 1.0 m (0.7–3.3 ft)**
May, 1960	**Chile**	**Santa Monica: 1.4 m (4.6 ft)**
May, 1964	**Gulf of Alaska**	**Santa Monica: 1.0 m (3.3 ft)**
February, 1965	Aleutian Islands	Santa Monica: 0.08 m (0.3 ft)
May, 1968	Japan	Santa Monica: 0.2 m (0.7 ft); Long Beach: 0.1 m (0.3 ft)
May, 1971	South Pacific	Los Angeles: 0.05 m (0.2 ft)
November, 1975	Hawaii	La Jolla: 0.1 m (0.3 ft)
June, 1977	South Pacific	Los Angeles: 0.05 m (0.2 ft); Long Beach: 0.12 m (0.4 ft)
1979 and 1989	Unknown source – affected Santa Monica Bay	Local oscillations (?)
July 30, 1995	North Chile	Los Angeles: 0.05 m (0.2 ft); San Diego: 0.05 m (0.2 ft)
June 23, 2001	South Peru	Los Angeles: 0.10 m (0.3 ft) La Jolla: 0.10 m (0.3 ft)

Date	Source	Wave Height
December 26, 2004	Off west coast of Sumatra	Los Angeles: 0.27 m (0.9 ft) La Jolla: 0.12 m (0.4 ft) San Diego: 0.32 m (1.05 ft) Santa Monica: 0.41 m (1.35 ft)
May 3, 2006	Tonga	La Jolla: 0.04 m (0.13 ft) Los Angeles: 0.08 m (0.26 ft) Santa Monica: 0.10 m (0.3 ft)
November 15, 2006	South Kuril Islands, Russia	Los Angeles: 0.11 m (0.36 ft) La Jolla: 0.13 m (0.43 ft) Santa Monica: 0.15 m (0.5 ft)
April 1, 2007	Solomon Islands	San Diego: 0.1 m (0.3 ft) Santa Monica: 0.11 m (0.36 ft)
August 15, 2007	South Peru	San Diego: 0.05 m (0.16 ft) Los Angeles: 0.06 m (0.2 ft) Santa Monica: 0.07 m (0.23 ft)
September 29, 2009	Samoa Islands Region	Los Angeles: 0.13 m (0.43 ft) Santa Monica: 0.15 m (0.49 ft)
October 7, 2009	Torres Islands, Vanuatu	Santa Barbara: 0.15 m (0.49 ft) Santa Monica: 0.05 m (0.16 ft)
February 27, 2010	**Offshore Maule, Chile**	**San Diego: 0.40 m (1.31 ft)** **Los Angeles: 0.42 m (1.38 ft)** **Santa Monica: 0.64 m (2.1 ft)**
March 11, 2011	**Offshore Honshu, Japan**	**San Diego: 0.63 m (2.1 ft)** **Los Angeles: 0.49 m (1.61 ft)** **Santa Monica: 0.84 m (2.76 ft)**
October 28, 2012	Haida Gwaii, Queen Charlotte Islands, British Columbia, Canada	San Diego: 0.05 m (0.16 ft) Los Angeles: 0.08 m (0.26 ft) Santa Monica: 0.08 m (0.26 ft)
February 6, 2013	Lata, Solomon Islands	La Jolla: 0.06 m (0.2 ft) Santa Monica: 0.08 m (0.26 ft)

Sources: Compiled from Lander and Lockridge (1989), McCulloch (1985), Legg et al., (2003), and http://www.ngdc.noaa.gov/

Santa Barbara Tsunami of 1812

A strong earthquake in the Santa Barbara area on December 21st, 1812 produced a tsunami that caused damage in Santa Barbara and Ventura counties and was reported along the coast of Southern California. However, the tsunami of 1812 occurred before the Newport Beach area was settled, so there are no data specific to Newport Beach for this event. The most likely source for the earthquake is a fault zone in the Santa Barbara Channel, although onshore faults east of Santa Barbara cannot be ruled out.

While some historical accounts suggest the tsunami produced a maximum one-mile runup and wave heights of 15 m (49 ft) at Gaviota, 9 to 10.5 m (29.5 – 34.5 ft) at Santa Barbara and 3.5 m (11.4 ft) at Ventura, contemporary records from the missions at Santa Barbara and Ventura do not mention tsunami runup or damage to nearby coastal communities (Lander and Lockridge, 1989). The mission records describe only a disturbed ocean and fear of tsunami, suggesting that the accounts of high waves, most of which were recorded years after the event, may have been exaggerated (Lander and Lockridge, 1989). For example, an account of "an old trader" printed in the San Francisco Bulletin 52 years after 1812, reported a 1-mile runup in Gaviota. From this account, the 15 m (49 ft) wave height reported above was derived using topographic maps.

Accounts collected by Trask (1856), 44 years after the event, report that waves damaged the lower part of the town of Santa Barbara, half a mile inland. Trask (1856) also recorded reports of a ship damaged by a tsunami wave near San Buenaventura (present day Ventura). This may be the same vessel reported by Los Angeles Star in 1857 to have been swept up a canyon at El Refugio Bay, near Gaviota. A third-hand account of tsunami damage to the mission in Ventura, located 4.5 m (14.8 ft) above sea level, is not corroborated by the mission records (Grauzinis et al., 1965). Grauzinis et al. (1965, based on data from Soloviev and Go, 1975; McCulloch, 1985; Marine Advisors, 1965; Iida et al., 1967; Wood, 1916; Heck, 1947; Toppozada et al., 1981), conclude that the most reliable historical data support a tsunami height of less than 3 m (9.8 ft) at Santa Barbara and Ventura, 3.5 m (11.4 ft) at El Refugio, and lower elsewhere in Southern California. This is roughly consistent with analysis of predicted tidal data for the region by Long (1988) who suggests a wave height of 2 m (6.6 ft) at Santa Barbara and Ventura.

Tsunami of January 1927

A magnitude 5.7 earthquake followed by several aftershocks occurred in the Imperial Valley, at the border between the United States and Mexico, on January 1, 1927. According to Montandon (1928), sea waves in San Pedro destroyed a seawall or embankment causing about three million dollars in damage (Lander and Lockridge, 1989). However, since the Imperial Valley is far from the coast, and the earthquake was moderate in size, it is doubtful that these two events are related, unless the earthquake triggered a submarine landslide.

Possible Tsunami of 1934

On August 21, 1934 large destructive waves were reported along the coast of Southern California from Malibu to Laguna Beach. The true source of the waves is not known, however several causative events have been suggested. Although official records show no large earthquakes in the area on the day of the waves, a small, magnitude 3 tremor was reported in the Balboa region before the waves struck. Submarine landsliding, volcanic activity, and unusual meteorological conditions (rogue waves?) have also been suggested as possible explanations for the waves. A runup of 270 m (886 ft) inland, 3 m (9.8 ft) above mean high tide level was recorded at Newport Beach, which flooded part of the City to a depth of one meter (3.3 ft). Four people were injured near the channel entrance to Newport Bay, at the western pier. Many houses were destroyed, including a two-story home in Balboa that was detached from its foundation. Part of the pavement on Balboa Peninsula was washed away, temporarily isolating the residents of this area from the mainland. Thousands of tons of debris were tossed onshore. The waves also flooded a moorage in Balboa Island and collapsed part of the breakwater in Long Beach (Lander and Lockridge, 1989).

Aleutian Island Tsunami of 1957

A magnitude 8.3 earthquake in the Aleutian Islands on March 9, 1957 generated a small tsunami in the San Diego area that damaged two ships in San Diego Harbor and caused minor damage at La Jolla (McMulloch, 1985; Iida et al., 1967; Salsman, 1959; Joy, 1968). A wave height of up to one meter (3.3 ft) was reported at Shelter Island, off the San Diego coast, although the tide gauge there recorded only a 0.2 m (0.7 ft) wave. No reports of damage were recorded in the City of Newport Beach.

Chilean Tsunami of 1960

On May 22, 1960, a moment magnitude 9.4 earthquake off the coast of Chile produced a tsunami that damaged coastal communities in Southern California between Santa Barbara and San Diego. A wave height of 1.4 m (4.6 ft) was recorded in Santa Monica and the tidal gauge in San Diego was carried away by the tsunami waves (Lander and Lockridge, 1989). Significant damage was recorded in the Los Angeles and Long Beach Harbors, where 30 small craft were sunk and over 300 were set adrift. Over 340 boat slips, valued at $300,000, were also damaged in the area. At Santa Monica, eight small boats were swept away and a runup of 91 m (300 ft) flooded a parking lot along the Pacific Coast Highway. Damage of $20,000 was reported in the Santa Barbara area. At San Diego, two passenger ferries were knocked off course by the waves; the first ferry was pushed against a dock in Coronado, destroying 80 m (260 ft) of the dock, and the second was rammed into a flotilla of anchored destroyers. The waves also rammed a 100-ton dredge into the Mission Bay Bridge, knocking out a 21 m (70 ft) section and sinking a barge at Seaforth Landing (Lander and Lockridge, 1989; Iida et al., 1967; Talley and Cloud, 1962; Joy, 1968).

Good Friday Earthquake Tsunami of 1964

On March 28, 1964 a moment magnitude 9.2 earthquake in the Gulf of Alaska produced a very large and damaging tsunami in the West Coast. The tsunami killed 16 people in northern California and Oregon and caused $8,000,000 in damage in California. Although damage was primarily focused in coastal areas north of San Francisco, Southern California experienced hundreds of thousands of dollars in losses. A wave height of 1 m (3.3 ft) was recorded in Santa Monica. In Los Angeles Harbor, the wave damaged six small-boat slips, pilings, and the Union Oil Company fuel dock. It also scoured the harbor sides, causing, all tolled, $175,000 to $275,000 in damage. The tsunami also destroyed eight docks in the Long Beach Harbor at a loss of $100,000 (Spaeth and Berkman, 1972). Minor damage was also reported elsewhere along the Southern California coast.

Chilean Tsunami of February 2010

The magnitude 8.8 earthquake off the coast of Chile caused a tsunami that arrived in southern California approximately 5 hours after the earthquake, with highest wave amplitudes reported one to six hours after the first wave arrival. The highest tide gauge readings were reported in Santa Barbara, Pismo Beach and San Diego Bay. Minor damage to docks and marine infrastructure was reported in Marina del Rey, Two Harbors (Catalina), Los Angeles, and Oceanside. Moderate damage to docks, concrete piers and boats was reported in North Shelter Island (San Diego Bay). No damage was reported in Newport Beach, Huntington Beach, Seal Beach, Long Beach, and La Jolla (Wilson et al., 2011).

Tohoku-oki Tsunami of March 2011

The magnitude 9.0 earthquake off the eastern coast of Japan generated a tsunami train that impacted the California coast, with tsunami activity lasting as much as 24 hours after the first wave arrived. Although most of the damage reported occurred in Northern California, especially at Crescent City and Santa Cruz, minor to moderate damage was reported in some harbors in Southern California. Specifically, the tsunami waves destroyed a dock and damaged 13 boats in Mission Bay, a boat was sunk and a dock was damaged in south Shelter Island (San Diego), a pylon was damaged when hit by a boat in Dana Point, a boat was pulled off its moorings in Huntington Beach, and minor damage to docks and boats was reported in Los Angeles and Long Beach. No damage was reported in Newport Beach, Sunset Beach, La Jolla, or Oceanside. The damage in Mission Bay was estimated at $136 thousand (Wilson et al., 2011).

Seismically Induced Inundation

Dam Failure Flooding

Seismically induced inundation refers to flooding that results when water retention structures (such as dams) fail due to an earthquake. Failure of these structures can also result from other causes, such as overtopping, foundation problems, or construction errors. Statutes governing dam safety are defined in Division 3 of the California State Water Code (California Department of Water

Resources, 1986). These statutes empower the California Division of Dam Safety to monitor the structural safety of dams that are greater than 25 feet in dam height or have more than 50 acre-feet in storage capacity.

Dams under State jurisdiction are required to have inundation maps that show the potential flood limits in the remote, yet disastrous possibility, that a dam is catastrophically breached. Inundation maps are prepared by dam owners to help with contingency planning; these inundation maps in no way reflect the structural integrity or safety of the dam in question. Because dam failure can have severe consequences, FEMA requires that all dam owners develop Emergency Action Plans (EAP) for warning, evacuation, and post-flood actions. Although there may be coordination with county officials in the development of the EAP, the responsibility for developing potential flood inundation maps and facilitation of emergency response is the responsibility of the dam owner. Dam owners are also required to prepare and submit emergency response plans to the State Office of Emergency Services, the lead State agency for the State dam inundation-mapping program. Cities and counties are required by State law to have in place emergency procedures for the evacuation and control of populated areas within the limits of dam inundation. In addition, legislation requires real estate disclosure upon sale or transfer of properties in the inundation area (AB 1195 Chapter 65, June 9, 1998; Natural Hazard Disclosure Statement).

There have been a total of 45 dam failures in California since the 19th century. The most significant dam failures in Southern California are listed in Table 7-6, and the two most significant dam failures, St. Francis Dam in 1928 and the Baldwin Hills Dam in 1963, are described further below.

Table 7-6: Dam Failures in Southern California

Dam Name	Location	Year	Failure Mechanism
Sheffield	Santa Barbara	1925	Earthquake slide
Puddingstone	Pomona	1926	Overtopping during construction
Lake Hemet	Palm Springs	1927	Overtopping
Saint Francis	San Francisquito Canyon	1928	Sudden failure at full capacity through foundation, more than 400 deaths.
Cogswell	Monrovia	1934	Breaching of concrete cover
Baldwin Hills	Los Angeles	1963	Leak through embankment turned into washout, 3 deaths.

St. Francis Dam, completed in 1926 in the San Francisquito Canyon near Saugus, was 180 feet high and 600 feet long. Its failure was a scandal that resulted in the almost complete destruction of the reputation of its builder, William Mulholland. Mulholland was an immigrant from Ireland who rose up through the ranks of the Los Angeles City Water Department to the position of chief engineer. It was he who proposed, designed, and supervised the construction of the Los Angeles Aqueduct, which brought water from the Owens Valley to Los Angeles.

St. Francis dam gave way on March 12, 1928, three minutes before midnight. Its waters swept through the Santa Clara Valley toward the Pacific Ocean, about 54 miles away. Sixty-five miles of valley were devastated before the water finally made its way into the ocean between Oxnard and Ventura. At its peak, the wall of water was said to be 78 feet high; by the time it hit Santa Paula, 42 miles south of the dam, the water was estimated to be 25 feet deep. Almost everything in its path was destroyed: livestock, structures, railways, bridges, and orchards. By the time it was over, parts of Ventura County lay under 70 feet of mud and debris. Over 400 people were killed and damage estimates topped $20 million.

The Baldwin Hills dam, an earthen dam that created a 19-acre reservoir to supply drinking water to West Los Angeles residents, failed on December 14, 1963 at 3:38 in the afternoon. This is one of the first disaster events documented in a live helicopter broadcast – the live telecast of the collapse from a KTLA-TV helicopter is considered the precursor to airborne news coverage that is now routine everywhere. As a pencil-thin crack widened (see Figure 7-9) to a 75-foot gash, 292 million gallons surged out. "The Baldwin Hills Dam collapsed with the fury of a thousand cloudbursts, sending a 50-foot wall of water down Cloverdale Avenue and slamming into homes and cars . . . Five people were killed. Sixty-five hillside houses were ripped apart, and 210 homes and apartments were damaged." The flood swept northward in a V-shaped path roughly bounded by La Brea Avenue and Jefferson and La Cienega boulevards.

It took 77 minutes for the impounded reservoir to empty, but it took a generation for the neighborhood below to recover, illustrating the severe, long-term impact of these disasters. Furthermore, failure of this tank foreshadowed the end of urban-area earthen dams as a major element of the Department of Water and Power's water storage system. It also prompted a tightening of Division of Safety of Dams control over reservoirs throughout the State.

Figure 7-9: Initial Failure of Baldwin Hills Dam. Dark spot in lower right-hand quadrant shows the beginning of the break in the dam.

Flooding Due to Failure of Above-Ground Water Storage Tanks

Seismically induced inundation can also occur if strong ground shaking causes structural damage to above-ground water tanks. If a tank is not adequately braced and baffled, sloshing water can lift a water tank off its foundation, splitting the shell, damaging the roof, and bulging the bottom of the tank (elephants foot) (EERI, 1992). Movement can also shear off the pipes leading to the tank, releasing water through the broken pipes. These types of damage occurred during Southern

California's 1992 Landers, 1992 Big Bear, and 1994 Northridge earthquakes. The Northridge earthquake alone rendered about 40 steel tanks non-functional (EERI, 1995), including a tank in the Santa Clarita area that failed and inundated several houses below. As a result of lessons learned from recent earthquakes, new standards for design of steel water tanks were adopted in 1994 (Lund, 1994). The new tank design includes flexible joints at the inlet/outlet connections to accommodate movement in any direction. All of Newport Beach's water steel tanks have been retroffited with flexible expansion joints to allow for movement during earthquakes.

Water lost from tanks during an earthquake can significantly reduce the water resources available to suppress earthquake-induced fires. Damaged tanks and water mains can also limit the amount of water available to residents. Furthermore, groundwater wells can be damaged during an earthquake, also limiting the water available to the community after an earthquake. Therefore, it is of paramount importance that the water storage tanks in the area retain their structural integrity during an earthquake, so water demands after an earthquake can be met. In addition to evaluating and retrofitting to meet current standards, this also requires that the tanks be kept at near full capacity as much as practical.

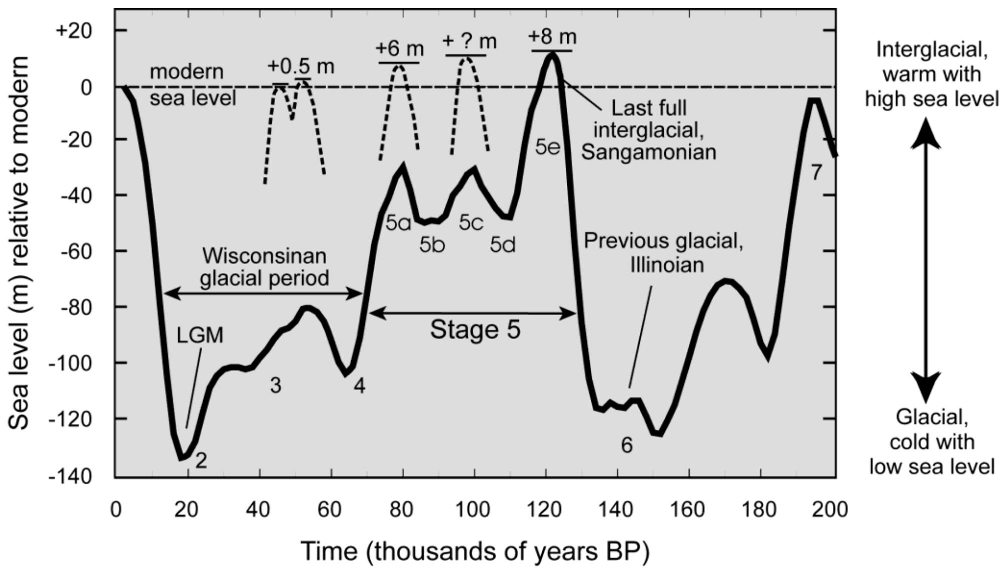
Flooding Due to Sea Level Rise

Sea Level Change

The geological record shows that the level of the oceans fluctuates with changes in global temperatures (see Figure 7-10 showing the changes in sea level over the last about two hundred thousand years). During the previous last major interglacial period (approximately 120,000 years ago), temperatures were about 2°F (1°C) warmer that today and sea level was approximately 20 to 26 feet (6 to 8 meters) higher than today (Mercer, 1970). During the last ice age (the last glacial maxima – LGM, approximately 20,000 years ago, see Figure 7-10), when global temperatures were 9°F (5°C) lower than today, much of the ocean's water was tied up in glaciers, sea level was as much as 430 feet (130 meters) lower than today (Oldale, 1985; Lajoie et al., 1991), and the California coast was 5 to 15 miles (8 to 25 km) farther offshore than its present position (Department of Boating and Waterways and State Coastal Conservancy, 2002). The last ice age ended approximately 18,000 years ago, and since then the world has been experiencing global warming such that many of the ice caps have melted, most of the continental-sized glaciers have retreated, and sea level has risen. Between about 18,000 and 5,000 years ago, the rise in sea level occurred rapidly, at an average rate of nearly 0.4 in (1 cm) a year. In the past about 5,000 years and up to about the end of the 19th century, sea level essentially stayed the same. Then, in the last century, sea level rise picked up speed again such that on average, global sea level between the years 1900 and 2000 rose 7 inches (see Figure 7-11). Higher rates of sea level rise are estimated in the next few decades, as shown on Figure 7-11.

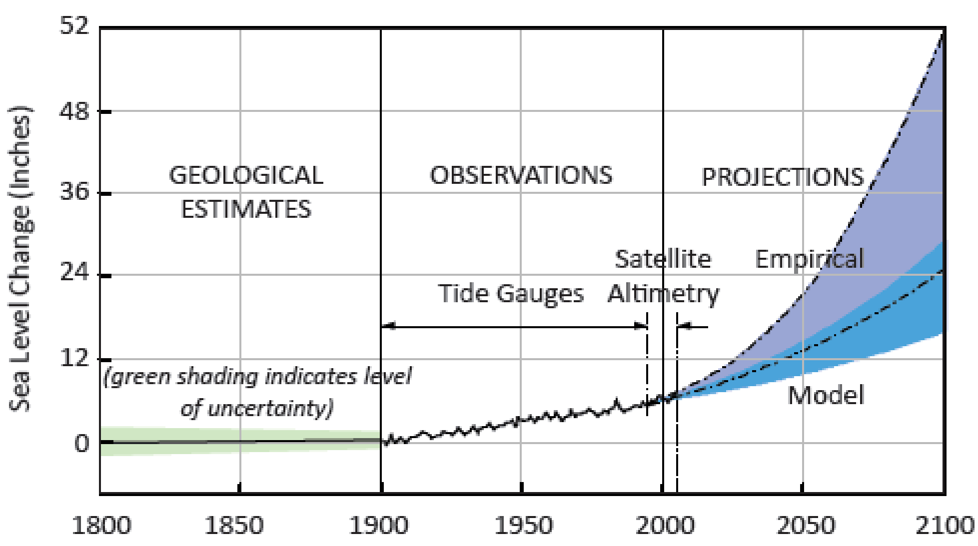
The scientific consensus is that global climate is changing, with an increase in sea water temperatures, melting of the last remaining glaciers, and an increase in more severe storms. Although the rise in sea level will be somewhat gradual, coastal communities are already experiencing the effects of global climate change in the form of more frequent storm flooding, and increased cliff, bluff and shoreline erosion. These conditions are already impacting infrastructure (including transportation routes, harbors, wastewater treatment plants, and storm water systems), and residential and commercial property.

Figure 7-10: Worldwide Sea Level Curve for the Past Two Hundred Thousand Years Using Current Sea Level as the Reference Point



From Martinson et al., 1987
(BP = before present; LGM = Last Glacial Maxima; sea level in meters)

Figure 7-11: Sea Level in Recent Times and Predictions of Future Sea Level



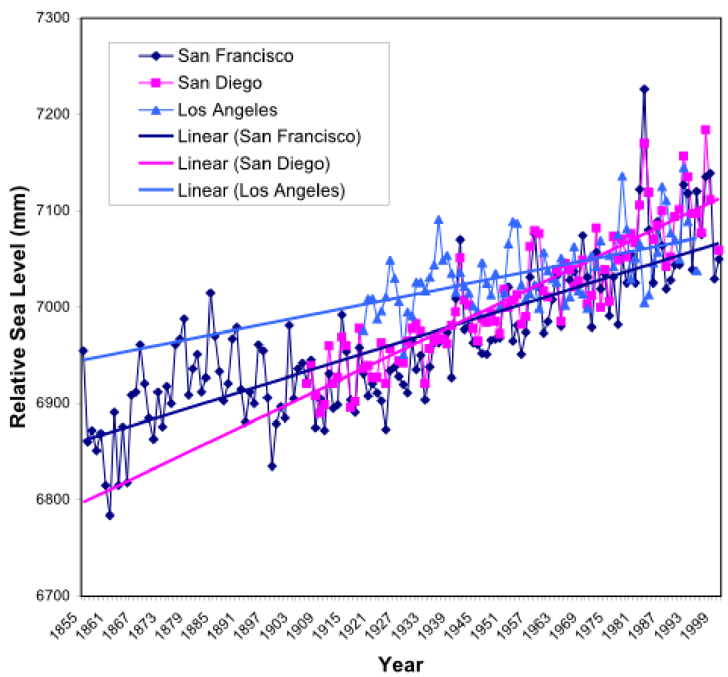
From Russell and Griggs (2012) who updated data from Shum and Kuo (2011)

When discussing shorter periods of time, one must distinguish worldwide (eustatic) sea level rise from relative sea level rise, which includes land subsidence or uplift. Also, as ocean temperatures rise, sea water expands, raising sea level even further. Although climate impacts sea level worldwide, the rate of sea level rise relative to a particular coast has more practical importance and is all that current monitoring stations can measure. Because, due to plate tectonics and other geological reasons, some coastal areas are sinking while others are rising, relative sea level rise in the United

States varies from more than 3 feet (1 meter) per century in Louisiana and parts of California and Texas, to 1 foot (30 centimeters) per century along most of the Atlantic and Gulf Coasts, to a slight drop in much of the Pacific Northwest (Titus et al., 1991; Knuuti, 2002). Large variations can also occur locally. For example, in San Francisco, the Presidio gauge near the entrance to the Golden Gate has measured a relative sea level rise of 0.06 inches/yr (1.41 mm/yr) in the past nearly 150 years. Across the bay, however, the 60-year-long gauge record at Alameda shows a relative mean sea level rise of only 0.035 inch/yr (0.89 mm/yr). Closer to home, in Los Angeles, the relative mean sea level trend for 87 years of record is 0.033 inch/yr (0.83 mm/yr), while in San Diego the 104-year-long record shows a linear trend in relative sea level rise of 0.081 inch/yr (2.06 mm/yr). In Newport Beach, 40 years of data (between 1955 and 1995) indicate an average sea level rise of 0.087 inch/yr (2.22 mm/yr), one of the fastest rates in the southern California region (Russell and Griggs, 2012).

For a comparison of the relative sea level rise measured at the San Francisco, Los Angeles, and San Diego gauges, refer to Figure 7-12. This figure briefly shows that quantifying sea level changes worldwide is not a simple task.

Figure 7-12: Historical Relative Sea Level Rise at Three Locations along the Pacific Coast of the United States (San Francisco, Los Angeles and San Diego)

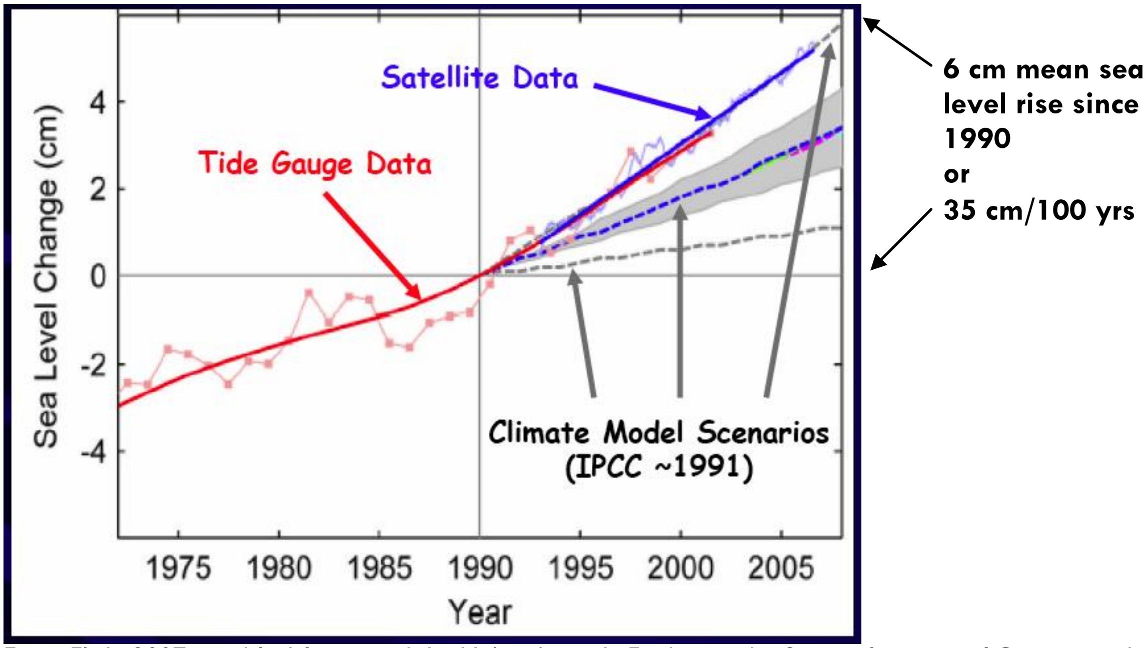


Linear Trends at each Location are shown by the Straight Lines

Source: Based on data obtained at http://www.nbi.ac.uk/psmsl/psmsl_individual_stations.html

After accounting for these local effects, worldwide sea level has risen 10 to 25 cm (4 to 10 inches) (Peltier and Tushingham, 1989), much of which has been attributed to global warming (Meier, 1984). Since 1990, sea level has risen approximately 6 cm, which calculates to about 35 cm per century (Flick, 2007), a much faster rate than the models predicted (see Figure 7-13).

Figure 7-13: Sea Level Rise – Observations Against Predictions



From Flick, 2007; modified from work by Helen Amanda Fricker at the Scripps Institute of Oceanography, San Diego.
IPCC = Intergovernmental Panel on Climate Change

Effects of Sea Level Rise

Although sea level rise by itself does not cause substantial changes in the landform, several processes associated with sea level rise can have dramatic effects on our environment. For example, a significant rise in sea level will inundate coastal wetlands and lowlands, and the increased surges and swells associated with this rise in sea level will accelerate coastal erosion and exacerbate coastal flooding, thereby threatening local structures and habitat. The combined effects of sea level rise and the high tides and large waves brought on by storms, especially during El Niño events, will, in the short-term, result in increased flooding of low-lying areas, and accelerated erosion of beaches and sea cliffs. Other related processes include higher water tables, increased sea-water intrusion into fresh water aquifers, and increased salinity of rivers, bays, and aquifers (Titus et al., 1991). The warmer climate may also result in a much higher probability of extremely warm years with increased precipitation in some areas, and drought in other areas. It is clear that global changes in climate are occurring, but the local impacts are still being determined.

Hazard Assessment

Hazard Identification – Flood Hazard Mapping in Newport Beach

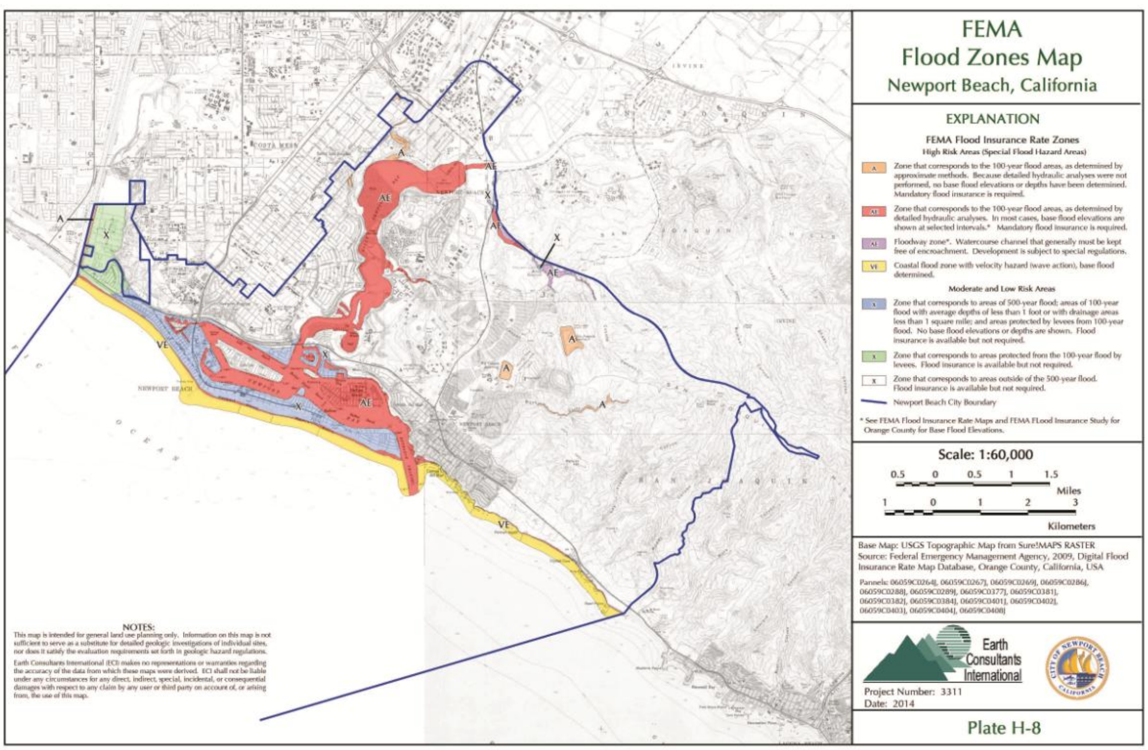
Hazard identification is the first phase of flood-hazard assessment. Identification is the process of estimating: 1) the geographic extent of the floodplain (i.e., the area at risk from flooding); 2) the intensity of the flooding that can be expected in specific areas of the floodplain; and 3) the probability of occurrence of flood events. This process usually results in the creation of a floodplain map. Floodplain maps provide detailed information that can assist jurisdictions in making policies and land-use decisions.

Inundation Due to Storm Flooding

The City of Newport Beach has participated in the National Flood Insurance Program since September 1, 1978 *(City ID No. – 060227)*. The extent of flooding on the Santa Ana River, San Diego Creek, and a few smaller streams within Newport Beach has been analyzed through Flood Insurance Studies, with the bulk of that work conducted by the U.S. Geological Survey in 1977. The potential flood zones in the City mapped by FEMA are presented in Flood Insurance Rate Maps (FIRMs). The most recent FIRM map for the City dates from December 3, 2009, and incorporates several letters of map revision and jurisdictional changes. Map 7-6 shows the FIRM inundation limits for both the 100-year and 500-year flood events. Please note that the 500-year flood zone includes the 100-year flood zone.

The 100-year flood (red and orange zones in Map 7-6) is anticipated to inundate the area from Beach Boulevard in Huntington Beach, to Fairview Park Bluffs in Costa Mesa, a narrow strip of undeveloped land at the base of the bluffs in Newport Beach, and the entire coastline. Both the 100- and 500-year floods will be contained within the channel of San Diego Creek, but Balboa Island will be under water and property along the margins of Newport Bay will be inundated. The 100-year flood zone also includes the central reaches of Buck Canyon, Bonita Canyon, and the San Joaquin and Big Canyon Reservoirs. Most of West Newport is protected from the 100-year flood by levees (green area on Map 7-6 and Plate H-8). The areas shown in blue on Map 7-6 are located within the 500-year flood zone. This includes all of Balboa Peninsula, and the areas next to the Newport Bay south of Coast Highway.

Map 7-6: FEMA Flood Zones Map for Newport Beach, California
(For a larger version of this map, refer to Plate H-8 in Appendix H)



Although, as indicated above, the FIRM map that covers Newport Beach is relatively recent, the bulk of the analyses supporting the map were made in 1977, and since then, there has been substantial development in the hills of Newport Beach, with the potential to increase runoff into the City's storm drains and flood-conveyance system. To address these issues, detailed hydrologic studies to study the impact of these developments on Coast Highway and adjacent areas were conducted as part of Phase IV-2 of the Newport Coast Planned Community (formerly called the Irvine Coast Planned Community prior to annexation to the City). This community encompasses much of the land in the San Joaquin Hills, including the Muddy Canyon and Los Trancos Canyon watersheds.

Los Trancos Canyon is one of two predominantly undeveloped watersheds in Newport Beach. The headwaters originate near Signal Peak (at an elevation of 1,150 feet above sea level) and drain an 1,180-acre watershed. Prior to development near the mouth of Los Trancos Canyon, The Keith Companies (1987; as reported in LSA, 1998) calculated a 100-year discharge of 1,952 cfs. After development, the modeled 100-year discharge increased to 2,377 cfs, most likely due to increased runoff associated with impervious surfaces (John M. Tettemer and Associates, 1998). However, according to the cited reports, the construction of detention basins should decrease the 100-year discharge to 1,683 cfs at Coast Highway. A single 9-foot by 10-foot arch culvert drains these flows beneath Coast Highway. Widening of Coast Highway necessitated extending this culvert, with a resulting decrease in conveyance through the culvert and a higher ponded water surface upstream of Coast Highway. This condition likely increases the potential for flooding at the Coast Highway crossing.

Muddy Canyon is the other predominantly undeveloped watershed in Newport Beach. The Keith Companies (1987, as reported in LSA, 1998) calculated a pre-development 100-year discharge of 1,470 cfs for the 990-acre Muddy Canyon watershed. After development, the 100-year discharge was estimated to increase to 1,908 cfs (John M. Tettemer and Associates, 1998). However, like in Los Trancos Canyon, detention projects are expected to reduce the post-development 100-year discharge to only 1,008 cfs. A single 8-foot by 6-foot arch culvert drains floodwaters beneath Coast Highway, but currently conveys less than the 100-year discharge. The post-development 100-year water surface behind the culvert is about 2 feet higher than the existing 100-year conditions. However, according to John M. Tettemer and Associates (1998), the culvert inlet was to be modified so all of the 100-year discharge would be conveyed for the post-development conditions.

As discussed previously, urban street flooding tends to occur in the City of Newport Beach when heavy rainfall coincides with high tides. During these instances, the low-lying streets in Newport Beach often become inundated. For example, when tides reach ~6.5 feet and heavy rain is falling, the streets around the Marcus and Finley Tracts on Balboa Peninsula flood. This condition also occurs along the lowest lying areas of Balboa Island. An 8.3-foot high tide would flood all of Newport Coast. To deal with these issues, the City of Newport Beach operates a total of 86 tide valves. These valves are usually closed to keep high tides from flooding the streets on Balboa Island and on the Peninsula. During rainstorms, urban runoff is in effect dammed by these tide valves. To mitigate this problem, the City pumps into the harbor and bays the urban runoff that has ponded at the street ends. This system has proven effective in minimizing the impacts of urban street flooding.

Inundation Due to Tsunamis and Rogue Waves

Because of the substantial increase in population in the last century and extensive development along the world's coastlines, a large percentage of the Earth's inhabitants live near the ocean. As a result, the risk of loss of life and property damage due to tsunamis has increased substantially. In fact, worldwide, tsunamis have been responsible for between 250,00 and 375,000 human deaths in the past decade alone, with between 225,000 and 350,00 of those attributed to the December 26, 2004 tsunami off of the west coast of Sumatra, and nearly another 20,000 to the March 11, 2011 tsunami off the east coast of Japan (the total number of fatalities caused by the Sumatra tsunami is, as of the writing of this report, still unclear, with different figures provided by different sources).

McCarthy et al. (1993) reviewed the historical tsunami record for California and suggested that the tsunami hazard in the Southern California region, from the Palos Verdes Peninsula south to San Diego, is moderate. However, the Southern California historical tsunami record is very short and likely underestimates the true hazard. Given that the recurrence interval for many of the faults in the world is in the order of hundreds to thousands of years, it is possible that Southern California has been impacted by teletsunamis for which we have no record. Also significant is the fact that there are several active faults immediately offshore of the Southern California area, and any of these could generate a future earthquake that could have a tsunami associated with it. Finally, several submarine landslides and landslide-susceptible areas have been mapped offshore, within 2 to 8.7 miles (3.5 to 14 km) of the coastline (Field and Edwards, 1980; McCulloch, 1985; Clarke et al., 1985).

Synolakis et al. (1997) reviewed the McCarthy et al. (1993) study and other data, and concluded that not only do early, pre-1980 methods give tsunami runup results that are more than 50 percent lower than what more current inundation models predict, but that there is a need to model near-shore tsunami events. For the Orange County coastline particularly, near-shore tsunamis should be considered worst-case scenarios, as these have the potential to cause high runups that would impact the coastline with almost no warning. In their 2005 report on tsunami threats, the California Seismic Safety Commission indicates that teletsunamis and locally generated tsunamis pose a significant threat to life and property in California.

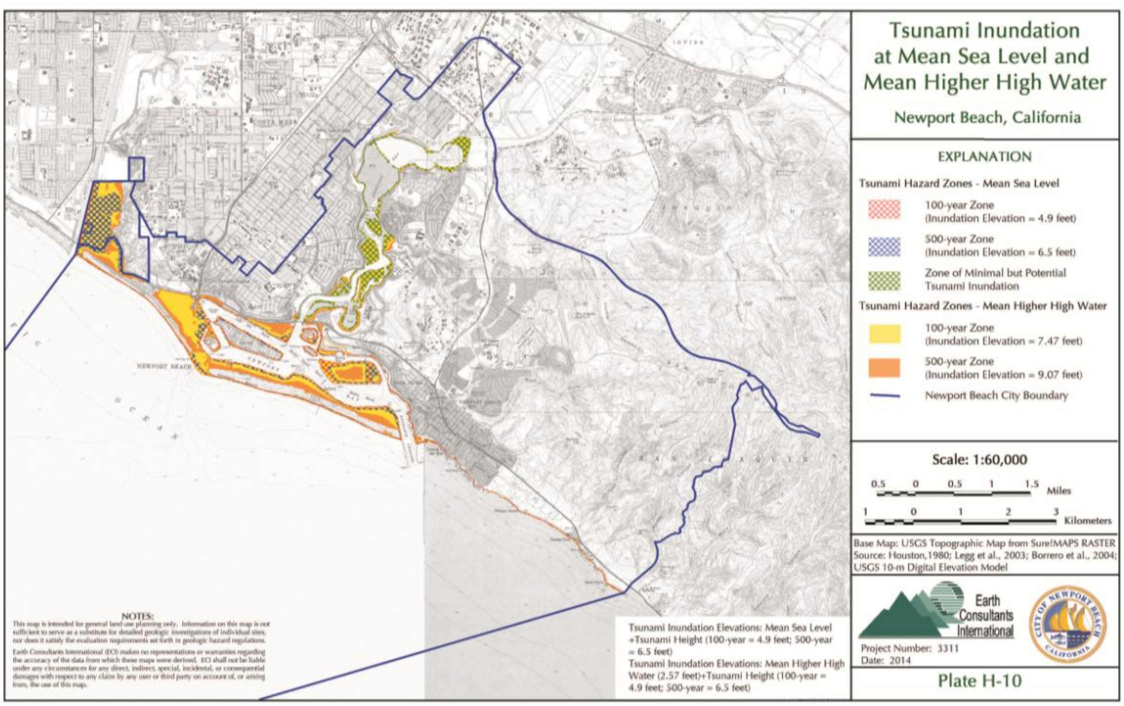
Having recognized the potential hazard, the next step was to quantify it so it can be managed appropriately. Although the record of tsunamis impacting the California coast goes back only to 1812, there are sufficient data from which mathematical models of tsunami runup for the California coast can be developed. Houston and Garcia looked at the worldwide, long-term historical data, and combined it with mathematical models to estimate the predicted, distantly generated, 100-year and 500-year probability tsunami runup elevations for the west coast of the United States (Garcia and Houston, 1975; Houston and Garcia, 1974; 1978; Houston et al., 1975; Houston, 1980; as presented in McCulloch, 1985).

These predictions are used by the Federal Insurance Administration to calculate flood-insurance rates, thus the 100- and 500-year terms risk levels selected, similar to storm flooding. As with flooding, the 100- and 500-year designations do not mean that these tsunamis occur only once every 100 or 500 years, but rather, these terms describe the tsunami that has a 1 percent (for 100-year) or 0.2 percent (for 500-year) probability of occurring in any one year. The 100-year and 500-year tsunami runup elevations are thought to have the potential to cause significant damage to harbors and upland areas, while smaller 50-year events may cause damage to boats and harbor facilities, but the onshore damage will be restricted to very low-lying areas. Smaller than 50-year tsunamis may still cause minor damage to unprotected boats and harbor facilities (CDMG, 1976). The 100-year (R_{100}) and 500-year (R_{500}) teletsunami runup heights predicted for Newport Beach are 1.49 and 1.98 m (4.9 and 6.5 ft), respectively (Houston, 1980, based on Figure 208 in McCulloch, 1985).

The predicted tsunami runup heights by Houston (1980) were used to prepare maps showing tsunami inundation zones for Newport Beach that were included in the City's 2006 Safety Element of the General Plan and the City's 2008 Disaster Mitigation Plan (see Map 7-7 below). For various reasons, these values are to be used only as a guide to quantify the risk of distantly generated tsunamis on the California coastline. Houston (1980) did not have the technology available to quantify the effect that estuaries, the offshore zone where water is 16 to 33 feet (5 to 10 meters) deep, and the shoreline have on tsunami runup (C. Synolakis, personal communication, 2002). Furthermore, Houston's (1980) predicted heights were based on mean sea level elevation data, and thus do not show the maximum credible heights that are possible if a tsunami coincides with peak high tide, or with storm-induced high water. To account for this, several scenarios were prepared as part of the Safety Element of the General Plan for Newport Beach to show the estimated inundation areas expected in the City under different sea level conditions. These scenarios are simple, linear, first-order assessments of inundation of all land areas at an elevation equal to or below the elevation of the water column calculated for each scenario, without taking into consideration the shallow bathymetry and near-shore topography, which are known to have a significant impact on tsunami inundation.

A tsunami inundation map assuming that the sea level at the time of impact is at mean sea level and mean higher high water is shown in Map 7-7, below. Mean sea level **(**MSL) is defined as the average height of the ocean surface for all tide stages, measured over a 19-year period based on hourly height observations made on an open coast, or in adjacent waters having free access to the sea (Bates and Jackson, 1987). Mean sea level is adopted as the *datum plane* or *zero elevation* for a local or regional area. In March 2005, the City of Newport Beach adopted the North American Vertical Datum (NAVD) as the official datum plane of the City (City Ordinance No. 2005-4; Code Amendment 2005-047). All other water levels and topographic elevation points in the City are now measured relative to this datum. Prior to 2005, the City used the NGVD29 (National Geodetic Vertical Datum) system, a system that has fallen in disuse; the NAVD88 system in this area is on average 2.37 feet higher than the NGVD29 datum.

Map 7-7: Tsunami Inundation Map at Mean Sea Level and Mean Higher High Water Level (for a larger version of this map, refer to Plate H-10)



Please note that Map 7-7, which shows the predicted tsunami inundation areas for Newport Beach for the predicted 100- and 500-year tsunami runup heights (4.9 and 6.5 feet, respectively) superimposed on mean sea level and mean higher high water, are based on the NGVD29 datum. This map shows that if a tsunami is generated by an earthquake on one of the faults offshore the

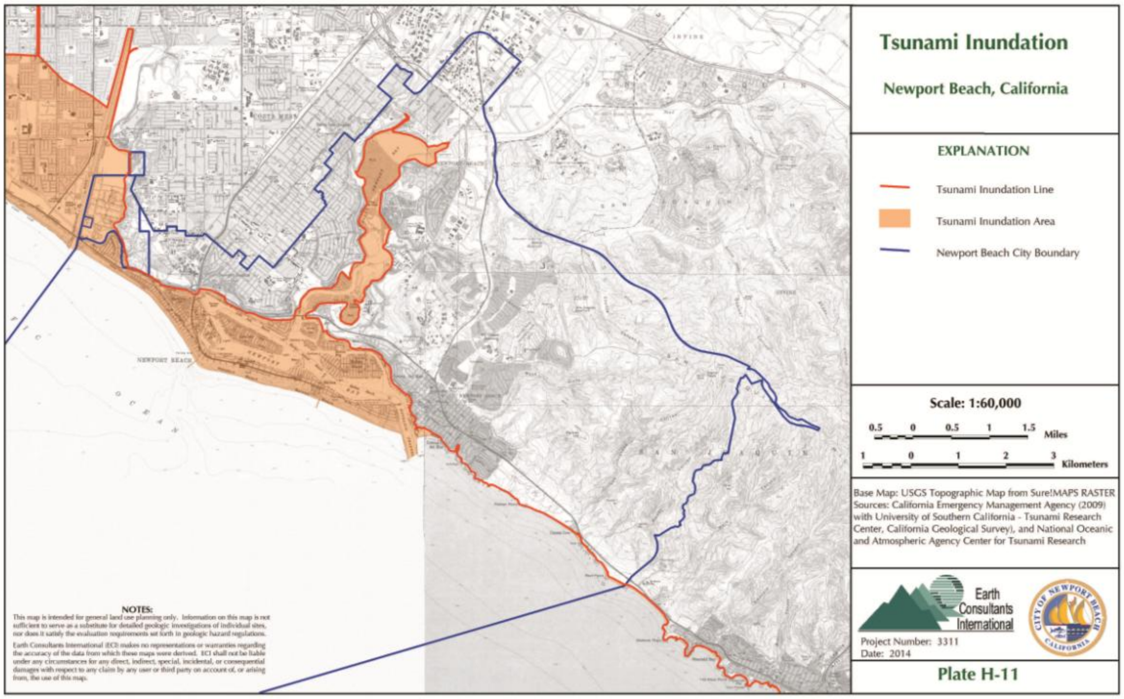
Southern California coast, Newport Bay and most of the harbor have the potential of being inundated. Specifically, if the tsunami occurs during mean sea level, low-lying areas adjacent to the coast, properties near the water in Balboa Island, and Lido and Linda Isles, and all moored boats are expected to be impacted by the wave runup. If the tsunami hits during mean higher high water, most of the harbor area, including the inland, developed portion of the Balboa Peninsula, Balboa Island, and Upper Newport Bay could be inundated. Near-shore sections of Lido Isle and Linda Isle would also be impacted, and Lido Isle would be cut off from the mainland due to flooding along Newport Boulevard and 32nd Street. Mean High Water (MHW) is referred to as the "average height of all the high waters recorded at a given place over a 19-year period or computed equivalent period" (Bates and Jackson, 1987). The MHW can often be recognized by the upper line of debris on the beach. For Newport Beach, the calculated MHW is 0.78 m (2.57 ft; using the NGVD29 datum). The water level in Upper Newport Bay is anticipated to rise some, but the data available are insufficient to quantify the hazard in this area.

Since the tsunami inundation map described above was prepared, a group of tsunami modelers, geologic hazard specialists and emergency planners have developed maximum tsunami inundation maps for a large section of coastal California. The maps were created using the Method of Splitting Tsunami (MOST) modeling program (Titov and Gonzalez, 1997; Titov and Synolakis, 1998) by researchers at the Tsunami Research Center at the University of Southern California. Draft inundation maps prepared using this software were checked in the field with emergency planners from local jurisdictions, and post-field draft tsunami maps were then sent to the local lead agencies for review and comments. Once the recommended changes were considered and implemented, as appropriate, the final inundation maps were sent to the local lead agencies and were also posted in state tsunami program websites. The final maps are available from the California Geological Survey website, via a map file (kmz format) that can be read in Google Maps (http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/Pages/Index.aspx). These maps show the worst-case scenario based on an analysis of both local and distant tsunami sources and their impact on 33 coastal populated areas along the California coastline (Wilson et al., 2008). The tsunami inundation map for the Newport Beach quadrangle issued by the California Emergency Management Agency in cooperation with the University of Southern California Center for Tsunami Research, and the California Geological Survey, dates from March 15, 2009 (see Map 7-8). Sources used to develop this map include surface-rupturing earthquakes on the Catalina and Newport-Inglewood faults, submarine landslides off the Palos Verdes peninsula, and earthquakes like the 1960 Chile, 1964 Alaska, and in the Central Aleutians and North Chile subduction zones.

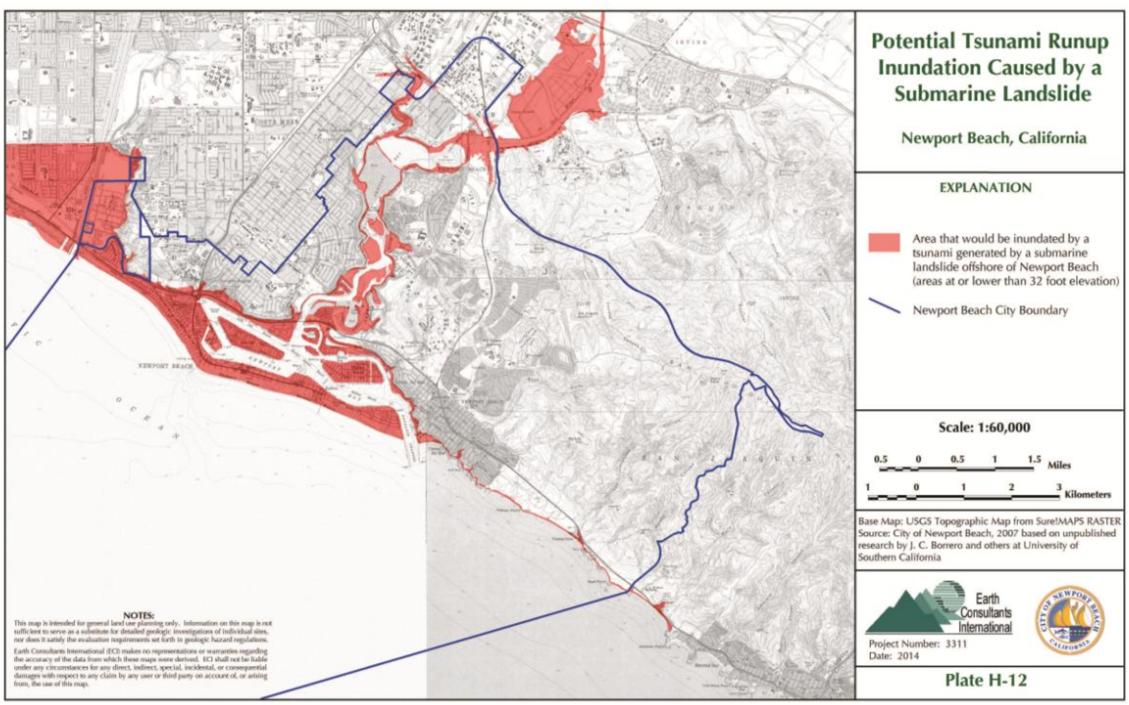
The local sources described in the paragraph above are based on collaborative work between the USC research group and Dr. Mark Legg (Legg et al., 2003), who conducted an evaluation of the tsunami risk to coastal Southern California cities by modeling potential locally generated tsunamis caused by either offshore faulting (such as on the Catalina fault) or submarine landsliding. These assessments were made after their initial models indicated that locally generated tsunamis are a concern: earthquakes in the Santa Barbara Channel could generate a 2 m (6.6 ft) runup, while an earthquake-induced submarine landslide could generate a runup of as much as 20 m (66 ft) (Borrero et al., 2001). An earthquake on the San Clemente fault could generate run-up of between 1.5 and 2.0 meters (4.9 and 6.6 ft) in the Newport Beach area.

The concern with these local tsunami sources is that travel time between the local source of an earthquake and the arrival of the first waves along the coastline is estimated at 10 to 20 minutes, which does not allow much time for broadcasting of warnings and evacuation, but the strong shaking should. Several wave crests are likely, with the second and third waves likely to be higher than the first. If some of these wave crests strike the coastline during high tide, there is a potential for even more severe destruction (Legg et al., 2003).

Map 7-8: Tsunami Inundation Map for the Newport Beach Area Prepared and Issued in 2009 by the California Emergency Management Agency, Earthquake and Tsunami Program (refer to text for additional information; for larger version of this map, refer to Plate H-11 in Appendix H)



Map 7-9: Tsunami Runup Inundation Caused by a Potential Submarine Landslide
(for a larger version of this map, refer to Plate H-12 in Appendix H)



If a locally generated tsunami hits during high tide, an even larger portion of Newport Beach would be inundated. The impacted area would be similar to the area shown on Map 7-9. Map 7-9 shows the area likely to be inundated if a submarine landslide-generated tsunami occurs. Dr. Jose Borrero and his colleagues at the University of Southern California have estimated that a potential submarine landslide anywhere along the steep Southern California offshore escarpment could generate a tsunami with a 30 to 33 foot runup in Orange County. The City of Newport Beach opted to use a 32-foot runup elevation for their tsunami evacuation plan; this is the map presented in Map 7-9 and Plate H-11. The low-lying coastal areas of Orange County, including most of West Newport and the low areas surrounding the bay, are expected to be impacted by such a tsunami. Additional modeling based on more detailed bathymetric data is needed to better quantify the potential impact to the region, but the preliminary analyses indicate that near-source tsunamis pose a low probability but high risk to the extensively developed coastal areas of Southern California.

Inundation Due to Catastrophic Failure of Water Storage Structures

Loss of life and damage to structures, roads, and utilities can result if a dam fails and the water impounded behind it is released suddenly. Several dams in the Newport Beach area and upstream from Newport Beach have the potential to inundate sections of the City if they fail catastrophically while their reservoirs are storing water.

Three dams located in the Newport Beach area fall under State jurisdiction: Big Canyon Reservoir, San Joaquin Reservoir, and Harbor View Dam. These dams are owned by the City of Newport Beach, the Irvine Water Company, and the County of Orange, respectively. They retain small reservoirs in the San Joaquin Hills. In addition, Bonita Canyon Dam, also located in Newport Beach, used to be under State Jurisdiction, but has been modified so that its crest elevation is now lower than it used to be, and below the threshold established by the State. All four dams have the potential to inundate localized sections of the City, but inundation maps showing the potential extent of this flooding are only available for Big Canyon, San Joaquin and Harbor View reservoirs (see Map 7-10). Portions of Newport Beach are also threatened by flooding from larger structures located inland from the City, but whose drainages flow through or adjacent to Newport Beach. These structures include Prado Dam, Santiago Creek Reservoir, and Villa Park Reservoir. If Seven Oaks Dam fails, the flow reportedly will be contained by Prado Dam Reservoir, and is therefore not expected to impact the City of Newport Beach. Each of these reservoirs is described further below.

Prado Dam reservoir straddles the boundary between San Bernardino and Riverside counties and is located approximately 2 miles west of the city of Corona. This dam is an earth-filled, concrete-capped structure that was completed in April 1941. Modifications to the dam that include raising the embankment and constructing new outlet works began in 2008, and were mostly completed by 2010. With the raising of the embankment the reservoir now covers an area of 10,256 acres (http://ocflood.com/sarp/prado; www.spl.usace.army.mil/), and has a new impoundment capacity of 362,000 acre-feet (http://ocflood.com/sarp/prado). Summary information on this dam and its reservoir are provided in Table 7-7, and for a picture of the dam, see Figure 7-14.

Flood maps that show the downstream inundation limits should this dam fail catastrophically using the new dam levels are not available and are not expected to be available before the year 2020 (http://www.spl.usace.army.mil/Media/FactSheets/tabid/1321/Article/477349/dam-safety-program.
aspx). Until then, Map 7-10 shows the projected southwestern limits of the flood inundation path near Newport Beach based on the original dam dimensions (purple zones). If this dam fails catastrophically while full of water, the inundation area will impact much of Orange County including Newport Beach, with flood waters reaching the City approximately 21.5 hours after dam failure (USACE, 1985). Flooding is expected to impact West Newport along the Santa Ana Delhi Channel

and San Diego Creek, and in Newport Bay as far south as the Coast Highway. Prior to the new modifications, it was estimated that more than 110,000 acres of residential, commercial, and agricultural land will be flooded. By the time floodwaters reach the ocean most areas from Long Beach to Newport Bay are likely to be inundated. Given the higher lake levels possible since the dam crest was raised, this map shows minimum inundation limits. Map 7-10 should be replaced if and when the U.S. Army Corps of Engineers release the new inundation maps for Prado Dam.

Table 7-7: Characteristics of Prado Dam and Reservoir

Name:	Prado
Department of Water Resources No.	9000-022
National ID No.	CA10022
Owner:	U.S. Army Corps of Engineers
Year Completed:	1941; enlarged in 2008-2010
Latitude; Longitude:	33.89°; -117.643°
Crest Elevation:	594.4 feet (new, post-2010 dimensions)
Stream:	Santa Ana River
Dam Type:	Earth-filled
Parapet Type:	N/A
Crest Length:	2,280 feet (prior to 2010)
Crest Width:	30 feet (prior to 2010, new width unknown)
Total Freeboard:	23 feet (prior to 2010)
Spillway crest elevation:	563 feet (new, post-2010 dimensions)
Material Volume:	3,389,000 cubic yards (prior to 2010)
Impoundment Capacity:	362,000 acre-feet (217,000 prior to 2010)
Drainage Area:	2,255 sq mi
Reservoir Area:	10,256 acres (new, post-2010 dimensions)

Map 7-10: Dam Failure Inundation Map
(a larger version of this map is available in Appendix H, as Plate H-9)

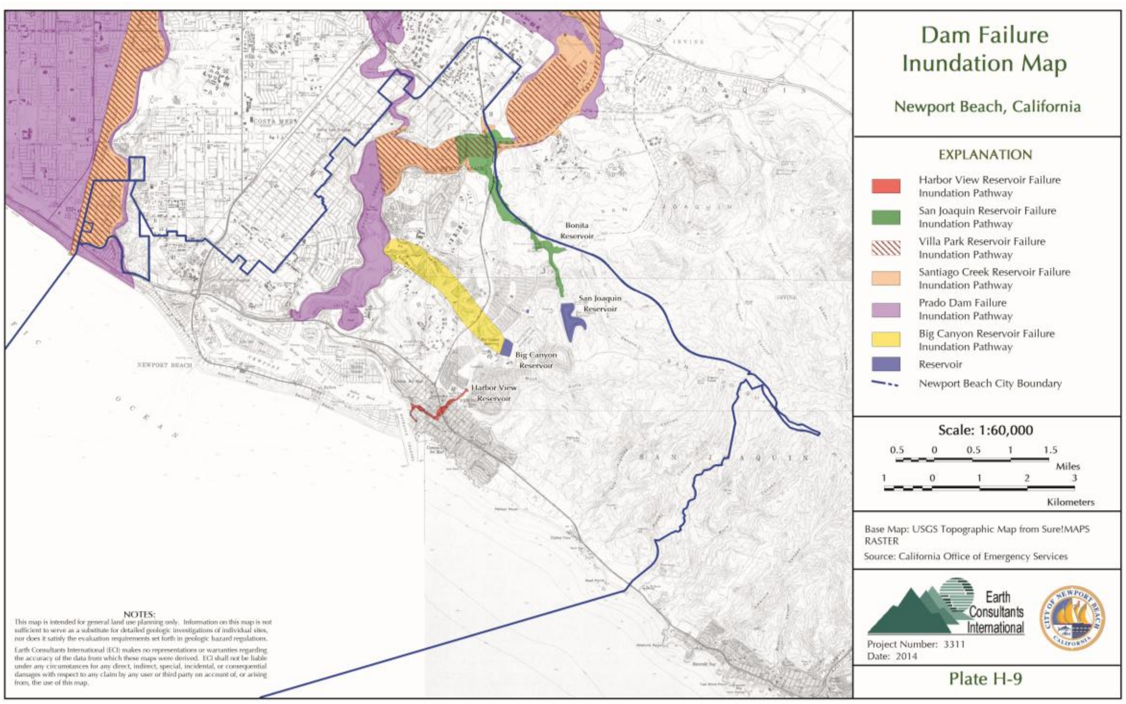


Figure 7-14: View to the North of Prado Dam (to the right-center), **and Prado Dam Reservoir** (in the Background)

(Photograph from www.spl.usace.army.mil/resreg/images/pradodam.jpg)

Prado Dam received a Dam Safety Action Class III (DSAC III) rating in December 2009 based on a Screening Portfolio Risk Analysis (SPRA) conducted in July 2009. A DSAC III rating is given to dams that are considered to be significantly inadequate, or when their probability of failure resulting in a combination of life, economic or environmental consequences is considered moderate to high. Prado Dam received a DSAC III rating because it has the potential for embankment seepage and piping, and because overtopping of the dam in the vicinity of the existing spillway are considered a possibility. Interim Risk Reduction Measures (IRRMs) that the Army Corps of Engineers have implemented include: 1) when the water level impounded behind the dam reaches an elevation of 528 feet, the dam shall be inspected by a Special Dam Inspection Team, and 2) the Emergency Action Plan needs to be updated annually.

Figure 7-15: View Upstream of Seven Oaks Dam

(Photograph from www.co.san-bernardino.ca.us/flood/dampage.htm)

Seven Oaks Dam is an earth and rock-filled dam (see Figure 7-15) located in San Bernardino County, approximately 8 miles northeast of the city of Redlands. Construction of the dam was completed in November 1999. Seven Oaks Dam was designed to protect San Bernardino County from flooding and to work in conjunction with Prado dam, which is located approximately 41 miles downstream, to provide 350-year flood protection. The reservoir has a capacity of 145,600 acre-feet and covers an area of 780 acres when full. Summary information on this dam and its reservoir are provided in Table 7-8. It is anticipated that the floodwaters resulting from a Seven Oaks dam failure would be contained by Prado dam and therefore would not pose a threat to Newport Beach.

Table 7-8: Characteristics of Seven Oaks Dam and Reservoir

Name:	Seven Oaks
Department of Water Resources No.	87-016
National ID No.	CA01530
Owners and Operators:	Orange County Flood Control District, San Bernardino County Flood Control District, and Riverside County Flood Control and Water Conservation District (built by the U.S. Army Corps of Engineers)
Year Completed:	1999
Latitude; Longitude:	34.1173°; -117.10°
Crest Elevation:	2610 feet
Stream:	Santa Ana River
Dam Type:	Rock
Parapet Type:	No Wall
Crest Length:	2,980 feet
Crest Width:	40 feet
Total Freeboard:	30 feet
Height:	550 feet
Material Volume:	38,000,000 cubic yards
Storage Capacity:	145,600 acre-feet
Drainage Area:	177 sq mi
Reservoir Area:	780 acres

Santiago Creek Reservoir dam is an earth-filled structure that has a storage capacity of 25,000 acre-feet. It is located 7 miles east of the city of Orange. Santiago Creek is the largest tributary to the lower Santa Ana River with a drainage basin area greater than 100 square miles. Summary information on this dam and its reservoir is provided in Table 7-9. The flood inundation path through Newport Beach, should the dam fail, is shown in orange shading on Map 7-10 and Plate H-9.

Villa Park Reservoir dam is located 3.5 miles downstream of Santiago Creek Reservoir, across Santiago Creek, and 4 miles east of the City of Orange downtown. Villa Park dam is an earth-filled structure that has a storage capacity of 15,600 acre-feet. Summary information on this dam and its reservoir is provided in Table 7-10. The flood inundation path through Newport Beach, should the dam fail, is shown on Map 7-10 with a stippled red pattern, within the drainage areas for the Santa Ana River and San Diego Creek.

Table 7-9: Characteristics of the Santiago Creek Dam and Reservoir

Name:	Santiago Creek
Department of Water Resources No.	75-000
National ID No.	CA00298
Owner:	Serrano Irrigation District & Irvine Ranch Water District
Year Completed:	1933
Latitude; Longitude:	33.7863°; -117.723°
Crest Elevation:	810 feet
Stream:	Santiago Creek
Dam Type:	Earth-filled
Parapet Type:	No wall
Crest Length:	1,425 feet
Crest Width:	10 feet
Total Freeboard:	16 feet
Height:	136 feet
Material Volume:	789,000 cubic yards
Storage Capacity:	25,000 acre-feet
Drainage Area:	63.1 sq mi
Reservoir Area:	650 acres

Table 7-10: Characteristics of the Villa Park Dam and Reservoir

Name:	Villa Park
Department of Water Resources No.	1012-000
National ID No.	CA00829
Owner:	County of Orange
Year Completed:	1963
Latitude; Longitude:	33.8163°; -117.765°
Crest Elevation:	584.3 feet
Stream:	Santiago Creek
Dam Type:	Earth-filled
Parapet Type:	No wall
Crest Length:	119 feet
Crest Width:	20 feet
Total Freeboard:	18.3 feet
Height:	118 feet
Material Volume:	835,000 cubic yards
Storage Capacity:	15,600 acre-feet
Drainage Area:	83.4 sq mi
Reservoir Area:	480 acres

Harbor View Dam is a small earth-filled structure; its reservoir is usually empty and used primarily for flood control. It is located approximately 700 feet upstream of Harbor View School, in Newport Beach, and has a storage capacity of 28 acre-feet. Summary information on this dam and its reservoir is provided in Table 7-11. The flood inundation path through Newport Beach, should the dam fail while full, is shown in red on Map 7-10.

Table 7-11: Characteristics of the Harbor View Dam and Reservoir

Name:	Harbor View
Department of Water Resources No.	1012-002
National ID No.	CA00830
Owner:	County of Orange
Year Completed:	1964
Latitude; Longitude:	33.6043°; -117.865°
Crest Elevation:	190 feet
Stream:	Jasmine Gulch
Dam Type:	Earth-filled
Parapet Type:	No wall
Crest Length:	330 feet
Crest Width:	60 feet
Total Freeboard:	20 feet
Height:	65 feet
Material Volume:	63,000 cubic yards
Storage Capacity:	28 acre-feet
Drainage Area:	0.39 sq mi
Reservoir Area:	3 acres

San Joaquin Dam is an earth-filled structure with a clay lining and asphalt surfacing. It is located in Newport Beach approximately half a mile east of Spyglass Hill Road. Its reservoir has a storage capacity of 3,036 acre-feet and an area of 50 acres; water in the reservoir is used for seasonal reclaimed water purposes. The reservoir maximizes storage during the winter months, with water withdrawn during the summer months, to provide landscape irrigation water for the cities of Irvine, and portions of Newport Beach, with an emphasis on Newport Coast. Summary information on this dam and its reservoir is provided in Table 7-12; Figure 7-16 shows a photograph of the dam. The flood inundation path through Newport Beach, should the dam fail, is shown in green on Map 7-10 (and Plate H-9 in Appendix H)..

Table 7-12: Characteristics of the San Joaquin Dam and Reservoir

Name:	San Joaquin
Department of Water Resources No.	1029-000
National ID No.	CA00853
Owner:	Irvine Ranch Water District
Year Completed:	1966
Latitude; Longitude:	33.6202°; -117.842°
Crest Elevation:	476 feet
Stream:	Tributary to Bonita Creek
Dam Type:	Earth-filled
Parapet Type:	No wall
Crest Length:	873 feet
Crest Width:	30 feet
Total Freeboard:	5.5 feet
Height:	224 feet
Material Volume:	1,911,000 cubic yards
Storage Capacity:	3,036 acre-feet
Drainage Area:	0.35 sq mi
Reservoir Area:	50 acres

Figure 7-16: View of San Joaquin Dam (at the top) and Reservoir
(North is to the top; photo courtesy of the City of Newport Beach; December 2007)

Bonita Dam is an earth-filled structure located approximately one mile downstream (north) of San Joaquin Dam on Bonita Creek. Although (pre-2011) it has the same reservoir area (50 acres) as San Joaquin Dam, it has a storage capacity of only 323 acre-feet. Summary information on this dam and its reservoir is provided in Table 7-13; please note that this information predates the modifications made to the dam that now exclude it from the State listing of dams. Modifications that reportedly were made to this structure include the construction of an earthen buttress on the existing dam face, the rehabilitation of the existing spillway, building a new plunge pool at the bottom of the rehabilitated spillway, increasing the spillway capacity, and constructing a permanent access road. These changes have increased the seismic stability of the dam (http://www.rbf.com/projects/projects.asp?id=136). The flood inundation path through Newport Beach, should the dam fail, is not available.

Big Canyon Dam is an earth-filled, asphalt-lined structure that provides fire protection and drinking water to residents of Newport Beach. The reservoir impounds sufficient water to supply the City for seven days. It has a storage capacity of 600 acre-feet and is located in a residential area near Pacific View Memorial Park and Lincoln School. The reservoir is covered with a polypropylene tarp that is meant to protect the water from debris. Failure of this structure would reportedly produce a flood wave between 300 and 1,000 feet wide on its course to Newport Bay. The limits of the inundation area, should this facility fail catastrophically, are shown in yellow on Map 7-10. However, failure is thought unlikely because a seismic analysis of the Big Canyon Dam shows that it can withstand a maximum magnitude earthquake (M = 7) on the Newport-Inglewood fault. This earthquake is anticipated to produce very strong ground motions, with a peak horizontal ground acceleration of 0.91g, in the area of the reservoir (URS, 2001). Summary information on this dam and its reservoir is provided in Table 7-14; a photograph of the reservoir is shown in Figure 7-17.

Table 7-13: Characteristics of the Bonita Dam and Reservoir

Name:	Bonita Canyon
Department of Water Resources No.	793-004
National ID No.	CA00747
Owner:	The Irvine Company
Year Completed:	1938
Latitude; Longitude:	33.632°; -117.848°
Crest Elevation:	151 feet (prior to 2011)
Stream:	Bonita Creek
Dam Type:	Earth-filled
Type:	No wall
Crest Length:	331 feet
Crest Width:	20 feet
Total Freeboard:	8 feet (prior to 2011)
Height:	51 feet (prior to 2011)
Material Volume:	43,000 cubic yards
Storage Capacity:	323 acre-feet
Drainage Area:	4.2 sq mi
Reservoir Area:	50 acres

There are currently no above-ground water tanks in Newport Beach, although at least one 3.4 million gallon reservoir has been proposed in the Irvine Coast Development along Pelican Hill Road (The Irvine Company, 1988). Any above-ground storage tanks proposed and built in the City need to be designed to the most current seismic design standards for liquid storage tanks. Any future tanks proposed and built in the City would be vulnerable to damage as a result of ground deformation, strong ground shaking, and locally, to surface fault rupture. Because the entire City of Newport Beach is susceptible to strong seismic ground motion, any future water tanks should incorporate earthquake resistant designs, including flexible pipe joints.

Table 7-14: Characteristics of the Big Canyon Dam and Reservoir

Name:	Big Canyon
Department of Water Resources No.	1058-000
National ID No.	CA00891
Owner:	City of Newport Beach
Year Completed:	1959
Latitude; Longitude:	33.6121°; -117.857°
Crest Elevation:	308 feet
Stream:	Tributary of Big Canyon Creek
Dam Type:	Earth-filled
Parapet Type:	No wall
Crest Length:	3,824 feet
Crest Width:	20 feet
Total Freeboard:	5.5 feet
Height:	65 feet
Material Volume:	508,000 cubic yards
Storage Capacity:	600 acre-feet
Drainage Area:	0.04 sq mi
Reservoir Area:	22 acres

Figure 7-17: View of Big Canyon Dam and Reservoir
(North to the top; photo courtesy of City of Newport Beach; December 2007)

Inundation Due to Hurricanes and Tropical Storms

Tropical cyclones are great masses of warm, humid, rotating air that occur between 10° and 25° latitude on both sides of the equator. Large tropical cyclones, those with wind speeds greater than 119 km/hr (74 mi/hr), are referred to as hurricanes in the North Atlantic and the Eastern Pacific Oceans (Garrison, 2002). Hurricane season, the time of the year when most hurricanes are generated, runs from June to the end of November, with peak activity from mid-August to late October (http://hurricanes.noaa.gov). Most hurricanes that affect the Southern California region are generated in the southern portion of the Gulf of California. Although only one hurricane-strength storm has been reported in Southern California – the 1858 hurricane in San Diego mentioned in Table 10-4 – many tropical storms, those with wind speeds less than 119 km/hr (74 mi/hr), have caused damage to southern California in the past.

The main hazards associated with tropical cyclones, and especially hurricanes, are storm surge, high winds, heavy rain, flooding, and tornadoes. The greatest potential for loss of life related to a hurricane for coastal communities is from the storm surge, which if combined with normal tides can increase the mean water level by 15 ft (4.6 m) or more (http://hurricanes.noaa.gov). Waves that high would breach or extend over the Balboa Peninsula and impact all development adjacent to the coastline, including areas along Corona del Mar and Crystal Cove. Even higher waves can be expected if the storm surge occurs during high tide.

Tropical storm-force winds and waves are strong enough to be dangerous to those caught in them. Water weighs approximately 1,700 pounds per cubic yard; therefore, extended pounding by frequent waves can demolish any structure not designed to withstand such forces. Hurricane and tropical-force winds can easily destroy poorly constructed buildings and mobile homes (see Section 10 – Windstorms). Debris such as signs, roofing material, and small items left outside become flying missiles in hurricanes. Extensive damage to trees, towers, underground utility lines (from uprooted trees), and fallen poles cause considerable disruption. High-rise buildings are also vulnerable to hurricane-force winds, particularly the upper floors, since wind speed tends to increase with height. It is not uncommon for high-rise buildings to suffer a great deal of damage, typically due to windows being blown out. Consequently, the areas around these buildings can be very dangerous.

Widespread rainfall of 6 to 12 inches (15 to 30 cm) is common during the landfall of a hurricane or tropical storm, frequently producing deadly and destructive floods. Such floods have been the primary cause of tropical cyclone-related fatalities over the past 30 years worldwide (http://hurricanes.noaa.gov). Hurricanes can also produce tornadoes that add to the storm's destructive power. In general, tornadoes associated with hurricanes are less intense than those that occur in the Central Plains area of the United States, but can still be locally devastating (see Section 10 for additional, more in-depth discussion on tornadoes in the Southern California area). Interestingly, some hurricanes produce no tornadoes, while others produce multiple ones. Either way, the effects of tornadoes, added to the larger area of hurricane-force winds, can produce substantial damage (http://hurricanes.noaa.gov).

Although only one hurricane-strength storm has reportedly hit the Southern California area in historical times, damage from wave swell and weather related to hurricanes that develop in the Baja California area has been reported in the region. Swells caused by offshore storms and hurricanes in Baja California can cause localized flooding and erosion of the Southern California coastline. Furthermore, historically, only one tropical-strength storm has made a landfall in Southern California: Near the end of September 1939, a tropical storm with sustained winds of 80.5 km/hr (50 mi/hr) came ashore at Long Beach. The storm generated five inches of rain in the Los Angeles basin on September 25th, and between 6 and 12 inches (15 and 30.5 cm) of rain in the surrounding mountains. In Newport Beach, this storm produced 30-foot high waves (as high as a three-story building) that tore away half of Newport Pier and destroyed most of Balboa Pier, damaged portions of the jetties, several homes and small vessels, and caused numerous drownings (P. Alford, personal communication, 2002). Other less severe but still significant storms that impacted the Southern California coastline occurred during 1927, 1938-1939, 1941, 1969, 1977-1978, 1983, 1988 (Kuhn and Sheppard, 1984; Walker et al., 1984; Pipkin et al., 1992), and even more recently in 1995, 1997-1998, and 2005. Many of these wet winters have been associated with El Niño events. More information about these storms is provided in Section 10 – Windstorms, and specifically, on Table 10-3.

In February 1994, an unusually strong westerly jet stream brought high winds and up to 3 inches of rainfall to Southern California. Serious flooding occurred in Newport Beach and Irvine. In Newport Beach, several schools flooded, whereas several landslides and mudslides occurred in various areas of southern Orange County and northern San Diego County.

Inundation Due to Sea Level Rise

Previous studies suggest that a 1 m (~39 in) rise in sea level would generally cause beaches to erode 200 to 400 m (650 to 1,300 ft) along the California coast (Wilcoxen, 1986). Given that the width of the beaches in Newport Beach varies between 15 and 190 m (50 and 600 ft), a sea level rise of as little as 15 cm (6 in) could have a negative impact on the low-lying areas around Newport Bay that are not protected by bulkheads and seawalls. Sea level rise would also cause increased sea-cliff retreat in the southern portion of the City where the beaches are narrow, and the surf pounds at the base of the bluffs, eroding away the soft bedrock that forms the cliffs.

How long would it take for sea level to rise 15 cm (6 in) in Newport Beach at the current rate? Although a long-term record of sea-level measurements is not available for the Newport Beach area, a 40-year record suggests that, if global warming is not exacerbated in the next few decades, a 6-inch rise could occur in about 70 years. However, the California Ocean Protection Council has adopted projections that suggest that by 2030, sea level along the California coast will have risen about 7 inches above the year 2000 levels. So, a sea level rise of 6 inches in Newport Beach could occur in as little as two decades. Projections specific to Newport Beach are difficult to quantify given that there is no local gauge and variability in sea level along the coastline is expected. Currently, the closest sea level gauges are located in San Diego and Los Angeles; historically these gauges have measured a lower rate of sea level rise than that measured in Newport Beach between 1955 and 1995, when there was a sea level gauge there. Using the San Diego and Los Angeles gauge records mentioned above, it could take anywhere between 70 and 180 years for sea level in Newport Beach to rise 6 inches, assuming that global warming is not exacerbated in the next decades. Obviously, local measurements of relative sea level change are necessary to better quantify these estimates and make more realistic predictions.

Vulnerability Assessment - Community Flood Issues

Vulnerability assessment is the second step of flood-hazard assessment. It combines the flood-prone areas identified previously with an inventory of the property within those areas. Understanding the population and property exposed to this hazard can assist in reducing risk and preventing loss from future events.

This assessment was conducted using the databases provided by HazUS, a regional multi-hazard loss estimation software developed by FEMA and the National Institute of Building Sciences. The primary purpose of HazUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates can be used by local, state, and regional officials to plan and stimulate efforts to reduce risks from multi hazards, and to prepare for emergency response and recovery. Additional information regarding HazUS, including its uses and limitations, is provided in Section 6 – Earthquakes. A modified HazUS analysis that looked at the number of structures within the FEMA-mapped 100- and 500-year flood zones was conducted for this study. The results of the analysis are presented below, in the Risk Analysis section.

Typically, vulnerability assessments of flooding hazards involve assessing the amount of property in the floodplain, as well as the type and value of structures on those properties. Input to the program can include FEMA flood inundation zones, or site-specific engineering studies of flood potential prepared by others rather than FEMA. Once that is done, a working estimate for potential flood losses can then be calculated. We used the FEMA maps available for Newport Beach to identify potential flooding areas, and to estimate the losses due to flooding. Please note, however, that these estimates are considered minima, as the Advisory Committee agreed that the results obtained from the HazUS analysis significantly under-represent the anticipated losses due to flooding in Newport Beach.

What is Susceptible to Damage During a Flood Event?

The largest impact that flood events have on communities is the loss of life and property. During certain years, property losses resulting from flood damage are extensive. Property loss from floods strikes both private and public property. Although there has been no significant flooding in Newport Beach since at least 1983, as described above, localized flooding does occur sporadically, as the February 1994, 1998 and 2005 storm records show.

The type of property damage caused by flood events depends on the depth and velocity of the floodwaters. Faster moving floodwaters can wash buildings off their foundations and sweep cars downstream. Pipelines, bridges, and other infrastructure can be damaged when high waters combine with flood debris. Extensive damage can be caused by basement flooding and landslide damage related to soil saturation from flood events. Most flood damage is caused by water saturating materials susceptible to loss (i.e., wood, insulation, wallboard, fabric, furnishings, floor coverings, and appliances). In many cases, flood damage to homes renders them unlivable.

Risk Analysis

Risk analysis is the third and most advanced phase of a hazard assessment. It builds upon the hazard identification and vulnerability assessment. A flood risk analysis for the City of Newport Beach should include two components: 1) the life and value of property that may incur losses from a flood event (defined through the vulnerability assessment); and 2) the number and type of flood events expected to occur over time. Within the broad components of a risk analysis, it is possible to predict the severity of damage from a range of events. Flow velocity models can assist in predicting the amount of damage expected from different magnitudes of flood events.

As mentioned above, the results presented here are based on the FEMA maps available for Newport Beach and vicinity. More specific, but time-consuming and therefore costly analyses can be made using data that is based on a hydrological analysis of landscape features. Changes in the landscape, often associated with human development, can alter the flow velocity and the severity of damage that can be expected from a flood event. Using GIS technology and flow velocity models, it is possible to map the damage that can be expected from flood events over time. It is also possible to estimate the effects of certain flood events on individual properties. These site-specific analyses were not conducted at this time, however, we did conduct limited HazUS flooding analyses for Newport Beach that consider both the 100- and 500-year flood events. The results of these analyses are presented in the following sections. For a detailed description of the HazUS software and methodology, please refer to Section 6.

General Building Stock Exposure and Potential Building-Related Losses

Hundreds to thousands of residential and commercial structures in Newport Beach are at risk of being impacted by flooding due to their geographic location within the floodplain. Table 7-15 shows the (HazUS-generated) number of structures located within the 100- and 500-year floodplains of the Santa Ana River and San Diego Creek. (Please note that the 500-year flood zone associated with the Santa Ana River is almost exactly the same as its 100-year flood zone, which is why the building exposure numbers for the Santa Ana River did not change).

Table 7-15: Building Exposure to 100- and 500-Year Floods by Stream Source

Flood Source	100-Year Floodplain	500-Year Floodplain*
Santa Ana River		
Residential	833	833
Commercial	27	27
Total Santa Ana River	860	860
San Diego Creek		
Residential	1,839	5,168
Commercial	82	418
Total San Diego Creek	1,921	5,586
Totals	2,781	6,446

* Count in this column includes the buildings in the 100-year flood zone

Between approximately 2,800 and 6,500 structures in Newport Beach are at risk of being impacted by storm flooding given their location in the floodplain. These figures do not include structures outside of the mapped flood zones that could still be impacted by street flooding, debris flows, and localized runoff draining adjacent slopes.

Building-related losses can be divided into two categories: direct building losses and business interruption losses. Direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. In 2005, the average flood claim in the United States was $83,282, in great part due to losses from Katrina, whereas in 2013, the average flood claim was $26,175 (http://www.iii.org/media/facts/statsbyissue/flood/). Using these two claim values as a guide, dollar losses associated with a 100-year flood in Newport Beach could amount to between $73 and $233 million. Losses associated with a low-probability 500-year flood could amount to between $170 million and $541 million in Newport Beach. These costs do not include the harder-to-estimate business interruption losses associated with the inability to operate a business because of the damage sustained during the flood. This includes loss of income for business owners, and loss of wages for employees of facilities impacted by the flood. Business interruption losses also include temporary living expenses and relocation expenses for those people displaced from their homes because of the flood.

Statewide, the 1996 floods destroyed 156 housing units. Of those units, 61 percent were mobile homes and trailers. Many older manufactured home parks are located in floodplain or low-lying areas. **Manufactured homes** have a lower level of structural stability than stick-built homes, and must be anchored to provide additional structural stability during flood events (and for earthquake preparedness, also). Because of confusion in the late 1980s resulting from multiple changes in NFIP regulations, there are some communities that do not actively enforce anchoring requirements. The flood analysis conducted for this study indicates that there are two mobile home parks in the City located within the 100-year floodplain of the Santa Ana River. Therefore, during a major storm, several of the manufactured homes in the City of Newport Beach may be damaged by flooding.

Shelter Requirements

Given the number of residential structures located within the 100- and 500-year flood zones, a significant storm-induced flood has the potential to displace residents from their homes. These individuals may require accommodation in temporary public shelters. Using an average of 2.25 people per housing unit, and assuming that the residents in 70 percent of the housing units in the 100-year flood zone need to evacuate their homes temporarily during and immediately following the storm resolves in more than 4,000 people displaced. A similar analysis for housing units within the 500-year flood zone, and assuming that 50 percent of those residents would be displaced resolves into more than 6,750 people needing short-term shelter. Many are likely to find shelter with family and friends that live outside the flood zone, but the City may have to provide temporary shelter for several hundreds to a few thousand people if these low-probability but not unlikely flood events happen. Similar numbers of displaced individuals in need of short- to long-term shelter are estimated if the Newport Beach area is impacted by a tsunami generated by a nearby source, whether as a result of an earthquake on an offshore fault, or movement of a submarine landslide.

Expected Damage to Essential Facilities

Essential facilities include hospitals, fire stations, police stations, and schools. Several of the educational and government facilities in the City are expected to be at least slightly damaged as a result of flooding given their location in the flood zones. Specifically, Fire Station No. 4 is located within the 100-year flood zone; whereas Fire Station No. 1, Fire Station No. 2 and Newport Beach

Elementary School are all located within the 500-year flood zone. Fire Stations No. 6 and No. 8, and Newport Coast Elementary School are located near the 100-year flood zone, and, in the event of flooding, access to and from these facilities could be difficult. Similarly, several of the essential facilities in the southern and southwestern portions of the City, including Hoag Presbyterian Hospital, may be cut-off from the rest of the City by rising flood waters as a result of flooding. These observations are summarized in Table 7-16 below. For a pictorial analysis, compare Plate H-1 with maps 7-6, 7-8, 7-9, and 7-10. Given that several local schools reported flood damage as a result of the February 6th, 1998 storm that brought in about 3 inches of rainfall to the area, these loss estimations may under-represent the actual losses that could be expected to essential facilities in the City.

Table 7-16: Estimated Damage to Essential Facilities

Scenario Flood	Essential Facilities Likely to be Impacted by Flooding
100-Year	1 fire station; restricted access to and from 2 fire stations and at least one school
500-Year	3 fire stations, coast guard station and 1 school; access to hospital restricted from the south.
Tsunami Flooding	3 to 4 fire stations, 1 school, coast guard station; restricted access to hospital and one fire station
Dam Inundation	1 school; restricted access to City Hall and 1 fire station

Business/Industry

Storm-flooding events impact businesses by damaging property and by interrupting business. Flood events can cut off customer access to a business as well as close a business for repairs. Roof leaks can impact the contents; in extreme cases, leaks can cause damage to sensitive electrical equipment, with the potential to cause the affected business thousands of dollars in material losses and potential loss of revenue. A quick response to the needs of businesses affected by flood events can help a community maintain economic vitality in the face of flood damage. Responses to business damages can include funding to assist owners in elevating or relocating flood-prone business structures, and loans to make building improvements, such as new roofs. Given that there are several commercial structures within the 100- and 500-year flood zones, business-related losses associated with damage to the structures and their contents or inventory, and business interruption losses associated with lost wages, loss of income, and relocation and rental income losses can be anticipated.

Furthermore, flooding in Newport Beach, whether as a result of storms, tsunami or sea-level rise, has the potential to impact the entire Balboa Peninsula and islands within the Bay. Depending on the strength of the flooding event or cause, the beach and bay areas may experience erosion and loss of usable land. These areas draw thousands of weekend and seasonal visitors, and thus flooding damage can result in substantial economic losses for the segment of the community that depends on these tourist dollars.

Public Infrastructure

Publicly owned facilities are a key component of daily life for all citizens of Orange County, including Newport Beach residents. Damage to public water and sewer systems, transportation networks, flood control facilities, emergency facilities, and offices can hinder the ability of the government to deliver services. Government can take action to reduce risk to public infrastructure from flood events, as well as craft public policy that reduces risk to private property from flood events. History shows that extensive flooding of streets can be anticipated during a major storm, tsunami, or dam failure. Several essential service buildings, including fire stations and schools, are expected to be impacted by severe flooding associated with a 100-year or larger storm and other flooding sources, as indicated in Table 7-16 above. Sewer systems can be overwhelmed, forcing the release of partially treated sewage onto the bay and beach. The economic losses associated with the cleanup and repair of the flooded areas has not been quantified, but would be substantial.

During natural hazard events, or any type of emergency or disaster, dependable road connections are critical for providing emergency services. **Roads systems** in the City of Newport Beach are maintained by multiple jurisdictions. Federal, State, county, and city governments all have a stake in protecting roads from flood damage. Road networks often traverse floodplains and floodway areas. Transportation agencies responsible for road maintenance are typically aware of roads at risk from flooding. An extensive network of residential streets is expected to be impacted by storm flooding, in addition to sections of the Coast Highway, and to a lesser extent, the southern termination of Newport Boulevard, one of the most important arterials in the City.

Bridges are key points of concern during flood events because they are important links in road networks, river crossings, and they can be obstructions in watercourses, hindering the flow of water during flood events. Scour at highway bridges involves sediment-transport and erosion processes that cause streambed material to be removed from the bridge vicinity. Nationwide, several catastrophic collapses of highway and railroad bridges have occurred due to scouring and a subsequent loss of support of foundations. This has led to a nationwide inventory and evaluation of bridges (Richardson and others, 1993). As discussed in Section 6, there are several bridges in the Newport Beach area that are included in both the Federal Highway Administration's National Bridge Inventory (http://www.fhwa.dot.gov/bridge/nbi.cfm) and Caltran's Local Highway Bridge Program (http://www.dot.ca.gov/hq/LocalPrograms/hbrr99/hbrr99a.htm) list classified as either structurally deficient or functionally obsolete. The structurally deficient bridge, as of May 2, 2013 when the State issued the latest list of bridges, is the north-bound Jamboree Bridge over San Diego Creek. The functionally obsolete bridges in Newport Beach, per the State list, include the Via Lido bridge over West Lido Channel, the Marine Avenue bridge over Balboa Island Channel, the Park Avenue bridge over the Grand Canal, the 38th Street bridge over Rivo Alto, and the Park Avenue bridge over Waters Way. A bridge classified as structurally deficient either has a significant defect such that a speed or weight limit must be applied to the bridge to ensure its safety, or its approaches flood regularly. A functionally obsolete bridge is one whose design is not suitable for its current use, such as lack of safety shoulders or the inability to handle current traffic volume, speed, size, or weight.

Scour processes are generally classified into separate components, including pier scour, abutment scour, and contraction scour. ***Pier scour*** occurs when flow impinges against the upstream side of the pier, forcing the flow in a downward direction and causing scour of the streambed adjacent to the pier. ***Abutment scour*** happens when flow impinges against the abutment, causing the flow to change direction and mix with adjacent main-channel flow, resulting in scouring forces near the abutment toe. ***Contraction scour*** occurs when flood-plain flow is forced back through a narrower opening at the bridge, where an increase in velocity can produce scour. ***Total scour*** for a particular site is the combined effects from all three components. Scour can occur within the main channel, on the flood plain, or both. While different materials scour at different rates, the ultimate scour attained for different materials is similar and depends mainly on the duration of peak stream flow acting on the material (Lagasse and others, 1991).

The State of California participates in the bridge scour inventory and evaluation program and a state-designated inspector must inspect all state, county, and City bridges every two years. The inspections are rigorous, looking at everything from seismic capability to erosion and scour. The bridges in the City of Newport Beach are State, county, city, or privately owned. To date, we have not found any records to indicate that the bridges in the Newport Beach area have been evaluated for scour, but most have been either analyzed and/or retrofitted for seismic purposes, as discussed above. Based on aerial photographs, we conducted a generalized assessment that includes the identification and evaluation of bridges that may be susceptible to scour during storm events. We used the following assumption for this evaluation: Bridges that cross channelized streams have a lower risk of scour because the concrete lining of the bed and banks resists undermining and erosion of bridge piers, although in intense floods, the concrete lining can still fail. The lower reaches of the Santa Ana River have been entirely channelized; therefore damage due to bridge scour is low, but not completely unlikely, as evidenced by the damage caused by the 1980 floods. In contrast, all other streams in Newport Beach have earthen or riprap-covered beds and banks, which allow for bed erosion and potential loss of bridge support.

The banks of San Diego Creek are comprised of earthen material with rock riprap sections near bridge crossings. The Jamboree, Highway 73, and MacArthur bridge crossings could be threatened by scour during flooding of San Diego Creek. Similarly, Bonita Canyon has an engineered channel comprised of earthen banks and riprap bridge protection. The bridges at MacArthur Boulevard and Bison Avenue could also be at risk during storm flow. There are no significant bridges crossing Big Canyon, Buck Gully, Los Trancos Canyon, or Muddy Canyon, therefore bridge scour is not a concern along these streams. During a 100-year or larger flood event, the Coast Highway bridge crossing Newport Bay could be impacted by flooding.

Drainage problems are known to occur sporadically in some specific areas of Newport Beach. However, the City does not consider these drainage issues more than a nuisance, and has pumping equipment to deal with flooding in these low spots when necessary. However, a 100-year or larger flood in the area could overwhelm this system of pumps, leaving Balboa Island and other low-lying areas in the City, like the Balboa Peninsula, under water until the storm abates and the floodwaters retreat.

Inadequate maintenance of the **storm-water systems** can also contribute to the flood hazard in urban areas. Regular inspection of culverts and storm drains to remove debris that may obstruct the flow of water during storms should be conducted to reduce the potential impacts from flooding.

Sanitation and sewerage services in the City of Newport Beach are provided by the City, the Irvine Ranch Water District, and the Costa Mesa Sanitary District. Wastewater collected in these service areas is collected, treated and disposed by the Orange County Sanitation District. The Orange County Sanitation District currently has two operating facilities that treat wastewater from residential, commercial and industrial sources in 21 cities and three special districts in central and northwestern Orange County. These facilities are located in Huntington Beach and Fountain Valley. Two pump stations located in Newport Beach, the Rocky Point and Bitter Point sewer pump stations, were replaced in the last five years. The original stations had been built decades ago, and no longer met current safety, electrical and building codes, posing a risk of sewage spills if incoming flows exceeded the pump stations' capacities. Beginning in the summer of 2013, the Orange County Sanitation District started a five-year program to rehabilitate several of the trunk sewer lines that extend into Newport Beach, typically enlarging the size of the sewer lines to accommodate larger flows. The five projects in Newport Beach include the Balboa Trunk, the District 6 Trunk Sewer Relief Project, the Dover Drive Trunk, the Newport Force Main, and the Southwest Costa Mesa Trunk. As of the writing of this report, the Balboa Trunk construction had been completed, and the Dover Drive Trunk and Newport Force Main projects were in construction (http://www.ocsd.com/residents/newport-beach-program). For additional information regarding these projects, refer to the Orange County Sanitation District's website at www.ocsd.com.

High water levels and runoff associated with short-term flooding as a result of storms (and possibly even a tsunami) can cause significant damage to infrastructure such as sewer and solid waste systems. Increased runoff during a downpour can result in sewage overflows into rivers, bays and the ocean, resulting in short-term contamination of surface waters with pathogens. Although the sewer lines extending into Newport Beach have been or are being replaced to accommodate larger flows, the larger flows they are being designed and constructed for are the result of increased urbanization. During heavy rains these pipes have to carry both the increased waste water generated by urbanization, and the storm waters; the resulting volumes may exceed the capacity of the pipes, even the newer ones. If this happens, untreated sewage would be discharged into the bay and ocean, as discussed before.

Current Flood Mitigation Activities

Recent storms have shown that flood damages to structures and businesses can cost thousands if not millions of dollars to repair. In most cases, these loss estimates do not even include lost revenue due to business interruption. The City of Newport Beach works to address its localized flooding problems both proactively and as they arise. Flooding mitigation activities include current mitigation programs and activities that have been and are being implemented by developers, residents, and State and City agencies. Some of the programs currently being administered by the City and other local agencies that help to reduce the City's vulnerability to flooding hazards are briefly described below. For additional information regarding the mitigation measures that the City has already implemented and will be implementing to reduce its flood hazard, refer to Sections 5 and 4 respectively.

Studies Prior to Development

All proposed large development projects require a site-specific hydrological evaluation to determine the potential impacts that development of the project may have on the flooding potential of the site and adjacent properties downgradient. As discussed in Section 9 – Landslides, geotechnical studies are also required to evaluate the potential for debris flows to impact the project and adjacent sites. Development in the 100-year flood zones is generally prohibited. Flood insurance is required for all structures located in the FEMA flood zones. Flood insurance is also recommended for structures outside the flood zones, but in areas that could be impacted by debris flows or mudflows.

Acquisition and Protection of Open Space in the Floodplain

Current efforts to increase public open space in Southern California are been paired with the need to restore and preserve natural systems that provide wildlife habitat and help to mitigate flood events. Public parks and publicly owned open spaces can provide a buffer between flood hazards and private property. This has been done extensively in the eastern portion of Newport Beach, where approximately 90 percent of the Newport Coast development area has been and will be left undeveloped as open space.

Improvements to the Water District's Infrastructure

Water service in the City is provided by the City, the Irvine Ranch Water District and the Mesa Consolidated Water District. Each of these agencies maintains a capital improvement program. Many water districts in the region are in the process of replacing old cast iron pipes with more ductile iron pipes, which will be more resilient in disaster situations. Water districts in the region are committed to working together during a disaster to provide water to the area's residents as soon as possible in the event that the water distribution system fails locally.

Stormwater Systems and Surface Water Quality

Storm drainage systems in Newport Beach are provided and maintained by the City, Orange County, and local community associations. In general, the County is responsible for maintaining the regional flood control system, while the City is responsible for local improvements. Each of these agencies maintains master and capital improvement plans. They all are required to conform to regional, state and federal regulatory requirements, including those pertaining to control of the discharge from municipal storm sewer systems to protect the environmental quality of surface waters.

Environmental quality problems include bacteria, toxins, and pollution. "Out of sight, out of mind" has traditionally been a common approach to dealing with trash, sediment, used motor oil, unused paint and thinner, and other hazardous substances that people dump into the sewer or storm drains. However, these substances eventually make their way into the rivers and oceans, where they can sicken surfers and swimmers, and endanger wildlife. The Clean Water Act of 1972 originally established the National Pollutant Discharge Elimination System (NPDES) to control wastewater discharges from various industries and wastewater treatment plants, known as "point sources," defined as discrete conveyances such as pipes or direct discharges from businesses or public agencies. In 1987, the Water Quality Act amended the NPDES permit system to include "nonpoint source" pollution; this refers to the introduction of bacteria, sediment, oil and grease, heavy metals, pesticides, fertilizers and other chemicals into our rivers, bays and oceans from less defined sources. These pollutants are washed away from roadways, parking lots, yards, and other areas by rain and dry-weather urban runoff, entering the storm drains, and ultimately the area's streams, bays and ocean.

The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point and nonpoint sources that discharge pollutants into waters of the United States. The City of Newport Beach is a Co-permittee in NPDES Permit No. CAS 618030 with the Orange County Flood Control District, the County of Orange and the incorporated cities in the Santa Ana region of the California Regional Water Quality Control Board. Each Co-permittee owns or operates a Municipal Separate Storm Sewer System (MS4). The NPDES permit directs each of the Co-permittees to keep pollutants out of its MS4 to the maximum extent practicable and to ensure that dry-weather flows entering recreational waters from the MS4 do not cause or contribute to exceedances of water quality standards. Some of the actions that the Permit requires the City of Newport Beach to enforce include the following:

- ✓ Control contaminants into storm drain systems;
- ✓ Educate the public about stormwater impacts;
- ✓ Detect and eliminate illicit discharges;
- ✓ Control runoff from construction sites;
- ✓ Implement "best management practices" or "BMPs" and site-specific runoff controls for new development and redevelopment; and
- ✓ Prevent pollution from municipal operations, including fixed facilities (like City Hall and fire stations) and field activities (like trash collection).

Non-point pollutants will generally enter the stormwater system and surface waters of the area during strong rainstorm events that create runoff. Stronger or more common rainstorms in the region as a result of climate change have the potential to result in increased flows of storm water impacted with sediment and contaminants like lead, and petroleum hydrocarbons.

However, given that some areas in Newport Beach appear to be more susceptible to flooding issues, due in great part to high tides and short but intense rainfall, as well as urban run off and modification of the natural environment, proactive measures that address the issues before flooding occurs could be implemented.

Tsunami Evacuation System

City of Newport Beach officials have recognized that the area is vulnerable to a low-probability but high-risk tsunami event, with the highest risk posed by a local tsunami source that will not allow for much warning before the first wave hits land. Limited roads into and out of the Newport Peninsula and the islands in Newport Bay, the areas at higher risk of being impacted by a tsunami, may limit the effectiveness of the evacuation efforts. As a result, people in the area are encouraged to evacuate to higher ground on foot, if at all possible. The City of Newport Beach has installed signs in tsunami hazard zones identifying the risk and showing the evacuation routes to take to higher ground. In addition, the City has developed brochures and other informational materials describing its tsunami hazard and what to do before, during and immediately after an earthquake that could generate a tsunami. For a direct link to the City's informational materials, go to http://www.newportbeachca.gov/index.aspx?page=1495.

Potential Human Actions in Response to Sea Level Change

The City of Newport Beach has started to evaluate its options and potential mitigation measures to respond to sea level rise due to climate change. Human response to sea level changes include: 1) no action, 2) use of barriers, such as levees, to protect the built areas, 3) raising the coastline by placing sand on the beach and raising the buildings and supporting infrastructure, and 4) retreat (Titus, 1990; Nordstrom, 2000). Problems resulting from the no-action option include loss of recreational beaches due to accelerated erosion, loss of bayside property through erosion and inundation of low-lying areas, and stranding of buildings and infrastructure on the beach. As residents move inland, there is increased competition for land and living space, and natural resources in the backbays become increasingly threatened. Eventually, abandonment of the barrier reefs or peninsulas, and islands in the bays could become necessary. This option however, is not likely to happen in the near future in areas like Newport Beach, where there is a strong social, economic, and cultural need to maintain the integrity of the beaches, harbors and islands, and there are economic resources available to implement other options.

The second option involves construction of seawalls and other flood protection structures around the threatened areas. The most significant advantage of this option is that major institutional changes in land use are not required (Titus, 1990; Nordstrom, 2000). Lots, houses and roads would not have to be raised or moved. However, the increased water levels around the bulkheads, seawalls and other artificial structures would result in increased breaking wave energy, higher storm runup, and increased beach loss. Structures would have to be designed or improved to withstand these environmental assaults. Beaches could be maintained by artificial nourishment, but at a great cost and frequency.

The third option is probably cost-prohibitive in most areas. This would require placing sand on the beach to raise the ground surface, and raising the buildings and supporting infrastructure. Borrowing the large volumes of sand required would no doubt trigger environmental issues that would prohibit implementation of this option. Even if this were accomplished at the local level, raising the beach could increase the likelihood of bayshore erosion (Titus, 1990).

Retreat is the most environmentally sensitive option, but it involves new legislation that allows for land acquisition by public authorities, use of setback lines and prohibition of reconstruction after damage. The economic and social costs of land loss and compensation issues make this option unpalatable to most; strong political and public opposition can be expected. In intensely developed, premium real estate areas like Newport Beach, implementation of this option is very unlikely. Nevertheless, if sea levels do rise substantially, this will ultimately prove to be the most cost-effective and possibly only option.

Flood Resource Directory

The following resource directory lists the resources and programs that can assist county communities and organizations. The resource directory will provide contact information for local, county, regional, State and Federal programs that deal with natural hazards. For additional information, refer to Appendix A.

County and Local Resources

Orange County Public Works Department
333 West Santa Ana Boulevard
Santa Ana, California 92701
Ph: 714-834-5400
http://www.ocwd.com

Sanitation District of Orange County
10844 Ellis Avenue
Fountain Valley, California 92708
Ph: 714-962-2411
http://www.ocsd.com

Irvine Ranch Water District
15600 Sand Canyon Ave
Irvine, CA 92618
Ph: 949-453-5300
http:// www.irwd.com

Mesa Consolidated Water District
1965 Placentia Ave
Costa Mesa, CA 92627
Ph: 949-631-1200
http://www.mesawater.org

Costa Mesa Sanitary District
628 W. 19th Street
Costa Mesa, California 92627
http://www.cmsdca.gov/

State Resources

Governor's Office of Emergency Services (Cal OES)
P.O. Box 419047
Rancho Cordova, CA 95741-9047
Ph: 916 845- 8911
Fx: 916 845- 8910

California Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95814
Ph: 916-653-5656

California Department of Water Resources (DWR)
1416 9th Street
Sacramento, CA 95814
Ph: 916-653-6192

California Department of Conservation: Southern California Regional Office
655 S. Hope Street, #700
Los Angeles, CA 90017-2321
Ph: 213-239-0878
Fx: 213-239-0984

Federal Resources and Programs

Federal Emergency Management Agency (FEMA)
FEMA provides maps of flood hazard areas, various publications related to flood mitigation, funding for flood mitigation projects, and technical assistance. FEMA also operates the National Flood Insurance Program. FEMA' s mission is to reduce loss of life and property and protect the nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery.

Federal Emergency Management Agency, Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607
Ph: 510-627-7100
Fx: 510-627-7112

Federal Emergency Management Agency, Mitigation Division
500 C Street, S.W.
Washington, D.C. 20472
Ph: 202-566-1600

FEMA' s List of Flood Related Websites
This site contains a long list of flood related Internet sites from "American Heritage Rivers" to "The Weather Channel" and is a good starting point for flood information on the Internet.
Contact: Federal Emergency Management Agency, Phone: (800) 480-2520
Website: http://www.fema.gov/nfip/related.htm

National Flood Insurance Program (NFIP)
In Southern California, many cities lie within flood zones as defined in FEMA Flood Maps. The City of Newport Beach is a community within a designated flood zone. As a result, flood insurance is available to citizens in the floodzone that adopt and implement NFIP building standards. The standards are applied to development that occurs within a delineated floodplain, a drainage hazard area, and properties within 250 feet of a floodplain boundary. These areas are depicted on federal Flood Insurance Rate Maps available through the county.
National Floodplain Insurance Program (NFIP)
500 C Street, S.W.

Washington, D.C. 20472
Ph: 202-566-1600

Other National Resources

The Floodplain Management Association

The Floodplain Management website was established by the Floodplain Management Association (FMA) to serve the entire floodplain management community. It includes full-text articles, a calendar of upcoming events, a list of positions available, an index of publications available free or at nominal cost, a list of associations, a list of firms and consultants in floodplain management, an index of newsletters dealing with flood issues (with hypertext links if available), a section on the basics of floodplain management, a list of frequently asked questions (FAQs) about the Website, and a catalog of Web links.
Floodplain Management Association
P.O. Box 50891
Sparks, NV 89435-0891
Ph: 775-626-6389
Fx: 775-626-6389

The Association of State Floodplain Managers

The Association of State Floodplain Managers is an organization of professionals involved in floodplain management, flood hazard mitigation, the National Flood Insurance Program, and flood preparedness, warning, and recovery. ASFPM fosters communication among those responsible for flood hazard activities, provides technical advice to governments and other entities about proposed actions or policies that will affect flood hazards, and encourages flood hazard research, education, and training. The ASFPM Web site includes information on how to become a member, the organization's constitution and bylaws, directories of officers and committees, a publications list, information on upcoming conferences, a history of the association, and other useful information and Internet links.
Contact: The Association of State Floodplain Managers
Address: 2809 Fish Hatchery Road, Madison, WI 53713 Phone: (608) 274-0123
Website: http://www.floods,org

National Weather Service

The National Weather Service provides flood watches, warnings, and informational statements for rivers in the City of Newport Beach.
National Weather Service
520 North Elevar Street
Oxnard, CA 93030
Ph: 805-988- 6615

Office of Hydrology, National Weather Service

The National Weather Service s Office of Hydrology (OH) and its Hydrological Information Center offer information on floods and other aquatic disasters, This site offers current and historical data including an archive of past flood summaries, information on current hydrologic conditions, water supply outlooks, an Automated Local Flood Warning Systems Handbook, Natural Disaster Survey Reports, and other scientific publications on hydrology and flooding.
National Weather Service, Office of Hydrologic Development
1325 East West Highway, SSMC2
Silver Spring, MD 20910
Ph: 301-713-1658
Fx: 301-713-0963

National Resources Conservation Service (NRCS), US Department of Agriculture
NRCS provides a suite of federal programs designed to assist state and local governments and landowners in mitigating the impacts of flood events. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis. The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners to put aside land that is either a wetland resource, or that experiences frequent flooding. The Emergency Watershed Protection Program (EWP) provides technical and financial assistance to clear debris from clogged waterways, restore vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more that one property.
National Resources Conservation Service
14th and Independence Ave., SW, Room 5105-A
Washington, DC 20250
Ph: 202-720-7246
Fx: 202-720-7690

USGS Water Resources (http:// water.usgs.gov)
This web page offers current US water news; extensive current (including real-time) and historical water data; numerous fact sheets and other publications; various technical resources; descriptions of ongoing water survey programs; local water information; and connections to other sources of water information.
USGS Water Resources
6000 J Street Placer Hall
Sacramento, CA 95819-6129
Ph: 916-278-3000
Fx: 916-278-3070

Bureau of Reclamation
The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The Bureau provides leadership and technical expertise in water resources development and in the efficient use of water through initiatives including conservation, reuse, and research. It protects the public and the environment through the adequate maintenance and appropriate operation of Reclamation's facilities and manages Reclamation's facilities to fulfill water user contracts and protect and/or enhance conditions for fish, wildlife, land, and cultural resources.
Mid Pacific Regional Office
Federal Office Building
2800 Cottage Way
Sacramento CA 95825-1898
Ph: 916- 978-5000
Fax 916- 978-5599
http://www.usbr.gov/

Army Corps of Engineers
The Corps of Engineers administers a permit program to ensure that the nation's waterways are used in the public interest. Any person, firm, or agency planning to work in waters of the United States must first obtain a permit from the Army Corps of Engineers. The Corps is responsible for the protection and development of the nation's water resources, including navigation, flood control, energy production through hydropower management, water supply storage and recreation.
US Army Corps of Engineers

P.O. Box 532711
Los Angeles CA 90053- 2325
Ph: 213-452- 3921

American Public Works Association
2345 Grand Boulevard, Suite 500
Kansas City, MO 64108-2641
Ph: 816-472-6100
Fx: 816-472-1610

Publications

Federal Emergency Management Agency, 2011, Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Buildings in Coastal Areas: FEAM P-55, Fourth Edition, August 2011.
Provides mitigation guidance for local officials and professionals in building design and construction.

Federal Emergency Management Agency, 2011, Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures: FEMA P-259, Third Edition, December 2011.
Provides engineering design and economic guidance on what constitutes feasible and cost-effective retrofitting measures for flood-prone residential structures.

Federal Emergency Management Agency, 2010, Home Builder's Guide to Coastal Construction Technical Fact Sheet Series: FEMA P-499, December 2010.
This document contains a series of 37 fact sheets that provide technical guidance and recommendations concerning the construction of coastal residential buildings.

Federal Emergency Management Agency, 2009, Homeowners' Guide to Retrofitting: FEMA P-312, Second Edition, December 2009.
Guide specifically for homeowners who want information on protecting their houses from flooding. Homeowners who need clear information about the options available and straightforward guidance that will help make decisions. The guide is written for readers who have little or no knowledge of flood protection methods or building construction techniques.

Federal Emergency Management Agency, 2009, Vertical Evacuation from Tsunamis: A Guide for Community Officials: FEMA P646A, June 2009.
This publication presents information on how vertical evacuation can be used and encouraged at the state and local level. It is meant to help state and local government officials and interested citizens by providing them with the information they need to address the tsunami hazard in their community, help determine if vertical evacuation is an option they should consider, and if so, how to fund, design and build such a refuge.

Federal Emergency Management Agency, 2008, Guidelines for Design of Structures for Vertical Evacuation from Tsunamis: FEMA P646, June 2008.
This publication presents general information on tsunami hazards, guidance on determining the tsunami hazard, including the need for tsunami depth and velocity on a site-specific basis, different options for vertical evacuation from tsunamis, determining tsunami and earthquake loads and structural design criteria, and structural design concepts.

Federal Emergency Management Agency, 2000, Above the Flood: Elevating Your Floodprone House: FEMA 347, May 2000.
This publication show how floodprone houses in south Florida were elevated above the 100-year

flood level following Hurricane Andres and also presents alternative elevating techniques.

NFIP Community Rating System Coordinator's Manual
Indianapolis, IN.
This informative brochure explains how the Community Rating System works and what the benefits are to communities. It explains in detail the CRS point system, and what activities communities can pursue to earn points. These points then add up to the "rating" for the community, and flood insurance premium discounts are calculated based upon that "rating." The brochure also provides a table on the percent discount realized for each rating (1-10). Instructions on how to apply to be a CRS community are also included.
Contact: NFIP Community Rating System
Phone: (800) 480-2520 or (317) 848-2898
Website: http://www.fema.gov/nfip/crs

Floodplain Management: A Local Floodplain Administrator's Guide to the NFIP
This document discusses floodplain processes and terminology. It contains floodplain management and mitigation strategies, as well as information on the NFIP, CRS, Community Assistance Visits, and floodplain development standards.
Contact: National Flood Insurance Program Phone: (800) 480-2520
Website: http://www.fema,gov/nfip/

Flood Hazard Mitigation Planning: A Community Guide, (June 1997).
Massachusetts Department of Environmental Management.
This informative guide offers a 10-step process for successful flood hazard mitigation. Steps include: map hazards, determine potential damage areas, take an inventory of facilities in the flood zone, determine what is or is not being done about flooding, identify gaps in protection, brainstorm alternatives and actions, determine feasible actions, coordinate with others, prioritize actions, develop strategies for implementation, and adopt and monitor the plan.
Contact: Massachusetts Flood Hazard Management Program Phone: (617) 626-1250
Website: http://www.magnetstate.ma.us/dem/programs/mitigate

Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials, (February 1987), FEMA-116.
This guidebook offers a table on actions that communities can take to reduce flood losses. It also offers a table with sources for floodplain mapping assistance for the various types of flooding hazards. There is information on various types of flood hazards with regard to existing mitigation efforts and options for action (policy and programs, mapping, regulatory, non-regulatory). Types of flooding which are covered include alluvial fan, areas behind levees, areas below unsafe dams, coastal flooding, flash floods, fluctuating lake level floods, ground failure triggered by earthquakes, ice jam flooding, and mudslides.
Contact: Federal Emergency Management Agency Phone: (800) 480-2520
Website: http://www.fema,gov

SECTION 8: WILDFIRES

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SECTION 8: WILDFIRES

Why are Wildfires a Threat to Newport Beach?

Fires have always been a natural part of the ecosystem in portions of southern California due to the region's weather, topography and native vegetation. The typically mild, wet winters characteristic of our Mediterranean climate result in an annual growth of grasses and plants that dry out during the hot summer months. This dry vegetation often provides fuel for wildfires in the autumn, when the area is intermittently impacted by Santa Ana winds, the hot, dry winds that blow across the region in the late fall. These winds often fan and help spread the fires. Furthermore, many of our native plants have a high oil content that makes them highly flammable.

Although wildfires can be highly disruptive and dangerous, the fact is that wildland fires are a necessary part of the natural ecosystem of southern California. Many of the native plants require periodic burning to germinate and recycle nutrients that enrich the soils. Native Americans took advantage of this, and used fire extensively to control their environment by enhancing feed for wildlife, decreasing insects and pests that impact wild foods, increasing the abundance and density of edible tubers, greens and other useful plants, and clearing underbrush to ease travel and provide increased visibility (Anderson, 2006). Wildfires become an issue, however, whenever they extend out of control into developed areas, with a resultant loss of property, and sometimes unfortunately, loss of life. The wildfire risk in the United States has increased in the last few decades with the increasing encroachment of residences and other structures into the wildland environment, and the increasing number of people living and playing in wildland areas. The National Interagency Fire Center estimates that approximately 15 percent of all wildland fires in the United States are started by lightning strikes, with humans causing the rest. The most common human causes of wildfires are arson, sparks from brush-clearing equipment and vehicles, improperly disposed cigarettes, and children playing with matches.

Wildfires pose a substantial hazard to life and property in communities built within or adjacent to hillsides and mountainous areas. As the 2003, 2006, 2007, 2009 and May 2014 fires in southern California have shown, the containment of wildfires that consume thousands to hundreds of thousands of acres of vegetated property require the participation of a multi-jurisdictional emergency response effort, with hundreds to thousands of people at or near the fire lines combating the flames, clearing brush ahead of the fire to establish defensible zones, and assisting evacuees. Under the right wind conditions, multiple ignitions can develop as a result of the wind transport of burning cinders (called fire brands) over distances of a mile or more. Wildfires in those areas where the wildland approaches or interfaces with the urban environment (referred to as the wildland-urban interface area or WUI area) can be particularly dangerous and complex, posing a severe threat to public and firefighter safety, and potentially causing devastating losses of property and life. This is so because when a wildland fire encroaches onto improved land, ignited structures can then sustain and transmit the fire from one building to the next. It has become increasingly clear that continuous planning, preparedness, and education are required to reduce the fire hazard potential and limit the destruction caused by fires. These mitigation measures are discussed in this document.

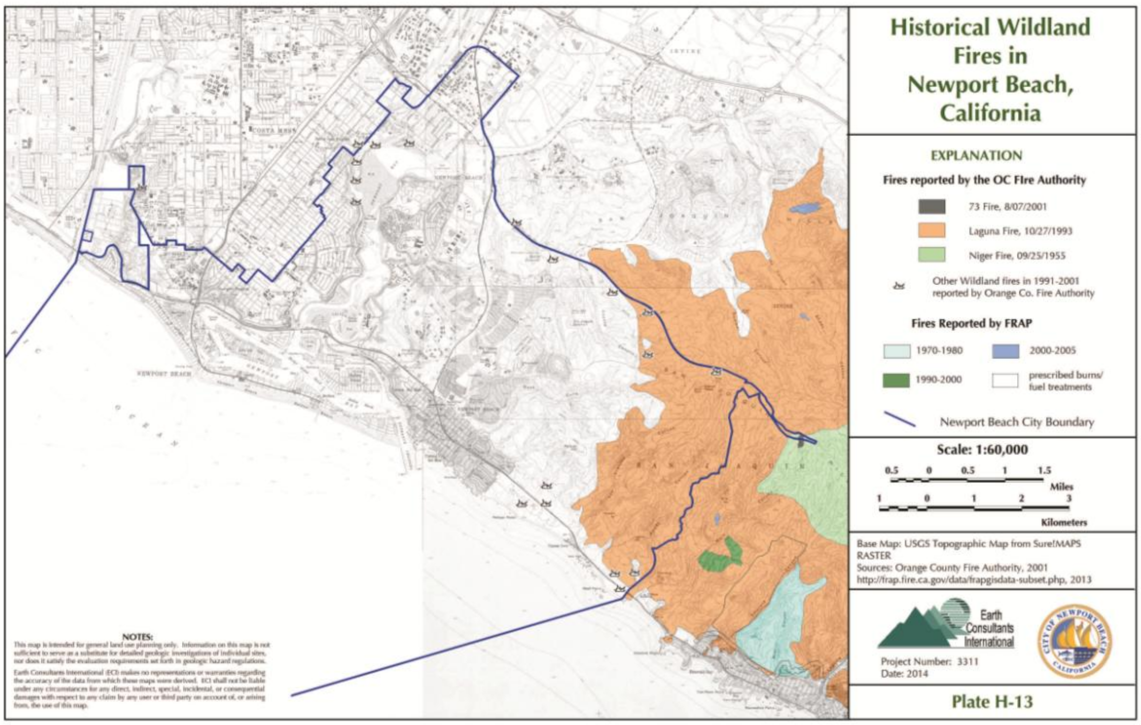
Historic Fires in Newport Beach and Vicinity

Several historical fires have impacted the Newport Beach area and vicinity over the years. The most devastating wildland fire in this area in recent history was the Laguna Beach fire of 1993. The 1993 fire, which was the result of arson, burned 14,437 acres and destroyed 441 homes.

This fire is still ranked in the top ten worst wildland fires in California. The 1993 fire spread into the Newport Coast area that is now part of the City of Newport Beach.

According to records kept by the Orange County Fire Authority, the Niger fire of 1955 burned 1,606 acres, impacting the northeastern-most corner of the current boundaries of the City of Newport Beach. The 73 Fire of 2001 burned only 6.63 acres, but because it occurred along the 73 Freeway, where it had the potential to impact traffic, it is considered a significant wildland fire. There have been several other smaller, less significant wildland and vegetation fires in the Newport Beach area, but records of these are limited. Those that were recorded by the Orange County Fire Authority between 1991 and 2001 are shown on Map 8-1 and Plate H-12.

Map 8-1: Historical Wildfires in the Newport Beach Area
(for a larger version of this map, refer to Plate H-13 in Appendix H)



Historic Fires in California

As mentioned above, large fires have been part of the southern California landscape for millennia. Researchers have determined that Native Americans in California used fire extensively to control their environment by enhancing feed for wildlife, decreasing insects and diseases that impact wild foods, increasing the abundance and density of edible tubers, greens and other useful plants, and clearing underbrush to ease travel and provide increased visibility (Anderson, 2006). It is estimated that as much as 12 percent of the State was burned every year by the various tribes (Coleman, 1994). One of the largest fires in Los Angeles County (60,000 acres) occurred in 1878, and the largest fire in Orange County's history, in 1889, burned over half a million acres. In the early 20th century, as development started to encroach onto the foothills, wildfires came to be unacceptable as they posed a hazard with the potential loss of property and life. As a result, in the early 1920s, the fire service began to prevent wildfires from occurring.

Unfortunately, over time, this led to an increase in fuel loads. Wildfires that impact areas with fuel buildup are more intense and significantly more damaging to the ecosystem than periodic, low-intensity fires. The 23 largest historic fires in California for the time period between 1923 and 2013 are listed in Table 8-1 below. Some of the most significant of these are discussed further in the sections below.

Table 8-1: Large Historic Fires in California for the Period 1923-2013
(in order of number of structures damaged)

	Fire Name	Date	County	Acres	Structures	Deaths
1	Tunnel	October 1991	Alameda	1,600	2,900	25
2	Cedar	October 2003	San Diego	273,246	2,820	15
3	Witch	October 2007	San Diego	197,990	1,650	2
4	Old	October 2003	San Bernardino	91,281	1,003	6
5	Jones	October 1999	Shasta	26,200	954	1
6	Paint	June 1990	Santa Barbara	4,900	641	1
7	Fountain	August 1992	Shasta	63,960	636	0
8	Sayre	November 2008	Los Angeles	11,262	604	0
9	City of Berkeley	September 1923	Alameda	130	584	0
10	Harris	October 2007	San Diego	90,440	548	8
11	Bel Air	November 1961	Los Angeles	6,090	484	0
12	Laguna	October 1993	Orange	14,437	441	0
13	Paradise	October 2003	San Diego	56,700	415	2
14	Laguna	September 1970	San Diego	175,425	382	5
15	Humboldt	June 2008	Butte	23,344	351	0
16	Panorama	November 1980	San Bernardino	23,600	325	4
17	Topanga	November 1993	Los Angeles	18,000	323	3
18	49er	July 1985	Ventura	118,000	312	0
19	Angora	June 2007	El Dorado	3,100	309	0
20	Simi	October 2003	Ventura	108,204	300	0
21	Slide	October 2007	San Bernardino	12,759	272	0
22	Sycamore	July 1977	Santa Barbara	805	234	0
23	Canyon	September 1999	Shasta	2,580	230	0

http://www.fire.ca.gov/communications/downloads/fact_sheets/20LSTRUCTURES.pdf; http://cdfdata.fire.ca.gov/incidents/; http://cdfdata.fire.ca.gov/incidents/incidents_statsevents
"Structures" is meant to include all loss - homes and outbuildings, etc.

The autumn of 2003 marked the most destructive wildfire season in California history (in terms of acreage burned and structures destroyed). In a ten-day period, 12 separate fires raged across southern California in Los Angeles, Riverside, San Bernardino, San Diego and Ventura counties. The massive "Cedar" fire in San Diego County alone consumed more than 2,800 homes and burned over a quarter of a million acres (see Tables 8-1 and 8-2, and Figure 8-1). Three other fires in 2003, named "Old," "Paradise," and "Simi" are in the list of top 20 fires in California based on damage. The 2003 California fires caused an estimated $975 million in damages.

Table 8-2: October 2003 Firestorm Statistics

County	Fire Name	Date Began	Acres Burned	Homes Lost	Homes Damaged	Lives Lost
Riverside	Pass	10/21/03	2,397	3	7	0
Los Angeles	Padua	10/21/03	10,446	59	0	0
San Bernardino	Grand Prix	10/21/03	69,894	136	71	0
San Diego	Roblar 2	10/21/03	8,592	0	0	0
Ventura	Piru	10/23/03	63,991	8	0	0
Los Angeles	Verdale	10/24/03	8,650	1	0	0
Ventura	Simi	10/25/03	108,204	300	11	0
San Diego	Cedar	10/25/03	273,246	2,820	63	15
San Bernardino	Old	10/25/03	91,281	1,003	7	6
San Diego	Otay / Mine	10/26/03	46,000	6	11	0
Riverside	Mountain	10/26/03	10,000	61	0	0
San Diego	Paradise	10/26/03	56,700	415	15	2
Total Losses			**749,401**	**4,812**	**185**	**23**

Source: http://www.fire.ca.gov/php/fire_er_content/downloads/2003LargeFires.pdf

Figure 8-1: View of the Cedar Fire of October 2003 Moving Down Oak Canyon, Toward the 52 Freeway, in San Diego County.

This fire burned more than 273,000 acres, destroyed 2,820 structures, damaged 63 others, and caused 15 fatalities. The fire was cased by a signal flare set off by a lost hunter. This is the largest fire by acreage burned in California since at least 1932, when reliable records were first kept.

The top fires, in acreage and damage caused, in Southern California for the years 2007 through 2012 are listed in Table 8-3. The three most significant fires in that time period in Southern California include the Zaca and Witch fires of 2007, and the Station fire of 2010 (see Figure 8-2). As of the writing of this report, the 2013 statistics were still not available from Cal-Fire. Table

8-3 also lists for each year between 2007 and 2012, inclusive, the total acres burned, total number of structures destroyed and damaged, and the number of fatalities in the State caused by wildland fires. Data for 2013 and 2014 were not available as of the writing of this report.

Figure 8-2: View of a Backfire to the Station Fire Behind Homes in La Crescenta.
The Station fire burned 160,557 acres, 209 structures and caused 2 deaths.
It is considered the 12th largest California fire by acreage burned
(http://cdfdata.fire.ca.gov/incidents/incidents_statsevents).
(Photograph by Jae C. Hong/AP Photo, taken on September 1, 2009).

Table 8-3: Top Wildland Fire Statistics for 2007-2012 in Southern California Only With Totals by Year for the Entire State

County	Fire Name	Date Began	Acres Burned	Structures Lost	Structures Damaged	Lives Lost
Santa Barbara	Zaca	07/04/07	240,207	1	0	0
San Diego	Witch	10/21/07	197,990	1,650	85	0
San Diego	Harris	10/21/07	90,440	472	257	1
San Diego	Poomacha	10/23/07	49,410	217	12	0
Orange	Santiago	10/21/07	28,400	24	20	0
2007 Total Fires California			**1,520,362**	**3,238**		**1**
Orange-Riverside	Freeway	11/15/08	30,305	189	129	0
Santa Barbara	Gap	07/01/08	9,443	4	0	0
Los Angeles	Sesnon	10/13/08	14,703	78	15	0
Los Angeles	Sayre	11/14/08	11,282	604	147	0
2008 Total Fires California			**1,443,065**	**2,440**		**12**
Los Angeles	Station	8/26/09	160,577	209	57	2
Santa Barbara	La Brea	08/08/09	91,622	2	0	0
Ventura	Guiberson	09/22/09	17,500	0	0	0
Santa Barbara	Jesusita	05/05/09	8,733	160	17	0
2009 Total Fires California			**451,969**	**579**		**3**

Table 8-3: Top Wildland Fire Statistics for 2007-2012 in Southern California Only With Totals by Year for the Entire State

County	Fire Name	Date Began	Acres Burned	Structures Lost	Structures Damaged	Lives Lost
Los Angeles	Crown	7/29/10	14,000	10	6	0
San Diego	Aliso	7/13/10	3,225	0	0	0
2010 Total Fires California			**134,462**	**92**		**0**
San Diego	Eagle	07/21/11	14,100	100	0	0
San Diego	Great	10/01/11	2,135	0	0	0
San Bernardino	Hill	09/08/11	1,153	3	2	0
2011 Total Fires California			**228,599**	**174**		**0**
San Diego	Vallecito Lightning Complex	8/13/12	22,829	0	0	0
San Diego	Banner 4	5/29/12	5,320	0	0	0
Los Angeles	Williams	09/02/12	4,192	0	0	0
Riverside	Buck	8/14/12	2,681	4	0	0
2012 Total Fires California			**829,224**	**270**	**29**	**0**
This table shows the largest fires, either in acreage or number of structures destroyed and damaged, reported by the CDF for each year. Source: Wildfire Activity Statistics Annual Reports (Redbooks) for each year included here, with data obtained from http://www.fire.ca.gov/fire_protection/ and National Climatic Data Center storm events database from https://www.ncdc.noaa.gov/stormevents/						

Wildfire Characteristics

There are three categories of interface fire: The **classic** wildland-urban interface occurs where well-defined urban and suburban development presses up against open expanses of wildland areas; the **mixed** wildland-urban interface characterized by isolated homes, subdivisions and small communities situated predominantly in wildland settings; and the **occluded** wildland-urban interface where islands of wildland vegetation occur inside a largely urbanized area. Certain conditions must be present for significant interface fires to occur. The most common conditions include: hot, dry and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). Once a fire has started, several conditions influence its behavior, including fuel, topography, weather, and degree of development, including dwelling density and accessibility, building construction (with emphasis on the use of fire-retardant construction materials and combustible roofs), and the availability of local mitigation measures and resources (such as nearby fire stations, fire hydrants, roads, fuel modification zones, fire sprinklers in structures, etc.). The most significant of these conditions are discussed further below.

The Interface

One challenge southern California faces regarding its wildfire hazard is the result of the increasing number of houses being built at the wildland-urban interface. Every year the growing population has expanded farther and farther into the hills and mountains, including forest lands. The increased "interface" between urban/suburban areas and the open spaces created by this expansion has produced a significant increase in threats to life and property from fires, and has pushed existing fire protection systems beyond original or current design and capability. Furthermore, human activities increase the incidence of fire ignition and potential damage. Because of the numerous Southern California wildfires that have occurred in recent years, property owners are increasingly more aware of the hazards associated with wildfires, and many are taking action to reduce their wildfire vulnerability using a variety of wildfire mitigation activities, such as vegetation management. Homeowners in fire-susceptible areas must have insurance.

Fuel

Fuel is the material that feeds a fire and is a key factor in wildfire behavior. Fuel is classified by volume and by type. Volume is described in terms of "fuel loading," or the amount of available vegetative fuel. The type of fuel also influences wildfire. Southern California has two distinct areas of risk for wildland fire: 1) The foothills and lower mountain areas most often covered with scrub brush or chaparral, and 2) the forested terrain at higher elevations, in the mountains. Only the first type occurs in the Newport Beach area and is thus discussed further below.

Chaparral is a primary fuel of Southern California wildfires. In Southern California, chaparral habitat ranges in elevation from near sea level to over 5,000 feet. Chaparral communities experience long dry summers and receive most of their annual precipitation from winter rains. Although chaparral is often considered as a single species, there are two distinct types: hard chaparral and soft chaparral. Within these two types are dozens of different plants, each with its own particular characteristics.

Chaparral communities have evolved so that they require fire to spawn regeneration. Many species invite fire through the production of plant materials with large surface-to-volume ratios, volatile oils and periodic die-back of vegetation. These species have further adapted to display special reproductive mechanisms following fire. For example, several species produce vast quantities of seeds which lie dormant until fire triggers germination. The parent plant which produces these seeds defends itself from fire with a thick layer of bark that allows enough of the plant to survive so that the plant can crown sprout following the blaze. In general, chaparral community plants have adapted to fire through the following methods: a) fire induced flowering, b) bud production and sprouting subsequent to fire, c) in-soil seed storage and fire-stimulated germination, and d) on-plant seed storage and fire-stimulated dispersal.

Chaparral vegetation creates one type of exposure, with fires burning through an area rather quickly, and typically at lower temperatures than forest fires. Studies also suggest that prescribed burning programs of chaparral-covered areas are not effective in halting shrubland fires. Under Santa Ana wind conditions, fires carry through all chaparral regardless of age of the vegetation stands (Keeley and Fotheringham, 2001).

An important element in understanding the danger of wildfire is the availability of diverse fuels in the landscape, such as natural vegetation, manmade structures and combustible materials. A house surrounded by brushy growth rather than cleared space allows for greater continuity of fuel and increases the fire's ability to spread. After decades of fire suppression, "dog-hair" thickets have accumulated, which enable high intensity fires to flare and spread rapidly.

Topography

Topography influences the movement of air, thereby directing a fire course. For example, if the percentage of uphill slope doubles, the rate of spread in wildfire will likely double. Gulches and canyons can funnel air and act as chimneys, which intensify fire behavior and cause the fire to spread faster. Solar heating of dry, south-facing slopes produces up-slope drafts that can complicate fire behavior. Unfortunately, hillsides with hazardous topographic characteristics are also desirable residential areas in many communities. This underscores the need for wildfire hazard mitigation and increased education and outreach to homeowners living in interface areas.

Although Newport Beach is a highly urbanized community, there are several areas in the City that consist of undeveloped, grass- and chaparral-covered hillsides. In fact, portions of the Newport Beach region and surrounding areas to the east and southeast include grass- and brush-covered hillsides with significant topographic relief that can facilitate the rapid spread of fire, especially if fanned by coastal breezes or Santa Ana winds. These canyons and hillsides are impacted by both strong seasonal Santa Ana wind conditions and westerly winds that can help transport embers up the west to southwest-facing canyons.

Weather

Weather patterns combined with certain geographic locations can create a favorable climate for wildfire activity. Areas where annual precipitation is less than 30 inches per year are extremely fire susceptible. High-risk areas in southern California share a hot, dry season in late summer and early fall when high temperatures and low humidity favor fire activity. The so-called "Santa Ana" winds, which are heated by compression as they flow southwestward from Utah to southern California, create a particularly high risk, as they can rapidly spread what might otherwise be a small fire.

The Newport Beach area typically has mild, wet winters that lead to an annual growth of grasses and plants. This vegetation dries out during the hot summer months and is exposed to Santa Ana wind conditions in the fall. During Santa Ana conditions, winds in excess of 15 to 25 miles per hour (mph) are typical; gusts in excess of 60 mph may occur locally (see Section 10). Santa Ana winds are generally consistent in their direction, but when combined with winds generated from burning vegetation, the wind direction generally becomes extremely erratic. This can stress fire-fighting resources and reduce fire-fighting success. Even with no unusual wind conditions, fire department response can be hindered by heavy traffic during peak hours, and by the long travel distances in the canyons and hillside areas of the southeastern part of the City. Furthermore, with the transportation corridors that now cut through these fire-prone areas, and the establishment of natural preserves in the canyons, there is an increased potential for fires, both accidental and purposely set, to impact the region. Therefore, enhanced onsite protection for structures and people in and near these wildfire-susceptible areas is necessary. The City of Newport Beach considers many of these factors in its definitions of Local Agency Very High Fire Hazard Severity Zones, Fuel Modification Zones, and Hazard Reduction Zones (Section 9.04.030 of the City of Newport Beach Municipal Code).

Recent concerns about the effects of climate change, particularly drought, are also contributing to concerns about wildfire vulnerability. The term drought is applied to a period in which an unusual scarcity of rain causes a serious hydrological imbalance. Unusually dry winters, or significantly less rainfall than normal, can lead to relatively drier conditions and leave reservoirs and water tables lower. Drought leads to problems with irrigation and may contribute to additional fires, and potentially additional difficulties in fighting fires.

Urban Development

Growth and development in scrubland and forested areas is increasing the number of human-made structures in the interface areas of southern California. Wildfire has an effect on development, yet development can also influence wildfire. Owners often prefer homes that are private, have scenic views, are nestled in vegetation and use "natural" construction materials. A private setting may be far from public roads, or hidden behind a narrow, curving driveway. These conditions, however, make evacuation and fire fighting difficult. The scenic views found along mountain ridges can also mean areas of dangerous topography. Natural vegetation contributes to scenic beauty, but it may also provide a ready trail of fuel leading a fire directly to the combustible fuels of the home itself.

In Newport Beach and adjacent areas, an increasing number of people use the surrounding undeveloped areas for recreation purposes, and as a result, there is an increased potential for fires to be accidentally or purposely set in the difficult-to-reach portions of the City.

Wildfire Hazard Identification and Regulatory Context

Wildfire hazard areas are commonly identified at the wildland-urban interface. Ranges of the wildfire hazard are further determined by the ease of fire ignition due to natural or human conditions and the difficulty of fire suppression. The wildfire hazard is also magnified by several factors related to fire suppression/control such as the surrounding fuel load, weather, topography and property characteristics. Generally, hazard identification rating systems are based on weighted factors of fuels, weather and topography. Since the early 1970s, several fire hazard assessment and classification systems have been developed for the purpose of identifying and quantifying the severity of the hazard in a given area. Many of these systems are regulatory in that they were implemented as a result of legislation enacted either at the State or Federal level, typically in response to a damaging fire or series of fires. Those that have been developed or used in California are described further below. Early systems characterized the fire hazard of an area based on a weighted factor that typically considered fuel, weather and topography. More recent systems rely on the use of Geographic Information System (GIS) technology to integrate the factors listed above to map the hazards, and to predict fire behavior and the impact on watersheds.

HUD Study System

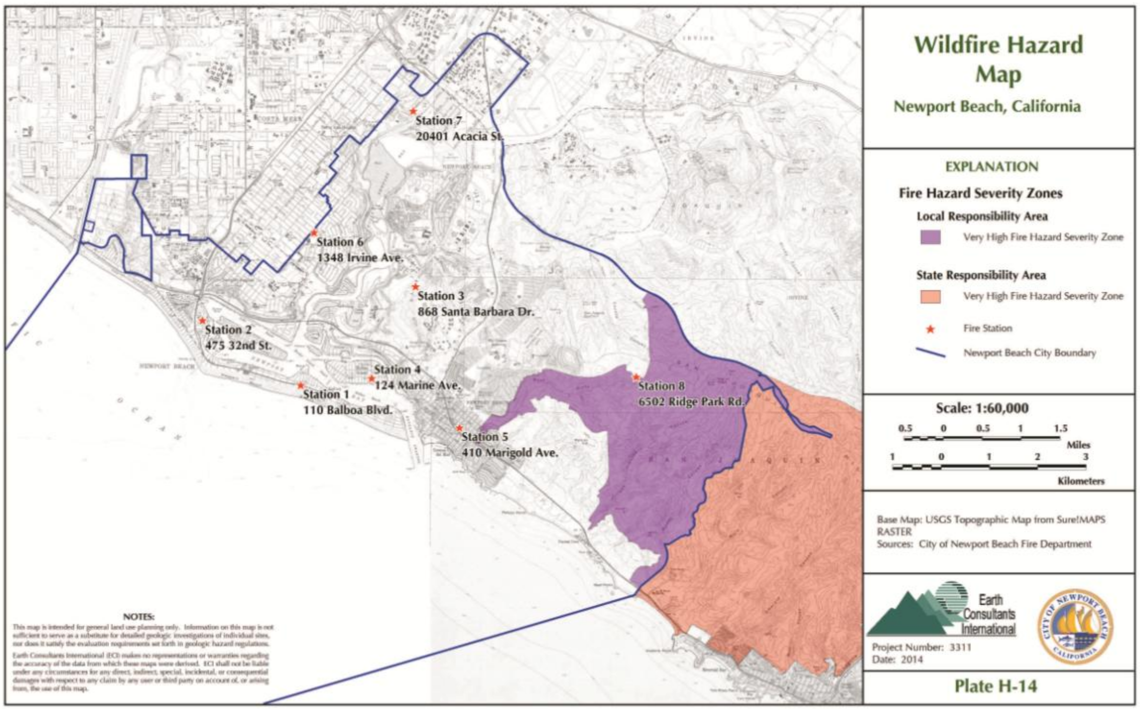
In April 1973, the California Department of Forestry (CDF – now the California Department of Forestry and Fire Prevention, also known as Cal Fire) published a study funded by the Department of Housing and Urban Development (HUD) under an agreement with the Governor's Office of Planning and Research (Helm et al., 1973). As is the case with several other more recent programs, the study was conducted in response to a disaster: during September and October 1970, 773 wildfires burned more than 580,000 acres of California land. The HUD mapping process relied on information obtained from US Geological Survey (USGS) 15- and 7.5-minute quadrangle maps on fuel loading (vegetation type and density) and slope, and combined it with fire weather information (available in real time at http://gacc.nifc.gov/oscc/predictive/fuels_fire-danger/index.htm) to determine the **Fire Hazard Severity** of an area. This system was the basis for several subsequent studies and programs that have been conducted as a result of more recent legislation, as described further below.

State Responsibility Areas System

Legislative mandates passed in 1981 (Senate Bill 81, Ayala, 1981) and 1982 (Senate Bill 1916, Ayala, 1982) that became effective on July 1, 1986, required the CDF to develop and implement a system to rank the fire hazards in California. Areas were rated as moderate, high or very high based primarily on fuel types. Thirteen different fuel types were considered using the 7.5-minute quadrangle maps by the U.S. Geological Survey as base maps (Phillips, 1983). Areas identified as having a fire hazard were referred to as **State Responsibility Areas** (**SRA**s) (Public Resources Code Section 4125). These are non-federal and non-incorporated lands covered wholly or in part by timber, brush, undergrowth or grass, for which the State has the primary financial responsibility of preventing and suppressing fires. SRAs also do not exceed a housing density of 3 unites per acre, and the land has watershed and/or range/forage value, effectively eliminating most desert lands from the SRA definition.

Crystal Cove State Park and Laguna Coast Wilderness Park immediately to the east-southeast of Newport Beach are located within a State Responsibility Area (see orange area on Map 8-2 and Plate H-13 in Appendix H).

Map 8-2: Wildfire Hazard Map for Newport Beach, Showing Local and State Responsibility Areas
(for a larger version of this map, refer to Plate H-14 in Appendix H)



Bates Bill Process

The Bates Bill (Assembly Bill 337, September 29, 1992) was a direct result of the great loss of lives and homes in the Oakland Hills Tunnel Fire of 1991. Prior to the adoption of this bill, the authority to apply wildland fire safety regulations in areas outside State control varied from one jurisdiction to the next, depending on the regulations adopted by individual legislative bodies. The original intent of the bill was to create a single fire district to provide coordinated response to any future fires in the area; the final document developed fire safety regulations to be applied consistently throughout the State (Collins, 2000). As part of this effort, the California Department of Forestry and Fire Protection (CDF), in cooperation with local fire authorities, was tasked to evaluate the fire hazard of **Local Responsibility Areas** (**LRA**s) and identify **Very High Fire Hazard Severity Zones** (VHFHSZs) therein. To accomplish this, the CDF formed a working group comprised of state and local representatives that devised a point system that considers fuel (vegetation), slope, weather, and dwelling density. To qualify as a VHFHSZ, an area has to score ten or more points in the grading scale.

Once the boundaries of a VHFHSZ have been delineated, the CDF notifies the local fire authorities that are responsible for fire prevention and suppression within that area. Since the State is not financially responsible for Local Responsibility Areas, local jurisdictions have final say regarding whether or not an area should be included in a VHFHSZ (Government Code Section 51178). Declaring an area a VHFHSZA means that the local fire department has to enforce the provisions of Section 4291 of the Public Resources Code. Local jurisdictions that do not follow the Bates system are required to follow at a minimum the model ordinance developed by the State Fire Marshal for mitigation purposes. The risk of fire in VHFHSZs needs to be addressed in the Safety Element of the General Plan (see section below entitled Senate Bill 1241, Kehoe Statutes of 2012).

The Local Responsibility areas in the City of Newport Beach are shown on Map 8-2. The purple area is zoned as a Very High Fire Hazard Severity Zone. The unshaded areas are generally considered to not have a wildland fire hazard, although there are Fuel Modification Zones and Hazard Reduction Zones within these areas (see Map 8-3).

California Fire Plan

The California Fire Plan is a cooperative effort between the State Board of Forestry and Fire Protection and the CDF. This system ranks the fire hazard of the wildland areas of the State using four main criteria: fuels, weather, assets at risk, and level of service (which is a measure of the fire department's success in initial-attack fire suppression). The California Fire Plan uses GIS-based data layers to conduct the initial evaluations, and local CDF Ranger Units are then tasked with field validation of the initial assessment. The final maps use a Fire Plan grid cell with an area of approximately 450 acres, which represents 1/81 of the area of a 7.5-minute quadrangle map (called Quad 81). The fire hazard of an individual cell is ranked as **moderate**, **high** or **very high**. The main objective of the California Fire Plan is to reduce total costs and losses from wildland fire in the State by protecting assets at risk before a fire occurs. To do so, the plan identifies prefire management prescriptions that can be implemented to reduce the risk, and analyzes policy issues and develops recommendations for changes in public policy. The most current California Fire Plan, as of the writing of this document, dates from 2010. For more information, including a digital copy of the entire 2010 Plan, go to http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan.

FireLine System

The Insurance Services Office (ISO) developed a program used by the insurance industry to identify those areas where the potential loss due to wildfire is greatest (ISO, 1997). ISO retained Pacific Meridian Resources of Emeryville, California to develop the FireLine software, which uses satellite-imagery interpretation to evaluate the factors of fuel types, slope and roads (access) to develop the risk rating. This is not a regulatory mapping program, but most insurance companies that provide insurance services to homeowners in California now use this system. Updated versions of this system are being developed that include the factors of elevation, aspect, and relative slope position.

National Fire Plan

Funding for the National Fire Plan was authorized by Congress in October 2000 in response to the wildfires of that year that burned millions of acres throughout the United States. These fires prompted politicians, fire managers, and government agencies to re-think their approach to fire management. Under Presidential Executive Order, the Secretaries of Agriculture and the Interior were tasked with preparing a report that outlined recommendations to minimize both the long- and short-term impacts of wildfires with a broader effort and closer cooperation between agencies and fire programs. The resultant report, entitled the "National Fire Plan," has as its main purposes to protect communities and restore ecological health on Federal lands (http://www.forestsandrangelands.gov/NFP/index.shtml). The Plan outlines five key points: 1) firefighting, 2) rehabilitation and restoration, 3) hazardous fuel reduction, 4) community assistance, and 5) accountability. The Plan, which was first funded in 2001, commits to funding for a continued level of "Hazardous Fuel Reduction" and new funding for a "Community

Assistance/Community Protection Initiative." The intent of the Community Assistance initiative is to provide communities that interface with federal lands an opportunity to get technical assistance and funding to reduce their threat of wildfires.

The plan is a cooperative effort of the U.S. Department of Agriculture's Forest Service, the Department of the Interior, and the National Association of State Foresters. National Fire Plan maps show communities that are within the vicinity of federal lands that are at high risk from wildland fire. The plan uses hazardous fuel reduction treatment techniques (including prescribed fire alone, mechanical treatment alone, mechanical treatment plus prescribed fire, and other/wildland fire use, such as allowing lightning-caused fires to burn) to reduce the impact of wildland fire on communities within the wildland-urban interface. For additional information refer to http://www.fireplan.gov/.

As part of the Community Assistance/Community Protection Initiative, the National Fire Plan funded a study to identify areas that are at high risk of damage from wildfire. Under this program, Federal fire managers authorized State foresters to determine which communities are at significant risk from wildland fire on Federal lands. In California, this task was undertaken by the California Fire Alliance (CFA), a cooperative group of State, Federal and local agencies, who in 2001 generated a list of communities at risk. Given California's extensive Wildland-Urban Interface (WUI), the list of communities extends beyond just those on or adjacent to Federal lands. As of 2014, the California Fire Alliance (CFA) has identified 1,289 fire-threatened communities in California, one of which is Newport Beach. Newport Beach was identified as a fire-threatened community in 2001 although the city is not located near federally regulated or Federal lands threatened by fire. Information on this program, is available at http://www.cafirealliance.org/communities_at_risk/.

BEHAVEPlus, FARSITE, FlamMap and FSPro

These are computer-based programs that can be used by local fire managers to calculate potential fire behavior in a given area using GIS data inputs for terrain and fuels. The purpose of these models is to predict fire behavior. Data inputs that can be used in the analyses include elevation, slope, aspect, surface fuel, canopy cover, stand height, crown base height and crown bulk density.

The oldest of these models is the BEHAVE Fire Behavior Prediction and Fuel Modeling System (Burgan and Rothermel, 1984; Burgan, 1987; Andrews, 1986; Andrews and Chase, 1989; Andrews and Bradshaw, 1990) that has been used since 1984. A newer version of it is referred to as the BehavePlus Fire Modeling System (Andrews and Bevins, 1999). BehavePlus is a suite of fire behavior systems that includes FlamMap, FARSITE, and FSPro. Input to the BehavePlus model is supplied interactively by the user; typically users run several calculations to evaluate and compare the effects that a range of values will have on the results. Each run consists of a set of uniform conditions.

FARSITE (Finney, 1995, 1998) is a deterministic modeling system that calculates the growth and behavior of a wildfire as it spreads through variable fuel and terrain under changing weather conditions (http://www.firemodels.org/index.php/farsite-introduction). This software can be used to project the growth of ongoing wildfires and prescribed fires, and can be used as a planning tool for fire suppression and prevention, and fuel assessment.

FlamMap (Finney, 2006; Stratton, 2006) is a mapping and analysis system that can be used to model fire behavior across the landscape under constant weather and fuel moisture conditions. The system provides the spatial component to the software suite. Because the environmental conditions remain constant, the software cannot be used to simulate temporal variations in fire behavior. Given that fuel is a variable in the input data, this software is well-suited to run landscape-level comparisons to evaluate the effectiveness of different fuel treatments under varying topographic conditions.

FSPro is used to calculate the probability that fire will spread from a known perimeter or point, but it does not provide fire perimeters, nor does it provide a projection of fire size. This piece of software requires more computing power than that typically provided by a personal computer (http://www.firemodels.org/index.php/behaveplus-introduction/behaveplus-overview).

Disaster Mitigation Act of 2000

This 2014 Disaster Mitigation Plan Update for the City of Newport Beach, and its predecessor, the 2008 Plan, were completed to satisfy the requirements of the federally mandated Disaster Mitigation Act of 2000. This Act requires local governments to prepare and adopt a Local Hazard Mitigation Plan that has been reviewed and approved by the State's Mitigation Officer (in this case the California Emergency Management Agency – Cal OES) and the Federal Emergency Management Agency (FEMA), as a condition of receiving mitigation project assistance. These documents are to focus on pre-disaster planning and activities as a way to reduce response and post-disaster costs.

Local Disaster (or Hazard) Mitigation Plans should be consistent with the policies contained in the General Plan, especially the Safety Element. Wildfire mitigation programs discussed in these two documents should be in agreement and integrated to ensure that the hazard of wildfire is addressed in an effective manner.

Community Wildfire Protection Plan (CWPP)

The Healthy Forests Restoration Act of 2003 was enacted in response to the widespread forest fires of 2002. The main purposes of the Act are to thin overcrowded forest stands, clear away vegetation and trees to create fuel breaks, provide funding and guidance to reduce or eliminate hazardous fuels in National Forests, improve forest fire fighting efforts, and encourage research into new methods to deal with destructive insects that affect forest communities. The Act also requires communities within the wildland-urban interface to prepare Community Wildfire Protection Plans. Communities that have such a Plan in place can influence where and how federal agencies implement fuel reduction projects on federal lands, and will also be given priority for funding of hazardous fuels reduction projects carried out under the auspices of the Healthy Forests Restoration Act.

Information on how to prepare and implement a CWPP can be obtained from http://www.forestsandrangelands.gov/communities/cwpp.shtml. CWPPs have to be developed as a collaborative effort between local, state and federal officials, in addition to non-governmental stakeholders that manage land in or near the community; must identify and priority areas for hazardous fuel reduction treatments on both federal and non-federal land; recommend the types and methods of fuel reduction to be used to reduce the risk to the community; and recommend measures that homeowners and communities can take to reduce the ignitability of structures.

In part to assist communities with their CWPP, the Orange County Fire Authority (OCFA) has prepared and issued the Orange County Unit Strategic Fire Plan (2012). This report outlines a comprehensive program to reduce government costs and citizen losses from wildland fire in Orange County. The document addresses issues associated with firefighter and public safety, wildland-urban interface issues, prescribed fire, fire suppression, preparedness, protection priorities and cooperation. The most recent version of the plan can be downloaded from http://cdfdata.fire.ca.gov/fire_er/fpp_planning_plans_details?plan_id=182. Furthermore, the OCFA has, at the Division and Battalion level, prepared tactical fire suppression plans for individual communities in or adjacent to the county's open spaces. The Newport/Laguna Coast Fire Plan covers the very large area of intermingled open spaces and densely populated areas within the incorporated cities of Laguna Beach, Newport Beach, and Irvine, unincorporated areas under the jurisdiction of the County, and the coastal areas of Newport Beach and Crystal Cove State Park. This document was a collaborative effort between the OCFA, the Newport Beach Fire Department, and the Laguna Beach Fire Department.

National Cohesive Wildland Fire Managements Strategy

The National Cohesive Wildland Fire Management Strategy (the Cohesive Strategy) is a three-phased effort undertaken and developed by the Wildland Fire Leadership Council in response to requirements of the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009. The FLAME Act set aside two monetary funds to address the impacts of increasing wildfire suppression costs and the effects that these costs have on other programs funded by the Department of the Interior and the Forest Service. The Act requires the Secretary of the Interior and the Secretary of Agriculture to jointly submit a report that addresses a cohesive wildfire management strategy. Among other items, the report needs to identify the most cost-effective ways to allocate the fire management budget, provide appropriate management response to wildfires, assess a community's level of risk, assess the impact of climate change on the frequency and severity of wildfires, and address the effects of invasive species on wildfire risk. The resulting document, referred to as the National Strategy, establishes a national vision for wildland fire management and includes a set of guidelines that can be tailored for local and regional needs. The Strategy's vision is as follows: "To safely and effectively extinguish fire, when needed; use fire where allowable; manage our natural resources; and as a Nation, live with wildland fire."

The Cohesive Strategy identifies three primary factors that can have a positive effect in addressing wildland fire problems:

1. *Restoring and maintaining resilient landscapes.* This factor must recognize the current lack of ecosystem health and variability from geographic area to geographic area, including the effects of climate change on ecosystem health. The strategy should address landscapes on a regional and sub-regional scale given how landscape conditions and needs vary depending on local climate and fuel conditions, among other elements. This is addressed for the city of Newport Beach and surrounding environments in the Orange County Fire Authority's Unit Strategic Fire Plan (2012) mentioned above.
2. *Creating fire-adapted communities.* The strategy offers options and opportunities to engage communities and work with them to become more resistant to wildfire threats, and respond in the event of a wildfire emergency.
3. *Responding to wildfires.* This element considers the full spectrum of fire management activities, and recognizes the differences in missions among local, state, tribal and Federal agencies.

Western Wildfire Risk Assessment

This is a study on wildfire risk conducted for the 17 western states and selected Pacific islands. The study, administered by the Council of Western State Foresters and the Western Forestry Leadership Coalition (WFLC), was conducted by the Timmons Group in the spring of 2013 (http://www.timmonsgis.com/projects/west-wide-wildfire-risk-assessment). The assessment reportedly provides the most up-to-date fuels dataset and risk assessment outputs for the West, which provide a baseline for quantifying mitigation activities and monitoring change over time.

The methodology used for the analysis was comparable across the entire study region, allowing for a consistent basis during interpretation and use of the data. According to the Timmons Group's website, the emphasis now is to put the assessment results to use by integrating the datasets into interactive web mapping applications.

Senate Bill 1241 (2012 Kehoe Statutes)

To address the increasing issues at the wildland-urban interface, Senate Bill 1241 (Kehoe, Statutes of 2012) revised the Safety Element requirements for state responsibility areas and very high fire hazard severity zones (Government Code Sections 65302 and 65302.5). Specifically, SB 1241 requires cities revising their Housing Element of the General Plan on or after January 1, 2014, to also review and update their Safety Element to address the risk of fire in state responsibility areas and very high fire hazard severity zones. SB 1241 requires the Safety Element include the following:

1. Fire hazard severity zone maps available from the Department of Forestry and Fire Protection.
    a. Historical data on wildfires available from local agencies;
    b. Information about wildfire hazard areas that may be available from the United States Geological Survey;
    c. General location and distribution of existing and planned uses of land in very high hazard severity zones and in state responsibility areas, including structures, roads, utilities, and essential public facilities;
    d. Local, state and federal agencies with responsibility for fire protection, including special districts and local offices of emergency services.

2. A set of goals, policies, and objectives based on the information identified in subparagraph (1) regarding fire hazards for the protection of the community from the unreasonable risk of wildfire.

3. A set of feasible implementation measures designed to carry out the goals, policies, and objectives based on the information identified in subparagraph (2) including, but not limited to:
    a. Avoiding or minimizing the wildfire hazards associated with new uses of land;
    b. Locating, whenever feasible, new essential public facilities outside of high fire risk areas, including, but not limited to, hospitals and health care facilities, emergency shelters, emergency command centers, and emergency communication facilities, or identifying construction methods or other methods to minimize damage if these facilities are located in a state responsibility area or very high fire hazard severity zone;
    c. Designing adequate infrastructure if a new development is located in a state responsibility area or in a very high fire hazard severity zone, including safe access for emergency response vehicles, visible street signs, and water supplies for structural fire suppression;
    d. Working cooperatively with public agencies with responsibility for fire protection.

4. If a city or county has adopted a fire safety plan or document separate from the General Plan, an attachment of, or reference to a city or county's adopted fire safety plan or document that fulfills commensurate goals and objectives and contains information required pursuant to this paragraph.

SB 1241 also requires that the draft Element of or draft amendment to the Safety Element of a county or a city's General Plan be submitted to the State Board of Forestry and Fire Protection and to every local agency that provides fire protection to territory in the city or county at least 90 days prior to either: 1) the adoption or amendment to the Safety Element of its General Plan for each county that contains state responsibility areas; or 2) the adoption or amendment to the Safety Element of its General Plan for each city or county that contains a very high fire hazard severity zone as defined pursuant to subdivision (b) of Section 51177.

Vulnerability and Risk

As discussed previously, the easternmost one-third of the City of Newport Beach is considered at risk from wildfire by the California Department of Forestry and the City's Fire Department. The local Very High Fire Hazard Severity Zones in the City's Local Responsibility Areas are shown in purple on Map 8-2 (and Plate H-13). These areas are based on vegetation, access, zoning and topography. California State law requires that fire hazard areas be disclosed in real estate transactions; that is, real-estate sellers are required to inform prospective buyers whether or not a property is located within a wildland area that could contain substantial fire risks and hazards [Assembly Bill 6; Civil Code Section 1103(c)(6)]. Real-estate disclosure requirements are important because in California the average period of ownership for residences is only five years (Coleman, 1994). This turnover creates an information gap between the several generations of homeowners in fire hazard areas: Uninformed, new homeowners may attempt landscaping or structural modifications that could be a detriment to the fire-resistant qualities of the structure, with potentially negative consequences.

A vulnerability assessment of the interface areas of the City at risk from wildfire requires knowledge about the population and total value of the property at risk, and an estimate of the area that would be impacted by the fire. Other key factors that need to be considered in the assessment of wildfire risk include ignition sources, building materials and design, community design, structural density, slope, vegetative fuel, fire occurrence and weather, as well as whether or not the area is experiencing a drought, and if it is, how long have drought conditions persisted. The National Wildland/Urban Fire Protection Program has developed the Wildland/Urban Fire Hazard Assessment Methodology tool for communities to assess their risk to wildfire. For more information on wildfire hazard assessment refer to http://www.firewise.org.

Unlike an earthquake, which has the potential to impact the entire region, wildfires at the wildland-urban interface are often contained thanks to the heroic efforts of the local fire departments, in some cases, if necessary, with help from other regional, State, and Federal agencies. Furthermore, as discussed above, there are computer models available (FARSITE, BEHAVEPlus, and FlamMap) that, given reasonable inputs regarding slope, wind, fuel availability, moisture conditions, and other parameters, can be used to forecast the area that would be impacted. Once the impacted area is determined, a risk assessment that looks at the population and property within that area can be conducted, from which loss estimates can be calculated. Many of the wildfire assessment methods discussed in the previous section use a compilation of a variety of these data to define wildfire-susceptible areas.

Community Wildfire Issues

What is Susceptible to Wildfire?

The hills and mountainous areas of southern California are considered to be at the wildland-urban interface. The development of homes and other structures has encroached and will continue to encroach onto the wildlands, expanding the wildland-urban interface areas. The neighborhoods at the interface are characterized by a diverse mixture of housing structures, development patterns, ornamental and natural vegetation, and natural fuels. In the event of a wildfire, this diverse mixture of vegetation, structures and development patterns, compounded by the local topography and weather at that specific time, can result in an unwieldy and unpredictable fire. Factors important in fighting such fires include access, vegetation management, proximity of water sources, distance from a fire station and available firefighting personnel and equipment. A review of past wildland-urban interface fires has shown that many structures are destroyed or damaged for one or more of the following reasons:

- ✓ Combustible roofing material;
- ✓ Wood construction;
- ✓ Structures with no defensible space;
- ✓ Fire department with poor access to structures;
- ✓ Subdivisions located in heavy natural fuel types;
- ✓ Structures located on steep slopes covered with flammable vegetation;
- ✓ Limited water supply; and
- ✓ Winds over 30 miles per hour.

Given that the southeastern one-third of the City of Newport Beach is located within the local VHFHSZ, there is a significant inventory of residential and commercial structures at risk from wildland fire. Also in this area are several schools and one fire station (Station No. 8 at 6502 Ridge Park Road). A second fire station (Station No. 5 at 410 Marigold Avenue) is just outside the very high fire hazard zone. Several important transportation routes, including Newport Coast Road, a small segment of Coast Highway, and the San Joaquin Hills Transportation Corridor extend, at least partly, through this area. Other facilities at risk from wildland fire include the large electrical transmission lines through Buck Gully.

Elements Critical to Wildfire Fighting Success

Road Access

Road access is a major issue for all emergency service providers. In some areas of the county, as development has encroached into the rural areas, the number of houses without adequate turn-around space has increased. In many single-family residential neighborhoods, there is not adequate space for emergency vehicle turnarounds, hindering emergency workers' access to the houses at risk. Narrow winding roads with inadequate turn-around space are particularly challenging as fire trucks are too long to maneuver in these roads. In these cases, fire fighters may evacuate the property owners and then leave themselves, unable to safely remain to save the threatened structures. In the planned developments in Newport Coast, all proposed roads are reviewed by the Fire Department to make sure that they comply with the minimum width, grade and turning radii requirements (see Table 8-4).

Fires at the wildland-urban interface tend to move quickly, with most of the damage or losses generally occurring in the first few hours after the fire starts (Coleman, 1994). Therefore, access to the wildland-urban interface for the purposes of emergency response is critical. This requires streets that meet minimum access and egress requirements so that they can be traversed by fire apparatus. The Newport Beach Municipal Code includes minimum width standards for local streets and width and length standards for cul-de-sacs. These standards are summarized in Table 8-4 below.

Table 8-4: Road Standards for Fire Equipment Access

Width of Fire Lanes	Minimum 20 feet wide with no parking on either side, minimum 28 feet wide with parking on one side, minimum 36 feet wide with parking on both sides.
Grades	Not to exceed 10 percent.
Turning Radius	No less than 20 feet inside radius and 40 feet outside radius, without parking. Cul-de-sacs with center obstructions require larger radii as approved by the Code Official.
Gates	Minimum width of any gate or opening required as a point of access shall be no less than 14 feet. Based on the length of the approach, this width may have to be larger. If there are separate gates for each direction of travel, then each gate shall be no less than 14 feet wide. Any point of access deemed necessary for emergency response shall remain unobstructed at all times. All electronically operated gates must be controlled by an approved key switch and approved remote opening device. Any secondary access points shall have a lock approved by the Newport Beach Fire Department.
Signage	All premises need to be identified with approved numbers or addresses in a position plainly visible and legible from the street or road fronting the property. Refer to Section 9.04.0450 of the City's Municipal Code for specifics on the minimum size of the letters and numbers.
Other Requirements for Fire Access Roadways	The fire code official is authorized to require more than one fire apparatus access road based on the potential for impairment of a single road by vehicle congestion, condition of terrain, climatic conditions or other factors that could limit access.

Water Supply

Fire fighters at the wildland-urban interface may be faced by limited water supply and lack of hydrant taps. Rural areas are characteristically outfitted with small-diameter pipe water systems, inadequate for providing sustained fire-fighting flows.

Areas at higher elevations may also be serviced by water that is pumped up to the higher elevations. In the event of a fire, there may be insufficient water pressure to do so. Emergency water storage is also critical, especially when battling large wildland fires. During the 1993 Laguna Beach (Orange County) fire, "water streams sprayed on burning houses sometimes fell to a trickle" (Platte and Brazil, Los Angeles Times, 1993), primarily because most water reservoirs in Laguna Beach were located at lower elevations, and the water district could not supply water to the higher elevations as fast as the fire engines were using it. Leaks and breaks in the water distribution system, including leaking irrigation lines and open valves in destroyed homes also reduced the amount of water available to the fire fighters. A seven-day emergency storage supply is recommended, especially in areas likely to be impacted by fires after earthquakes, due to the anticipated damage to the main water distribution system as a result of ground failure due to fault rupture, liquefaction, or landsliding.

Interface Fire Education Programs and Enforcement

Fire protection in wildland-urban interface areas relies more heavily on landowners taking measures personally to protect their properties. Property owners are more likely to take the initiative if they are informed of the risk. Therefore, public education and awareness should play a greater role in interface areas. In those areas with strict fire codes, property owners who resist maintaining the minimum brush clearances on their property should be cited for failure to clear brush.

The Need for Mitigation Programs

Continued development into the wildland-urban interface will have a growing impact on the wildfire risk of the area. Wildfires in southern California occur periodically, often with catastrophic results, with the history of deadly and expensive fires going back decades, if not a century. Continued growth and development underscores the increased need for natural hazards mitigation planning in southern California.

Fires After an Earthquake – The Threat of Urban Conflagration

Although this section deals primarily with the hazard of wildfires, there is another type of fire hazard that needs to be addressed. Specifically, large fires following an earthquake in an urban region, although rare, have the potential to cause great losses. The two largest peace-time urban fires in history, the 1906 San Francisco and 1923 Tokyo, were both caused by earthquakes. The conflagration in San Francisco after the 1906 earthquake was the single largest urban fire, and the single largest earthquake loss, in U.S. history. Three days of fires consumed more than 28,000 buildings within a 12-square-kilometer area. The cost is staggering: $250 million in 1906 dollars, or about $5 billion at today's prices. Although the threat that existed in San Francisco was and is far greater than that in Newport Beach today, there are some sections of Newport Beach where, due to ground failure as a result of either fault rupture or liquefaction, breaks in the gas mains and the water distribution system could lead to a significant fire-after-earthquake situation. Refer to the maps in Appendix H for information regarding those areas of the City susceptible to surface fault rupture and liquefaction.

The 1989 Loma Prieta earthquake, the 1994 Northridge earthquake, and the 1995 Kobe, Japan earthquake all demonstrate the current, real possibility of a fire-following-an earthquake developing into a conflagration. In the United States, all the elements that would hamper fire-fighting capabilities are present: density of wooden structures, limited personnel and equipment to address multiple fires, debris blocking the access of fire-fighting equipment, and a limited water supply.

Of the examples above, let us look at the earthquake closest to home. The moderately sized, M6.7 Northridge earthquake of 1994 caused several structural fires, many the result of broken gas mains: the earthquake caused 15,021 natural gas leaks that resulted in three street fires, 51 structural fires (23 of these caused total ruin) and the destruction by fire of 172 mobile homes. In one incident, the earthquake severed a 22-inch gas transmission line and a motorist ignited the gas while attempting to restart his stalled vehicle. Response to this fire was impeded by the earthquake's rupture of a water main; five nearby homes were destroyed. Elsewhere, one mobile home fire started when a downed power line ignited a ruptured transmission line. In many of the destroyed mobile homes, fires erupted when inadequate bracing allowed the homes to slip off their foundations, severing gas lines and igniting fires. There was a much greater incidence of mobile home fires (49.1 per thousand) than other structure fires (1.1 per thousand).

The damages from the 1994 earthquake reminded researchers of the findings of a study published in 1988 by the California Division of Mines and Geology (Toppozada and others, 1988). This study identified projected damages in the Los Angeles area as a result of an earthquake on the Newport-Inglewood fault. The earthquake scenario estimated that thousands of gas leaks would result from damage to pipelines, valves and service connections. This study prompted the Southern California Gas Company to start replacing their distribution pipelines with flexible plastic polyethylene pipe, and to develop ways to isolate and shut off sections of supply lines when breaks are severe. Nevertheless, as a result of the 1994 Northridge earthquake, the Southern California Gas Company reported 35 breaks in its natural gas transmission lines and 717 breaks in distribution lines. About 74 percent of the 752 leaks were corrosion related. Furthermore, in the aftermath of the earthquake, 122,886 gas meters were closed by customers or emergency personnel. Thankfully, most of the leaks were small and could be repaired at the time of service restoration, but the costs and time associated with these repairs were considerable.

History indicates that fires following an earthquake have the potential to severely tax the local fire suppression agencies, and develop into a worst-case scenario. Earthquake-induced fires can place extraordinary demands on fire suppression resources because of multiple ignitions. The principal causes of earthquake-related fires are open flames, electrical malfunctions, gas leaks, and chemical spills. Downed power lines may ignite fires if the lines do not automatically de-energize. Unanchored gas heaters and water heaters are common problems, as these readily tip over during strong ground shaking (State law now requires new and replaced gas-fired water heaters to be attached to a wall or other support).

Many factors affect the severity of fires following an earthquake, including ignition sources, types and density of fuel, weather conditions, functionality of the water systems, and the ability of firefighters to suppress the fires. Casualties, debris and poor access can all limit fire-fighting effectiveness. Water availability in Los Angeles County following a major earthquake will most likely be curtailed due to damage to the water distribution system — broken water mains, damage to the aqueduct system, damage to above-ground reservoirs, etc.

Loss-estimation scenarios were conducted for the City of Newport Beach using HazUS. Specifics of this analysis are discussed in detail in Section 6 – Earthquakes. Four different earthquake scenarios were considered for the City. The results of these loss estimations indicate that Newport Beach could experience between 2 and 16 ignitions immediately following an earthquake, with the San Andreas fault earthquake scenario triggering 2 ignitions, and the San Joaquin Hills and Newport-Inglewood faults triggering about 15 and 16 ignitions, respectively. An earthquake on the Whittier fault is thought capable of triggering 3 ignitions in the City. The burnt area resulting from these ignitions will vary depending on wind conditions. Normal wind conditions of about 10 miles per hour (mph) are expected to result in burn areas of between 3 and 100 acres. If Santa Ana wind conditions are present at the time of the earthquake, the burnt areas can be expected to be significantly larger.

The fires triggered by an earthquake on the Whittier fault are anticipated to displace about 40 people. The fires triggered by the other earthquake scenarios are expected to impact between 99 (San Andreas fault) and 707 people (Newport-Inglewood fault).

Existing Wildfire Mitigation Activities

Hazard mitigation programs in fire hazard areas currently include fire prevention, vegetation management, legislated construction requirements, and public awareness. Each of these programs is described further below.

Fire Prevention

Fire prevention aims to reduce the incidence and extent of fire by preventing wildfires from occurring in the first place. Over the years, a variety of fire prevention programs have been developed and implemented by Federal, State, and local agencies. These programs typically include education, engineering, patrolling, code enforcement, and signing (Greenlee and Sapsis, 1996). Smokey Bear is one of the best-known characters that both children and adults recognize, attesting to the success of public education programs aimed at fire prevention. Quantitative studies show that fire losses arising from human fires, especially those caused by children, dropped substantially after the Smokey Bear fire prevention program was introduced, in some cases by as much as 80 percent (Greenlee and Sapsis, 1996). Therefore, fire prevention is a well-understood program with a high degree of success. However, as discussed above, by preventing fire from occurring, fuel loads are allowed to increase, with the potential for high intensity fires and resultant damage. Therefore, fire prevention needs to be complemented with a variety of other programs that will guarantee long-term success in reducing the losses resulting from fires.

Fire prevention can include limiting access to fire hazard areas during certain times of the year. Although not apparent from Map 8-2, the wildfire susceptibility of an area changes from one season to the next, and from year to year, typically in response to local variations in precipitation, temperature, vegetation growth, and other conditions. When the fire danger in a Very High Fire Hazard Zone is deemed to be of special concern, local authorities rely on increased media coverage and public announcements to educate the local population about being fire safe. For example, to reduce the potential for wildfires during fire season, the City of Newport Beach can opt to close hazardous fire areas to public access during at least part of the year. By monitoring the site-specific wildfire susceptibility of a region, the Fire Department can establish regional prevention priorities that help reduce the risk of wildland fire ignition and spread, and help improve the allocation of suppression forces and resources, which can lead to faster control of fires in areas of high concern.

Restricted public access to hiking trails in and around the City of Newport Beach when a red flag condition is in effect helps reduce the opportunity for human-caused wildfires in the area. Continued use of signs during high and extreme fire conditions along the freeways and roads that cut through the wildland areas in the City and adjacent areas can also help reduce the fire hazard by alerting and educating motorists and residents.

The City of Newport Beach has a variety of fire prevention programs in place. Routine (annual or bi-annual) fire prevention inspections are conducted on a citywide basis by the Fire Department for residential, commercial, and industrial-type occupancies. The Life Safety Services Division of the City's Fire Department inspects all new and existing public assemblies, educational facilities, institutions and hospitals, high-rise buildings, hazardous materials occupancies, malls and large retail centers, and certain residential dwellings. The inspections are conducted for the purpose of enforcing the Fire Code and hazardous materials regulations, for Fire Department personnel from within that jurisdictional area to become familiar with the premises (this is helpful in the event that they need to respond to a fire or emergency), and to instruct occupants about fire prevention methods and procedures.

Newport Beach's Life Safety Services Division is comprised of several different units, each with specific responsibilities. Life Safety Services members have the powers of a peace officer (Calif. Penal Code 830.37 (b)) in enforcing the City's Fire Code. The responsibilities of each unit are described further below:

- **Fire Code Inspection** – conducts inspections of new and existing structures.
- **Development Plan Review** – reviews proposed developments for conformance with fire protection requirements including fire-resistive construction, landscaping, emergency access, available fire flow, and built-in fire detection and suppression systems.
- **Fire Investigation and Arson** – investigates fire cause and origin, administers aggressive code enforcement, and analyzes cost recovery for negligent or malicious acts causing fire. All members of this unit have full police powers as set in California Penal Code Section 830.37(a).
- **Vegetation Management** – reviews existing properties for compliance with fuel management requirements; administers and enforces the weed abatement and brush clearance program, and contracts for fire hazard reduction measures, including fuel breaks, fire roads, and non-compliant parcels.
- **Hazardous Materials and Waste Management** – administers hazardous materials disclosure laws and legislation, as well as conducts inspection of facilities that use or store hazardous materials for environmental compliance.
- **Public Education** – provides public fire safety education for groups or individuals on the hazards associated with the wildland-urban interface area.

Vegetation Management

Although, as discussed above, wildland fire is a significant potential hazard in some portions of Newport Beach, there are several management tools that can be implemented to reduce this hazard to manageable levels. Experience and research have shown that **vegetation management** is an effective means of reducing the wildland fire hazard in southern California. As a result, in areas identified as susceptible to wildland fire, jurisdictions typically require property owners to use a combination of maintenance approaches aimed at reducing the amount and continuity of the fuel (vegetation) available.

Fuel or vegetation treatments often used include mechanical, chemical, biological and other forms of biomass removal (Greenlee and Sapsis, 1996) or **fuel modification** within a given distance from habitable structures. The intent is to create a **defensible space** that slows the rate and intensity of the advancing fire, and provides an area at the urban-wildland interface where firefighters can set up to suppress the fire and save the threatened structures. Defensible space is defined as an area, either natural or man-made, where plant materials and natural fuels have been treated, reduced, or modified. However, removal of the native vegetation and maintenance of a wide strip of bare ground is not aesthetically acceptable and it increases the potential for water runoff and soil erosion. Native vegetation can be replaced with a green belt of low-lying, vegetation, but the increased use of water and maintenance requirements can make this option undesirable.

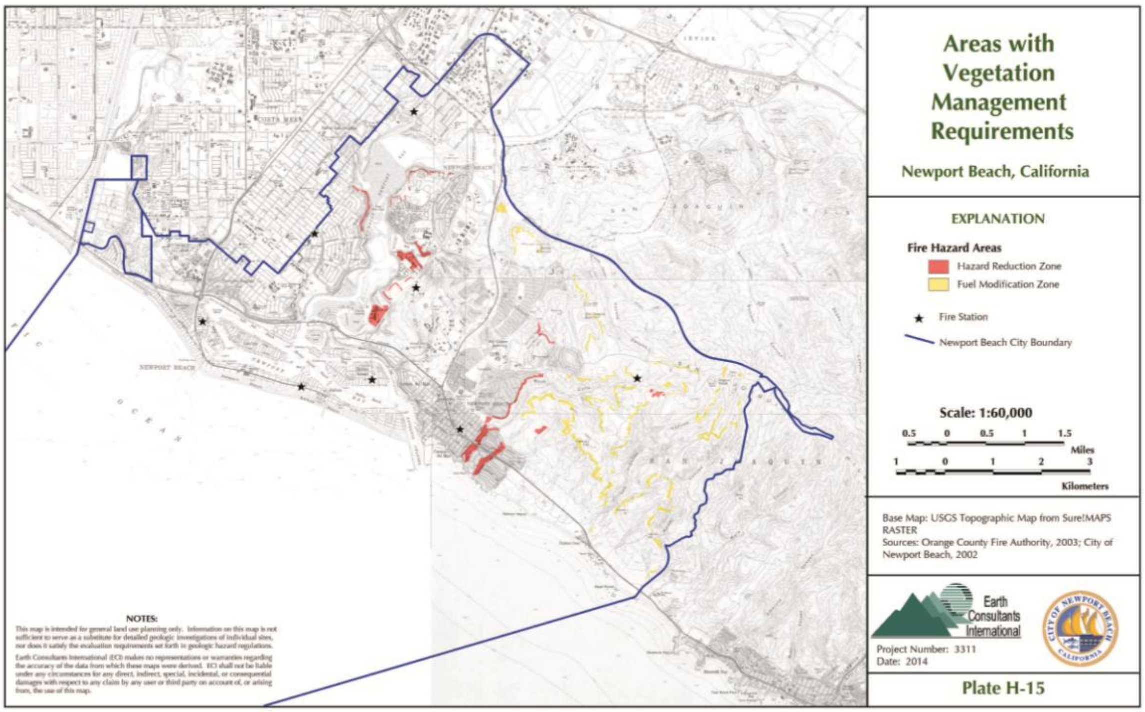
Another vegetation management approach used in some areas of southern California, including the Newport Beach areas of Buck Gully, Morning Canyon and some parts of Newport Coast, is referred to as **hazard reduction.** This method places emphasis on the space near structures that provides natural landscape compatibility with wildlife, water conservation and ecosystem health. Immediate benefits of this approach include improved aesthetics, increased health of large remaining trees and other valued plants, and enhanced wildlife habitat.

Fuel Modification Zone requirements are imposed when a new community or development is proposed adjacent to a wildland area. Any project in or adjoining a wildland fire hazard area is required to submit a Fire Protection Plan for review and approval before a grading or building permit for new construction is issued. These plans need to meet the criteria of the Newport

Beach Fire Department's Fuel Modification Plan and Maintenance Standard (Guideline G.02 - Fuel Modification Plans and Maintenance Standard).

In Newport Coast, the Orange County Fire Authority has the responsibility for reviewing and approving fuel modification zones and the inspection of the installation of these zones until the area is completely built out. The City of Newport Beach has the responsibility of ensuring that these areas are maintained in accordance with the Fire Protection Plan approved by the Orange County Fire Authority.

Map 8-3: Areas with Vegetation Management Requirements in Newport Beach
(refer to Plate H-14 in Appendix H for a larger version of this map)



A **fuel modification zone** is a ribbon of land surrounding a development within a fire hazard area that is designed to diminish the intensity of a wildfire as it approaches the structures. Fuel modification includes both the thinning (reducing the amount) of native combustible vegetation, and the removal and replacement of native vegetation with fire-resistive plant species. **The minimum width of a fuel modification zone is 170 feet**. These areas may be owned by individual property owners or by a homeowners' association. In the case of Newport Coast, local homeowners' associations own the majority of the fuel modification areas. Emphasis is placed on the space near structures that provides natural landscape compatibility with wildlife, water conservation and ecosystem health.

The fuel modification zone is typically divided into four areas referred to as the A, B, C and D zones (see Figure 8-3). The A Zone is the closest to the homes; the B, C and D zones lie outside the fence line and are within the common area typically owned by an association. Any dead or dying vegetation shall be removed from all zones, and certain fire-prone species of vegetation are required to be removed when found in any of the four fuel modification zones.

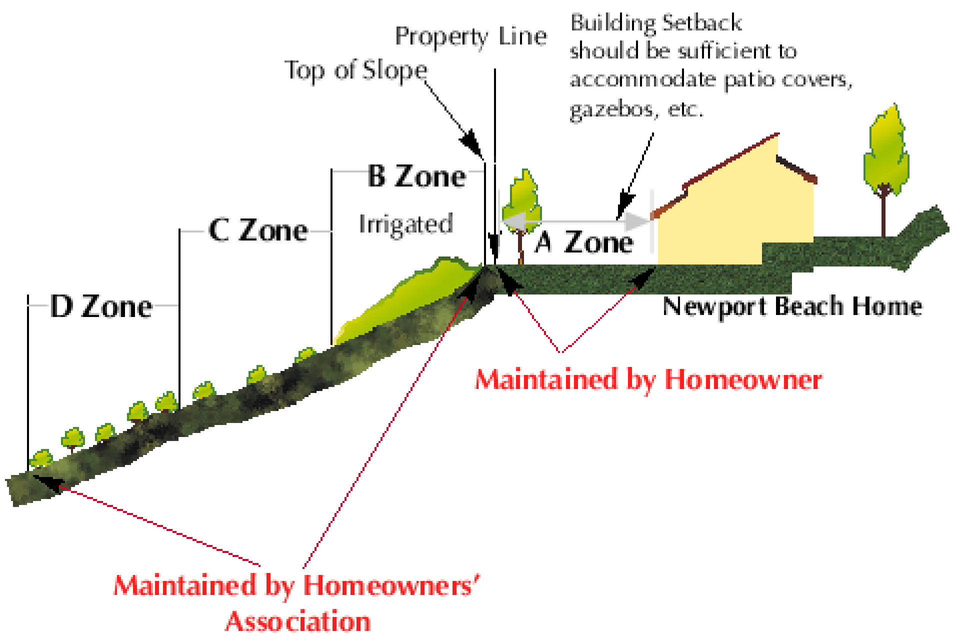
- The **A Zone** is the defensible space where firefighters will set up hose lines to extinguish the approaching fire. The A zone includes ornamental plants and single specimen trees. All plants in this area are required to be irrigated and must be selected from the City-approved plant list.

- The **B Zone** is the next 50 feet. This zone is an area where natural vegetation has been replaced with fire-resistive, drought-tolerant plants from the City-approved Fire Resistive Plant list. The B zone is fitted with automatic water sprinklers on a permanent basis. Non-approved vegetation must be removed from this zone.

- The **C and D zones** are the next 100 feet away from the homes. Each of these zones is a minimum of 50 feet in width. These zones are called the thinning zones. Natural vegetation is reduced by 50 percent in the C zone, and by 30 percent in the D zone. A way to imagine this thinning principle is as follows: in the 50 percent thinning zone (C zone) two people can walk side by side around clumps of vegetation. In a 30 percent thinning zone (D Zone), two people would have to walk single file between clumps of natural vegetation. These areas are not irrigated.

In addition to reduction of the vegetation hazards, structures immediately adjacent to the wildland areas and all structures located in a High Fire Hazard Severity Zone are hardened by being constructed under the provisions of the California Building Code Chapter 7A and the Newport Beach Municipal Code. These provisions include the installation of Class A roof assemblies, installation of dual glazed windows, ignition-resistant construction, and special attic venting requirements.

Figure 8-3: Fuel Modification Zones Required in Fire Hazardous Areas in Newport Coast



The Fuel Modification and Hazard Reduction Zone Guidelines and Standards adopted by Newport Beach for vegetation management in defensible areas are designed to be a fire prevention partnership between property owners and the City in order to prevent disastrous fires. The ordinance is designed to minimize fire danger by controlling density and placement of flammable vegetation. It does not recommend indiscriminate clearing of native coastal sage scrub and other types of plants that perform important roles in erosion control. The mitigation measures provided herein are the minimum required standards. In some high fire hazard areas or during certain times of the year, when due to the hot, dry weather there is an increased risk of wildfires, the Fire Marshal may determine that conditions warrant greater fire protection measures than what the minimum standards provide for. In that event, the Fire Marshal has the authority to supercede the requirements described above.

These standards require property owners in fire hazard areas, especially at the wildland-urban interface, to conduct maintenance, modifying or removing non-fire-resistive vegetation around their structures to reduce the fire danger. This affects any person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining the WUI area. Other specific maintenance actions that can be undertaken by property owners in the fire hazard areas include:

- Remove all dead vegetation and keep grasses and weeds maintained within 100 feet of any building and within 10 feet of any roadway. These provisions are part of an amendment to the Hazardous Vegetation Ordinance adopted in 1990. In extreme cases, clearance up to 200 feet from a structure and 50 feet from a roadway may be required by the Fire Department.
- Grasses and other vegetation located more than 30 feet from any building and less than 18 inches in height may be maintained where necessary to prevent erosion. Large trees and shrubs in that area should be at least 18 feet apart.
- Remove leafy foliage, dead wood, combustible ground cover, twigs, or branches within 3 feet of the ground from mature trees located within 100 feet of any building or within 10 feet of any roadway.
- Remove dead limbs, branches, and other combustible matter from trees or other growing vegetation adjacent to or overhanging any structure.
- Remove any portion of a tree that extends within 10 feet of a chimney or stovepipe.
- Trim and maintain all vegetation away from the curb line up to a height of 13.5 feet to accommodate emergency vehicles.
- Maintain 5 feet vertical clearance between roof surfaces and any overhanging portions of trees.
- Property owners in the urban-wildland interface area can request that the Fire Department conduct a comprehensive fire safety survey of their homes and property. The Fire Department inspects the residences for compliance with applicable regulations, and prepares a report for use by the homeowner to reduce its fire hazard. Implementation of the recommended mitigation measures may help the homeowner obtain a reduction in the cost of fire insurance.

It is the philosophy of the Newport Beach Fire Department to prevent catastrophic brush fires through comprehensive code enforcement efforts and, when necessary, a rapid response of properly trained and equipped firefighters. Successfully preventing fires requires a partnership between the community and the Newport Beach Fire Department to maintain the hill areas free of hazardous brush and combustible vegetation.

Hazard Abatement Notices

Each year, Fire Department personnel survey the hillside areas and issue notices of violation for hazardous vegetation. If uncontrolled or high weeds, brush, plant material, or other items prohibited under the City's Municipal Code are present in a property, the Fire Marshal has the authority to give the property owner of record a notice to abate the hazard. The property owner has 30 days to comply. If the owner does not abate the hazard during the time period specified in the notice, the City may take further action to reduce the fire hazard. Further action may include the following:

- ✓ The City or its contractor may enter the parcel of land and remove or otherwise eliminate or abate the hazard;
- ✓ upon completion of the work, the City can bill the property owner for the cost of the work plus any administrative costs, or the cost can become a special assessment against that parcel; and
- ✓ upon City Council confirmation of the assessment and recordation of that order, a lien may be attached to the parcel, to be collected on the next regular property tax bill levied against the parcel.

The Fire Marshal has to notify the property owner of the intention to abate the fire hazard by certified mail. The notices have to be mailed at least 15 days prior to the date of the proposed abatement. The property owner may appeal the decision of the Fire Marshal requiring the maintenance of an effective firebreak by sending a written appeal to the Fire Chief within 10 days of the notice. For additional information regarding the Notification and Abatement procedures, refer to Section 9.04.030 of the City's Municipal Code.

Legislated Construction Requirements in Fire Hazard Areas

Building construction standards for such items as roof coverings, fire doors, and fire resistant materials help protect structures from external fires *and* contain internal fires for longer periods. That portion of a structure most susceptible to ignition from a wildland fire is the **roof**, due to the deposition of burning cinders or brands. Burning brands are often deposited far in advance of the actual fire by winds. Roofs can also be ignited by direct contact with burning trees and large shrubs (Fisher, 1995). The danger of combustible wood roofs, such as wooden shingles and shakes, has been known to fire fighting professionals since at least 1923, when California's first major urban fire disaster occurred in Berkeley. It was not until 1988, however, that California was able to pass legislation calling for, at a minimum, Class C roofing in fire hazard areas. Then, in the early 1990s, there were several other major fires, including the Paint fire of 1990 in Santa Barbara, the 1991 Tunnel fire in Oakland/Berkeley, and the 1993 Laguna Beach fire, whose severe losses were attributed in great measure to the large percentage of combustible roofs in the affected areas. In 1994-1996 new roofing materials standards were approved by the California legislature for Very High Fire Hazard Severity Zones.

So what do these Classes A, B and C mean? To help consumers determine the fire resistance of the roofing materials they may be considering, roofing materials are rated as to their fire resistance into three categories that are based on the results of test fire conditions that these materials are subjected to under rigorous laboratory conditions, in accordance with test method ASTM-E-108 developed by the American Society of Testing Materials. The rating classification provides information regarding the capacity of the roofing material to resist a fire that develops outside the building on which the roofing material is installed (The Institute for Local Self Government, 1992). The three ratings are as follows:

Class A: Roof coverings that are effective against **severe** fire exposures. Under such exposures, roof coverings of this class:

- Are not readily flammable;
- Afford a high degree of fire protection to the roof deck;
- Do not slip from position; and
- Do not produce flying brands.

Class B: Roof coverings that are effective against **moderate** fire exposures. Under such exposures, roof coverings of this class:

- Are not readily flammable;
- Afford a moderate degree of fire protection to the roof deck;
- Do not slip from position; and
- Do not produce flying brands.

Class C: Roof coverings that are effective against **light** fire exposures. Under such exposures, roof coverings of this class:

- Are not readily flammable;
- Afford a measurable degree of fire protection to the roof deck;
- Do not slip from position; and
- Do not produce flying brands.

Non-Rated Roof coverings have not been tested for protection against fire exposure. Under such exposures, non-rated roof coverings:

- May be readily flammable;
- May offer little or no protection to the roof deck, allowing fire to penetrate into attic space and the entire building; and
- May pose a serious fire brand hazard, producing brands that could ignite other structures a considerable distance away.

In very high fire hazard severity zones, new construction and reconstruction are required to have, as a minimum, Class A roofing assemblies. If more than 50 percent of the roof on an existing structure is replaced during any one-year period, the entire roof must then consist of Type A roofing materials. Any repair or replacement of less than ten percent of an existing roof must consist of materials equal to or greater in fire resistance than the existing roof and not less than Class C.

In other areas, when more than 50 percent of the roof area on existing structures is replaced within one year, the entire roof covering must consist of materials equal to or greater than the existing roof and not less than Class B. In addition, any roof materials applied in the alteration, repair, or replacement of 10 percent or more of the roof shall also be equal to or greater than the existing roof and not less than Class B. Repair or replacement of less than 10 percent shall consist of materials equal to or greater than the existing roof and not less than Class C. All new structures in these areas must have Class A roof assemblies. Section 1505 (Table 1505.1) of the 2013 California Building Code provides minimum roof covering classifications for different types of construction.

Attic ventilation openings are also a concern regarding the fire survivability of a structure. Attics require significant amounts of cross-ventilation to prevent the degradation of wood rafters and ceiling joists. This ventilation is typically provided by openings to the outside of the structure, but these openings can provide pathways for burning brands and flames to be deposited within the attic. Therefore, it is important that all ventilation openings be properly screened to prevent this. Additional prevention measures that can be taken to reduce the potential for ignition of attic spaces are to "use non-combustible exterior siding materials and to site trees and shrubs far enough away from the walls of the house to prevent flame travel into the attic even if a tree or shrub does torch" (Fisher, 1995).

In the Very High Fire Hazard Severity Zones in the City of Newport Beach, attic or foundation ventilation openings in vertical walls and attic roof vents must comply with the 2013 California Building Code, Chapter 7A Section 706A.

The type of **exterior wall construction** used can also help a structure survive a fire. Ideally, exterior walls should be made of non-combustible materials such as stucco or masonry. During a wildfire, the dangerous active burning at a given location typically lasts about 5 to 10 minutes (Fisher, 1995), so if the exterior walls are made of non-combustible or fire-resistant materials, the structure has a better chance of surviving. For the same reason, the type of **windows** used in a structure can also help reduce the potential for fire to impact a structure. Single-pane, annealed glass windows are known for not performing well during fires; thermal radiation and direct contact with flames cause these windows to break because the glass under the window frame is protected and remains cooler than the glass in the center of the window. This differential thermal expansion of the glass causes the window to break. Larger windows are more susceptible to fracturing when exposed to high heat than smaller windows. Multiple-pane windows, and tempered glass windows perform much better than single-pane windows, although they do cost more. Fisher (1995) indicates that in Australia, researchers have noticed that the use of metal screens helps protect windows from thermal radiation. Some homeowners may consider the use of exterior, heavy-duty metal blinds that are dropped down into position, at least on the windows in the exposed portion of the structure facing the wildland area.

The City of Newport Beach has construction requirements for **cornices, eaves, overhangs, soffits, and exterior balconies** in Very High Fire Hazard Severity Zones. According to Section 707A of the 2013 California Building Code, these need to be made of non-combustible construction materials, enclosed in one-hour fire-resistive material, or made of heavy timber construction. Space between rafters at the roof overhangs need to be protected by non-combustible materials or protected by double 2-inch nominal solid blocking under the exterior wall covering.

Public Awareness

Individuals can make an enormous contribution to fire hazard reduction and need to be educated about their important role. The Newport Beach Fire Department has several outreach programs aimed at providing fire safety education to the public. These presentations are given to local schools, service clubs and associations, homeowners groups, the Chamber of Commerce, Board of Realtors, businesses and other professional organizations.

The Fire Department has also prepared and distributes informational brochures to hillside property owners. The brochures describe mitigation measures that can be implemented to reduce the fire hazard, and describe how property owners can help themselves to prevent loss of property or life as a result of a wildland fire. In addition to the specific requirements in the Municipal Code mentioned in the sections above regarding appropriate landscaping and construction materials, there are other steps that homeowners can take to reduce the risk of fire on their property. Some of these are listed below. This list is not all-inclusive, but provides a starting point and framework to work from.

- Mow and irrigate your lawn regularly.
- Dispose of cuttings and debris promptly, according to local regulations.
- Store firewood away from the house.
- Be sure the irrigation system is well maintained.
- Use care when refueling garden equipment and provide regular maintenance for your garden equipment.
- Store and use flammable liquids properly.
- Dispose of smoking materials carefully.
- Do not light fireworks (in accordance with the Municipal Code).
- Become familiar with local regulations regarding vegetation clearing, disposal of debris, and fire safety requirements for equipment.
- Follow manufacturers' instructions when using fertilizers and pesticides.
- Keep the gutters, eaves, and roof clear of leaves and other debris.
- Occasionally inspect your home, looking for deterioration, such as breaks and spaces between roof tiles, warping wood, or cracks and crevices in the structure.
- Use non-flammable metal when constructing a trellis and cover it with high-moisture, non-flammable vegetation.
- Install automatic seismic shut-off valves for the main gas line to your house. Information for approved devices, as well as installation procedures, is available from the Southern California Gas Company.

Other Mitigation Programs and Activities

Firewise

This is a program developed within the National Wildland/ Urban Interface Fire Protection Program and it is the primary federal program addressing interface fire. It is administered through the National Wildfire Coordinating Group whose extensive list of participants includes a wide range of federal agencies. The program is intended to empower planners and decision makers at the local level. Through conferences and information dissemination, Firewise increases support for interface wildfire mitigation by educating professionals and the general public about hazard evaluation and policy implementation techniques. Firewise offers online wildfire protection information and checklists, as well as listings of other publications, videos and conferences.

The interactive home page allows users to ask fire protection experts questions and to register for new information as it becomes available.

Wildfire Resource Directory

Local Resources

Newport Beach Fire Department

The Newport Beach Fire Department is responsible for fire suppression on all private lands within the City of Newport Beach. The Newport Beach Fire Department constantly monitors the fire hazard in the City and has ongoing programs for investigation and alleviation of hazardous situations. Fire fighting resources in the immediate Newport Beach area are provided by eight Newport Beach Fire Department Stations (see Table 8-6). The general telephone number for the Newport Beach fire department is **949-644-3104. For emergencies, dial 911.**

Each engine or truck company has a staff of three persons per 24-hour shift. Each paramedic ambulance has a staff of two firefighter-paramedics per 24-hour shift.

Table 8-4: Fire Stations in the City of Newport Beach

Fire Station No.	Street Address	Location Area	Units Available		
			Ladder Trucks	*Engine Companies*	*Paramedic Ambulances*
1	110 Balboa Blvd. East	Balboa	0	1	0
2	475 32nd St.	Lido	1	1	1
3	868 Santa Barbara Dr.	Newport Center	1	1	1
4	124 Marine Avenue	Balboa Island	0	1	0
5	410 Marigold Avenue	Corona del Mar	0	1	1
6	1348 Irvine Avenue	Mariners	0	1	0
7	20401 SW Acacia St.	Santa Ana Heights	0	1	0
8	6502 Ridge Park Road	Newport Coast	0	1	0

Newport Beach has automatic aid agreements with the cities of Costa Mesa, Santa Ana, Huntington Beach, and Fountain Valley, and with the Orange County Fire Authority. These agreements obligate these fire departments to help each other under pre-defined circumstances. **Automatic aid** agreements obligate the nearest fire company to respond to a fire regardless of the jurisdiction. **Mutual aid** agreements obligate fire department resources to respond outside of their district upon request for assistance.

Numerous other agencies are available to assist the City if needed. These include local law enforcement agencies that can provide support during evacuations and to discourage people from traveling to the fire zone to watch the fire, as this can hinder fire suppression efforts. Several State and Federal agencies have roles in fire hazard mitigation, response, and recovery, including: the Office of Emergency Services, the Fish and Wildlife Service, National Park Service, US Forest Service, Office of Aviation Services, National Weather Service, and National Association of State Foresters, the Department of Agriculture, the Department of the Interior, and, in extreme cases, the Department of Defense. Private companies and individuals may also assist.

County Resources

Orange County Fire Authority

1 Fire Authority Road
Irvine, California 92602
Telephone: (714) 573-6000
http://www.ocfa.org/

The Orange County Fire Authority (OCFA) delivers fire, emergency medical and rescue services, and hazardous materials incidents response in the unincorporated Orange County region and, when needed, to its partner cities. It also provides aircraft fire and rescue services to John Wayne Airport.

The Operations Department of the OCFA is divided into six geographic areas referred to as operational divisions, each under the command of a Division Chief. Most divisions are in turn divided into two Battalions, commanded by field Battalion Chiefs. The OCFA has 71 fire stations (5 to 10 stations per Battalion). The OCFA also provides public education programs to schools, businesses, childcare providers and other members of the community, coordinates the inspection of all commercial buildings, investigates all fires, and enforces hazardous materials regulations. The OCFA works with developers and jurisdictional planning departments on development projects that have the potential to impact fire protection services, conducts new construction inspections, fire safety inspections, and State Fire Marshal required inspections to high rises, jails, board and care, and day-care inspections. For a complete list of services and more information on the OCFA, refer to their website.

State Resources

California Division of Forestry & Fire Protection
1416 9th Street
PO Box 944246
Sacramento California 94244-2460
(916) 653-5123
http://www.fire.ca.gov/php/index.php

Office of the State Fire Marshal (OSFM)
1131 "S" Street
Sacramento, CA 95814
PO Box 944246
Sacramento, CA 94244-2460
Tel. (916) 445-8200
Fax. (916) 445-8509

Federal Resources and Programs

The role of the federal land managing agencies in the wildland-urban interface is reducing fuel hazards on the lands they administer; cooperating in prevention and education programs; providing technical and financial assistance; and developing agreements, partnerships and relationships with property owners, local protection agencies, states and other stakeholders in wildland-urban interface areas. These relationships focus on activities before a fire occurs, which render structures and communities safer and better able to survive a fire occurrence.

Federal Emergency Management Agency (FEMA) Programs

FEMA is directly responsible for providing fire suppression assistance grants and, in certain cases, major disaster assistance and hazard mitigation grants in response to fires. The role of FEMA in the wildland-urban interface is to encourage comprehensive disaster preparedness plans and programs, increase the capability of state and local governments and provide for a greater understanding of FEMA programs at the Federal, State and local levels.

- **Fire Suppression Assistance Grants**: Fire Suppression Assistance Grants may be provided to a state with an approved hazard mitigation plan for the suppression of a forest or grassland fire that threatens to become a major disaster on public or private lands. These grants are provided to protect life and improved property and encourage the development and implementation of viable multi-hazard mitigation measures and provide training to clarify FEMA's programs. The grant may include funds for equipment, supplies and personnel. A Fire Suppression Assistance Grant is the form of assistance most often provided by FEMA to a state for a fire. The grants are cost-shared with states. FEMA's US Fire Administration (USFA) provides public education materials addressing wildland-urban interface issues and the USFA's National Fire Academy provides training programs.

- **FEMA Hazard Mitigation Grant Program**: Following a major disaster declaration, the FEMA Hazard Mitigation Grant Program provides funding for long-term hazard mitigation projects and activities to reduce the possibility of damages from all future fire hazards and to reduce the costs to the nation for responding to and recovering from the disaster.

National Wildland/Urban Interface Fire Protection Program

Federal agencies can use the National Wildland/Urban Interface Fire Protection Program to focus on wildland-urban interface fire protection issues and actions. The Western Governors' Association (WGA) can act as a catalyst to involve state agencies, as well as local and private stakeholders, with the objective of developing an implementation plan to achieve a uniform, integrated national approach to hazard and risk assessment and fire prevention and protection in the wildland-urban interface. The program helps states develop viable and comprehensive wildland fire mitigation plans and performance-based partnerships.

U.S. Forest Service Program

The U. S. Forest Service (USFS) is involved in a fuel-loading program implemented to assess fuels and reduce hazardous buildup on forest lands. The USFS is a cooperating agency and, while it has little to no jurisdiction in State and Local Responsibility Areas, it has an interest in preventing fires in the interface, as fires often burn into forest lands.

Other Federal and National Resources

Federal Wildland Fire Policy, Wildland/Urban Interface Protection

This is a report describing federal policy and interface fire. Areas of needed improvement are identified and addressed through recommended goals and actions. http://www.fs.fed.us/land/wdfire7c.htm

National Fire Protection Association (NFPA)

This is the principal federal agency involved in the National Wildland/Urban Interface Fire Protection Initiative. NFPA has information on the Initiatives programs and documents.
Public Fire Protection Division
1 Battery March Park.
P.O. Box 9101
Quincy, MA 02269-9101
Phone: (617) 770-3000

National Interagency Fire Center (NIFC)

The NIFC in Boise, Idaho is the nation's support center for wildland firefighting. Seven federal agencies work together to coordinate and support wildland fire and disaster operations. These agencies include the Bureau of Indian Affairs, Bureau of Land Management, Forest Service, Fish and Wildlife Service, National Park Service, National Weather Service and Office of Aircraft
National Interagency Fire Center
3833 S. Development Ave.
Boise, Idaho 83705
(208) 387-5512
http://www.nifc.gov/

United States Fire Administration (USFA) of the Federal Emergency Management Agency (FEMA)

As an entity of the Federal Emergency Management Agency, the mission of the USFA is to reduce life and economic losses due to fire and related emergencies through leadership, advocacy, coordination and support.
USFA, Planning Branch, Mitigation Directorate
16825 S. Seton Ave.
Emmitsburg, MD 21727
(301) 447-1000
http://www.fema.gov/hazards/fires/wildfires.shtm - Wildfire Mitigation
http://www.usfa.fema.gov/index.htm - U.S. Fire Administration

Additional Resources

Firewise - The National Wildland/Urban Interface Fire Program

Firewise maintains a Website designed for people who live in wildfire prone areas, but it also can be of use to local planners and decision makers. The site offers online wildfire protection information and checklists, as well as listings of other publications, videos and conferences.
Firewise
1 Battery March Park.
P.O. Box 9101
Quincy, MA 02269-9101
Phone: (617) 770-3000
http://www.firewise.org/

Publications:

National Fire Protection Association Standard 299: Protection of Life and Property from Wildfire, National Wildland/Urban Interface Fire Protection Program, (1997), National Fire Protection Association, Washington, D.C.
This document, developed by the NFPA Forest and Rural Fire Protection Committee, provides criteria for fire agencies, land use planners, architects, developers and local governments to use in the development of areas that may be threatened by wildfire. To obtain this resource:
National Fire Protection Association Publications
(800) 344-3555
http://www.nfpa.org or http://www.firewise.org

National Volunteer Fire Council
Provide training courses, tools and resources designed to help firefighters address structural assessments in the wildland urban interface and well as prepare communities before the next wildfire. Their website lists courses for fire personnel and home owners, home assessment tools, videos, apps, and other webpages that provide additional information. http://www.nvfc.org/programs/wildland-fire-assessment-resources

An International Collection of Wildland- Urban Interface Resource Materials
(Information Report NOR- 344). Hirsch, K., Pinedo, M., & Greenlee, J. (1996). Edmonton, Alberta: Canadian Forest Service.
This is a comprehensive bibliography of interface wildfire materials. Over 2,000 resources are included, grouped under the categories of general and technical reports, newspaper articles and public education materials. The citation format allows the reader to obtain most items through

a library or directly from the publisher. The bibliography is available in hard copy or diskette at no cost. It is also available in downloadable PDF form.
Canadian Forest Service, Northern Forestry Centre, I-Zone Series
Phone: (780) 435-7210
http://www.prefire.ucfpl.ucop.edu/uwibib.htm

Wildland/Urban Interface Fire Hazard Assessment Methodology.
National Wildland/Urban Interface Fire Protection Program, (1998).
NFPA, Washington, D.C.
Firewise (NFPA Public Fire Protection Division)
Phone: (617) 984-7486
http://www.firewise.org

Fire Protection in the Wildland/Urban Interface: Everyone's Responsibility.
National Wildland/Urban Interface Fire Protection Program, (1998). Washington, D.C.
Firewise (NFPA Public Fire Protection Division)
Phone: (617) 984-7486
http://www.firewise.org

SECTION 9: LANDSLIDES

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SECTION 9: LANDSLIDES

Why are Landslides a Threat to the City of Newport Beach?

Landslides are a serious geologic hazard in almost every state in the United States. Nationally, landslides cause 25 to 50 deaths each year. The best estimate of direct and indirect costs of landslide damage in the United States ranges between $1 and $2 billion annually. In California, landslides are a significant problem, in part because of the region's seismic activity, and in part because the region is underlain by weak soils and rocks, especially when saturated. Some landslides result in private property damage, whereas other landslides impact transportation corridors, fuel and energy conduits, and communication facilities. They can also pose a serious threat to human life.

The City of Newport Beach is located in an area of widely diverse terrain at the southern margin of the geographic area known as the Los Angeles Basin. The City is bounded on the northwest by the broad, nearly flat-lying coastal plain of Orange County – the great outwash plain of the Santa Ana River. To the northeast lie the foothills of the Santa Ana Mountains and the smaller Tustin Plain. Rugged coastal mountains are present to the south.

The City's landscape can best be described by geographic area, each reflective of its distinct topographic features. The central and northwestern portions of the City are situated on a broad mesa that extends southeastward to join the San Joaquin Hills. Commonly known as Newport Mesa, this upland is comprised of a series of Pleistocene-aged marine terraces uplifted to their present elevation. The mesa has been deeply dissected by stream erosion, resulting in moderate to steep bluffs along the Upper Newport Bay estuary. The nearly flat-topped surface rises from about 50 to 75 feet above mean sea level at the northern end of the estuary in the Santa Ana Heights area, to about 100 feet above sea level in the Newport Heights, Westcliff, and Eastbluff areas.

Along the southwestern margin of the City, sediments flowing from the two major drainage courses that transect the mesa have formed the beaches, sandbars, and mudflats of Newport Bay and West Newport. These lowland areas were significantly modified during the last century in order to deepen channels for navigation and form habitable islands. Balboa Peninsula, a barrier beach that protects the bay, was once the site of extensive low sand dunes.

In the southern part of the City, the San Joaquin Hills rise abruptly from the sea, separated from the present shoreline by a relatively flat, narrow shelf. Originally formed by wave abrasion, this terrace or platform is now elevated well above the water and is bounded by steep bluffs along the shoreline. Elevations of the Balboa Peninsula and the harbor islands generally range from about 5 to 10 feet above sea level. The coastal platform occupied by Corona Del Mar is at an elevation of about 95 to 100 feet above sea level, and the San Joaquin Hills, site of the Newport Coast development area, rise to an elevation of 1,164 feet at Signal Peak.

The two major drainages that have contributed greatly to the development of the City's landforms are the Santa Ana River and San Diego Creek. At one time, the natural course of the Santa Ana River hugged the western side of Newport Mesa, carving steep bluffs and feeding sediment into Newport Bay. In an attempt to reduce flooding on the coastal plain, the river was confined to man-made levees and channels by the early 1920s. North of the City, numerous streams draining the foothills, including Peters Canyon Wash, Rattlesnake Wash, Hicks Canyon, Agua Chinon, and Serrano Creek, merged with San Diego Creek and collectively cut a wide channel through the mesa, later filling it with sediment (Upper Newport Bay and the harbor area). The collected drainages are now contained in the man-made San Diego Creek Channel, and directed into Upper Newport Bay near the intersection of Jamboree Road and University Drive. The Bay also receives water from the Santa Ana Delhi Channel near Irvine Avenue and Mesa Drive.

The portion of the San Joaquin Hills that lies within the City is drained by several deep canyons, including Buck Gully, Los Trancos Canyon, and Muddy Canyon, as well as numerous smaller, unnamed canyons. Carrying significant amounts of water only during the winter, these streams flow directly to the Pacific Ocean. Drainage courses on the north side of the hills, including Bonita and Coyote Creeks, are tributaries of San Diego Creek.

Development in the City began in the late 1800s with the arrival of the railroads and the McFadden (Newport) Pier. Development gradually spread outward from the rail lines and beaches, eventually covering most of Newport Mesa and the low hills to the south. More recently, residential developments and a major transportation corridor (State Route 73) made significant advances into the rugged terrain of the San Joaquin Hills. These types of projects require major earthwork activities, typically involving the movement of millions of cubic yards of earth. Because the severity of geologic hazards increases in the hills, corrective grading often accounts for a significant portion of the overall yardage.

The physical features described in the previous paragraphs are a reflection of the geologic and climatic processes that have played upon this region in the past few million years. The City of Newport Beach lies at the northern end of the Peninsular Ranges, a geologic/geomorphic province characterized by a northwest-trending structural grain aligned with the San Andreas fault, and represented by a series of northwest-trending faults, mountain ranges and valleys stretching from Orange County to the Mexican border. Displacements on faults in this region are mainly of the strike-slip type, and where they have been most recently active, they have deformed the landscape and altered drainage patterns. An example of such faulting in the Newport Beach area is the Newport-Inglewood fault zone, which trends in a southeasterly direction across the Los Angeles Basin, and leaves the coastline at the northwestern corner of the City, continuing offshore to the south. Predominantly right-lateral in movement, the Newport-Inglewood fault is responsible for uplifting the chain of low hills and mesas that extends from Beverly Hills to Newport Beach across the relatively flat coastal plain. The location and structure of the fault zone is known primarily from a compilation of surface mapping and deep, subsurface data, driven initially by an interest in oil exploration (all of the hills and mesas, including Newport Mesa, have yielded petroleum), and later by a shift toward evaluating earthquake hazards. The fault is an active structure and was the source of the 1933 M6.4 Long Beach earthquake. Despite the name, this earthquake was actually centered closer to Newport Beach, near the mouth of the Santa Ana River (Hauksson and Gross, 1991).

The San Joaquin Hills are the westernmost range in the Peninsular Ranges province. The hills are structurally complex, consisting of tilted fault blocks, and numerous north and northwest-trending Tertiary- and Quaternary-age faults. Within the hills, the major structural feature is the Pelican Hill fault zone, which trends northwesterly from Emerald Bay to the Big Canyon area. The fault zone is several hundred feet wide, and has left the adjacent bedrock in a highly sheared, folded, and fractured condition (Munro, 1992; Barrie et al., 1992). The Pelican Hill fault, as well as the other faults exposed in the hills, has largely been determined to be inactive during Holocene time (Clark et al., 1986).

In recent years, scientists have discovered that the northern end of the province, primarily the Los Angeles metropolitan area, is underlain by a series of deep-seated, low-angle thrust faults. When these faults do not reach the surface, they are called "blind thrusts." Faults of this type are thought to be responsible for the uplift of many of the low hills in the Los Angeles Basin, such as the Repetto or Montebello Hills. Previously undetected blind thrust faults were responsible for the M5.9 Whittier Narrows earthquake in 1987, and the destructive M6.7 Northridge earthquake in 1994.

It has long been recognized that the San Joaquin Hills are part of a northwest-trending anticline (a convex fold) that extends from San Juan Capistrano to the Huntington Mesa (Vedder et al., 1957; Vedder, 1975). Research conducted in the past two to three decades has suggested that the anticline, which includes the Newport and Huntington Mesas as well as the San Joaquin Hills, is part of a structure that is being uplifted by an active blind thrust fault that dips southward beneath the area (Grant et al., 1999). The growth of the San Joaquin Hills has been recorded in remnants of marine terraces of various ages that cap the northern and western slopes. These terraces consist of wave-eroded, sediment-covered platforms (similar to the one present at the base of the hills today) that have been uplifted as the hills rose above sea level. Based on measurements of terrace elevations and dating of the sediments, uplift of the hills is thought to have started approximately 1.2 million years ago, and is believed to have continued into the Holocene at a rate of about 0.25 meters per 1,000 years (Barrie et al., 1992; Grant et al., 1999), although additional research is being conducted to confirm this. Recognition of the San Joaquin Hills thrust fault extends the area of active blind thrusts and associated folding southward from Los Angeles into the Newport Beach area (Grant et al., 1999). Furthermore, recent studies have suggested that there are buried thrust faults offshore, in the Southern California Continental Borderland, that are also accommodating crustal shortening (Rivero et al., 2000, 2011). If this is the case, then there are additional potential seismic sources offshore that could cause strong ground shaking and associated secondary hazards, such as landsliding, in Newport Beach.

What is a Landslide?

Landslides are downslope movements of relatively large landmasses, either as nearly intact bedrock blocks, or as jumbled mixes of bedrock blocks, fragments, debris, and soil. Landslides are a type of "mass wasting" which denotes any down slope movement of soil and rock under the direct influence of gravity. The term "landslide" encompasses events such as rock falls, topples, slides, spreads, and flows, and in general, landslides can be broken down into two categories: 1) rapidly moving (mud or debris flows, rock falls, and rock topples), and 2) slow moving (earth flows and slumps). Movement of larger landmasses can range from rapid to very slow. Rapidly moving landslides or debris flows pose the greatest risk to human life, and people living in or traveling through areas prone to rapidly moving landslides are at increased risk of serious injury or worse. Slow moving landslides can cause significant property damage, but are less likely to result in serious human injuries.

Geologists also describe the type of movement of a landslide as either 1) translational (where movement occurs along a relatively planar dipping surface), 2) rotational (where sliding material moves along a curved surface) or 3) wedge (where movement occurs on a wedge-shaped block formed by intersecting planes of weakness, such as fractures, faults and bedding). The size of a landslide usually depends on the geology and the initial cause of the landslide. Landslides vary greatly in their volume of rock and soil, the length, width, and depth of the area affected, frequency of occurrence, and as mentioned above, speed of movement. Shallow slides are generally about 15 feet or less in depth and involve the near surface soil, and possibly the underlying weathered bedrock. Deeper slides most often consist of bedrock blocks, either severely broken or relatively intact, depending on the bedrock structure and mode of failure.
Landslides can be initiated by rainfall, earthquakes, volcanic activity, changes in ground water, disturbance and change of a slope by man-made construction activities, or any combination of these factors. Landslides can also occur underwater, causing large waves that could damage low-

lying coastal areas. The potential for slope failure is dependent on many factors, including slope height, slope steepness, shear strength and orientation of the underlying geologic unit, as well as moisture content. For example, water can increase the plasticity of weak clays lining joints or shears, forming planes of weakness along which a landmass can fail.

For engineering of earth materials, these factors are combined in calculations to determine if a slope meets a minimum safety standard. The generally accepted standard is a factor of safety of 1.5 or greater (where 1.0 is equilibrium, and less than 1.0 is failure). Natural slopes, graded slopes, or graded/natural slope combinations must meet these minimum engineering standards where they impact planned homes, subdivisions, or other types of developments. Slopes adjacent to areas where the risk of economic losses from landsliding is small, such as parks and mountain roadways, are often allowed a lesser factor of safety. From an engineering perspective, landslides are generally unstable (may be subject to reactivation), and may be compressible, especially around the margins, which are typically highly disturbed and broken. The headscarp area above the landslide mass is also unstable, since it is typically oversteepened, cracked, and subject to additional failures. Numerous landslides and suspected landslides consisting of highly fragmented, jumbled bedrock debris as well as largely coherent bedrock blocks were mapped in the San Joaquin Hills. Many of the steeper hillsides in the San Joaquin Hills likely did not meet the minimum factor of safety, and slope stabilization was needed or will be needed prior to development of these areas. In the now-graded areas of Newport Coast, several of these landslide-prone areas are expected to have been made more stable through a variety of engineering methods prior to development.

Failure of a slope occurs when the force that is pulling the slope downward (gravity) exceeds the strength of the earth materials that compose the slope. They can move slowly (millimeters per year), or can move quickly and disastrously, as is the case with debris flows. Debris flows can travel down a hillside at speeds up to 200 miles per hour (more commonly, 30 – 50 miles per hour), depending on the slope angle, water content, and type of earth and debris in the flow. These flows are initiated by heavy, usually sustained, periods of rainfall, but sometimes can happen as a result of short bursts of concentrated rainfall in susceptible areas. Burned areas charred by wildfires are particularly susceptible to debris flows, given certain soil characteristics and slope conditions.

What is a Debris Flow?

This type of failure is the most dangerous and destructive of all types of slope failure. A debris flow (also called mudflow, mudslide, and debris avalanche) is a rapidly moving slurry of water, mud, rock, vegetation and debris. Larger debris flows are capable of moving trees, large boulders, and even cars. This type of failure is especially dangerous as it can move at great speeds, is capable of crushing buildings, and can strike with very little warning. The development of debris flows is strongly tied to exceptional storm periods of prolonged rainfall. Failure occurs during an intense rainfall event, following saturation of the soil by previous rains.

A debris flow most commonly originates as a soil slip in the rounded, soil-filled "hollow" at the head of a drainage swale or ravine. The rigid soil mass is deformed into a viscous fluid that moves down the drainage, incorporating into the flow additional soil and vegetation scoured from the channel. Debris flows also occur on canyon walls, often in soil-filled swales that do not have topographic expression. The velocity of the flow depends on the viscosity, slope gradient, height of the slope, roughness and gradient of the channel, and the effects of baffling by vegetation. Even relatively small amounts of debris can cause damage from inundation and/or impact (Ellen and Fleming, 1987; Reneau and Dietrich, 1987). Recognition of this hazard led FEMA to modify its National Flood Insurance Program to include inundation by "mudslides."

Watersheds that have been recently burned typically yield greater amounts of soil and debris than those that have not burned. Erosion rates during the first year after a fire are estimated to be 15 to 35 times greater than normal, and peak discharge rates range from 2 to 35 times higher. These rates drop abruptly in the second year, and return to normal after about 5 years (Tan, 1998). In addition, debris flows in burned areas are unusual in that they can occur in response to small storms and do not require a long period of antecedent rainfall. These kinds of flows are common in small gullies and ravines during the first rains after a burn, and can become catastrophic when a severe burn is followed by an intense storm season (Wells, 1987). The United States Geological Survey (USGS), as part of its National Landslide Hazards Program, has been developing tools and methodologies to identify and quantify slope stability hazards posed by burned watersheds. These tools include the installation of instruments in recently burned watersheds and canyons to collect data on rainfall, flow stage, soil moisture, and other parameters. The data collected help "advance the understanding of post-fire runoff, erosion, and debris flow generation . . . and provide information from the burned area to the National Weather Service for warning decision-making" (http://landslides.usgs.gov/monitoring/). Such tools help communities with emergency planning and in dealing with post-fire rehabilitation (USGS, 2001).

Historic Southern California Landslides

Historically, there have been many landslides in the Southern California area. Landslides recorded in the 20th century alone caused losses of more than $5 billion (in 2000 dollars). Many of these landslides have occurred after particularly wet winters, others in response to strong ground shaking during an earthquake. Some of the most dramatic of these cases are briefly described below (Highland and Schuster, undated).

1956 Portuguese Bend Landslide, Palos Verdes

Cost: $14.6 million (2000 dollars), on California Highway 14 in the Palos Verdes Hills. The Portuguese Bend landslide is a reactivated ancient slide that began its modern movement in August 1956, when displacement was noticed at its northeast margin. Reactivation is blamed in part to human activity, including the extensive use of septic tanks and seepage pits for residential structures. Movement gradually extended downslope so that the entire eastern edge of the slide mass was moving within six weeks. By the summer of 1957, the entire mass was sliding towards the sea.

1969 Glendora, Los Angeles County

Cost: $26.9 million (2000 dollars), in Los Angeles County. The winter of 1969 was one of the wettest on record in the Southern California area. The rain caused many of the streams draining the San Gabriel Mountains to overflow, resulting in debris flows that damaged 175 houses in the Glendora area alone.

1977-1980 Monterey Park and Repetto Hills, Los Angeles County

Cost, $14.6 million (2000 dollars); 100 houses damaged due to debris flows.

1978 Bluebird Canyon, Orange County

Cost: $52.7 million (2000 dollars); 60 houses destroyed or damaged. On October 2, 1978, a portion of the Bluebird Canyon slope gave way, in great part due to the unusually heavy rains in March that may have contributed to initiation of the landslide. Although the 1978 slide area was approximately 3.5 acres, it is suspected to be a portion of a larger, ancient landslide.

1979 Big Rock, Los Angeles County

Cost: approximately $1.08 billion (2000 dollars; rockslide that caused damage to California Highway 1 (Pacific Coast Highway) in the Malibu area. High groundwater levels attributed to the use of septic tanks is considered a leading cause of this landslide.

1980 Southern California Landslides

Cost: $1.1 billion in damage (2000 dollars). Heavy winter rainfall in 1979-80 caused damage in six Southern California counties. A sequence of five days of continuous rain that started on February 8 dropped more than 7 inches of water by February 14. Slope failures began to develop by February 15 and then very high-intensity rainfall occurred on February 16. As much as 8 inches of rain fell in a 6-hour period in many locations.

1978-1979, 1980 San Diego County

San Diego County experienced major damage from storms in 1978, 1979, and 1979-80, as did neighboring areas of Los Angeles and Orange Counties. One hundred and twenty landslides were reported to have occurred in San Diego County during these two years. Rainfall for the rainy seasons of 1978-79 and 1979-80 was 14.82 and 15.61 inches (37.6 and 39.6 cm) respectively, compared to a 125-year average (1850-1975) of 9.71 inches (24.7 cm). Significant landslides occurred in the Friars Formation, a geologic unit known to be slide-prone. [Of the nine landslides that caused damage in excess of $1 million in the northern part of San Diego County, seven occurred in the Friars Formation, and two in the Santiago Formation.]

1983 San Clemente, Orange County

Cost: $65 million (2000 dollars), California Highway 1. Litigation associated with this landslide ultimately cost approximately $43.7 million (2000 dollars).

1983 Big Rock Mesa, Malibu, Los Angeles County

Cost: $706 million (2000 dollars) in legal claims; 13 houses condemned and 300 more threatened due to rockslide triggered by intense rainfall.

1994 Northridge Earthquake Landslides

As a result of the magnitude 6.7 Northridge earthquake, more than 11,000 landslides occurred over an area of 10,000 km^2. Most landslides occurred in the Santa Susana Mountains and in mountains north of the Santa Clara River Valley. The landslides destroyed dozens of homes, blocked roads, and damaged oil-field infrastructure.

1995 Los Angeles and Ventura Counties Landslides

Above-normal rainfall in March triggered damaging debris flows, deep-seated landslides, and flooding. Several deep-seated landslides were triggered by the storms, the most notable being the La Conchita landslide, which in combination with a local debris flow, destroyed or badly damaged 14 homes in the small town of La Conchita, about 20 km west of Ventura. There also was widespread debris-flow and flood damage to homes, commercial buildings, and roads and highways in areas along the Malibu coast that had been devastated by wildfire two years before.

2005 La Conchita Landslide, Ventura County

Cost – undetermined yet, but most likely in the billions, including litigation. On January 10, 2005 a landslide struck the sea-side community of La Conchita destroying 13 homes, severely damaging 23 others, and killing 10 people. The landslide occurred in an area known for prior landslide activity (more recently in 1995), and was the direct result of intense rainfall in the area, compounded by weak sediments and steep slopes. The landslide material failed almost simultaneously, and descended down the slope as a highly fluid, rapidly moving debris flow, with top speeds estimated at 30 feet per second (ft/sec) (Jibson, 2005).

2005 Blue Bird Canyon Landslide, Laguna Beach, Orange County

Cost – undetermined yet, but probably in the billions, in great part due to litigation. On June 1, a landslide began moving in the area, almost certainly in response to the extremely wet winter rains earlier that year, in January and February. This landslide occurred in the same general area as the 1978 landslides. 17 houses were destroyed, 11 were damaged, and another 23 were threatened. Fortunately, no one died or was seriously hurt.

Conditions Conducive to Slope Failures

Locations at risk from landslides or debris flows include the following:

- ✓ On or close to steep hills;
- ✓ Steep road-cuts or excavations;
- ✓ Existing landslides or places of known historic landslides (such sites often have tilted power lines, trees tilted in various directions, cracks in the ground, and irregular-surfaced ground);
- ✓ Steep areas where surface runoff is channeled, such as below culverts, V-shaped valleys, canyon bottoms, and steep stream channels;
- ✓ Fan-shaped areas of sediment and boulder accumulation at the outlets of canyons; and
- ✓ Canyon areas below hillside and mountains that have recently (within 1-6 years) been subjected to a wildland fire.

The conditions leading to failure can be varied. The most common of these are described in detail below.

Natural Conditions

Natural processes can cause landslides or re-activate historical and pre-historical landslide sites. The removal or undercutting of shoreline-supporting material along bodies of water by currents and waves produces countless small slides each year. Seismic tremors can trigger landslides on slopes historically known to have landslide movement. Earthquakes can also cause additional failure (lateral spreading) that can occur on gentle slopes above steep streams and riverbanks.

Weathering of geologic materials produces conditions conducive to landslides, while human activity often further exacerbates many landslide problems. Many landslides are difficult to mitigate, particularly in areas of large historic movement with weak underlying geologic materials.

Rock falls occur when blocks of material come loose on steep slopes. Weathering, erosion, or excavations, such as those along highways, can cause falls where the road has been cut through bedrock. Rock falls are fast moving with the materials free falling or bouncing down the slope. In falls, material is detached from a steep slope or cliff. The volume of material involved is generally small, but large boulders or blocks of rock can cause significant damage.

As the list of historical landslides suggests, landslides are often triggered by periods of heavy rainfall. Earthquakes, subterranean water flow and excavations may also trigger landslides. Certain geologic formations are more susceptible to landslides than others. Human activities, including locating development near steep slopes, can increase susceptibility to landslide events. Landslides on steep slopes are more dangerous because movements can be rapid.

Wildland fires in hills covered with chaparral are often a precursor to debris flows in burned out canyons. The extreme heat of a wildfire can create a soil condition in which the earth becomes impervious to water by creating a waxy-like layer just below the ground surface. Since the water cannot be absorbed into the soil, it rapidly accumulates on slopes, often gathering loose particles of soil that combine to form a sheet of mud and debris. Debris flows can often originate miles away, upstream, from a developed area, and approach the built environment at the mouth of a canyon at a high rate of speed with little warning.

Impacts of Development

As communities modify their terrain and influence natural processes, it is important to be aware of the physical properties of the underlying soils as they, along with climate, create landslide hazards. Even with proper planning, landslides will continue to threaten the safety of people, property, and infrastructure, and without proper planning, landslide hazards would be even more common and more destructive. The increasing scarcity of buildable land, particularly in urban areas, increases the tendency to build on geologically marginal land. Additionally, hillside housing developments in Southern California are prized for the view lots that they provide.

Thus, although landslides are a natural occurrence, human impacts can substantially affect the potential for landslide failures to occur. Grading and construction can decrease the stability of a hill slope by adding weight to the top of the slope, removing support at the base of the slope, and increasing water content. Grading for road construction and development can increase slope steepness. Other human activities effecting landslides include excavation, drainage and groundwater alterations, and changes in vegetation (as discussed further below). Proper planning and geotechnical engineering if applied judiciously, however, can be implemented to reduce the threat to people, property, and infrastructure posed by unstable slopes.

Excavation and Grading

Slope excavation is common in the development of home sites or roads on sloping terrain. Grading these slopes sometimes results in slopes steeper than the pre-existing natural slopes. Since slope steepness is a major factor in landslides, these steeper slopes can be at an increased risk for landslides. The added weight of fill placed on slopes can also result in an increased landslide hazard. Small landslides can be fairly common along roads, both along the road cut and the road fill sections. Landslides occurring below new construction sites are indicators of the potential impacts stemming from excavation. Alternatively, if unstable slope conditions are recognized and engineered for during grading, originally unstable or marginally stable slopes can be made safer.

Alterations to Drainage and Groundwater Systems

Water flowing through or above ground is often the trigger of landslides. Any activity that increases the amount of water flowing into landslide-prone slopes can increase landslide hazards. Broken or leaking water or sewer lines and seepage fields can be especially problematic, as can water retention facilities that direct water onto slopes. However, even lawn irrigation in landslide-prone locations can result in damaging landslides. Ineffective storm water management and excess runoff can also cause erosion and increase the risk of landslide hazards. Drainage can be affected naturally by the geology and topography of an area. Development that results in an increase in impervious surfaces (such as concrete- or asphalt-paved roads) impairs the ability of the land to absorb water and may redirect water to other areas. Channels, streams, ponding, and erosion on slopes all indicate potential slope problems.

Road and driveway drains, gutters, downspouts, and other constructed drainage facilities can concentrate and accelerate runoff flow. Ground saturation and concentrated velocity flow are major causes of slope problems and may trigger landslides.

Changes in Vegetation

Removing vegetation from very steep slopes can increase landslide hazards. Areas that experience wildfire and land clearing for development may have long periods of increased landslide hazard. Also, certain types of non-native ground covers require extensive irrigation to remain green. As a result, clearing and replacement of native ground covers with non-native covers can lead to an increase in slope failures.

Landslide Hazard Assessment

Hazard Identification

Identifying hazardous locations is an essential step towards implementing more informed mitigation activities. Evidence of past slope failures are found throughout the San Joaquin Hills in Newport Beach. In fact, landslides have been and remain a significant risk as development reaches higher elevations within the hills. Although an active landslide tends to affect a relatively small area (as compared to a damaging earthquake), and is generally a problem for only a short period of time, the dollar loss can be high. Insurance policies typically do not cover landslide damage, and this can add to the anguish of the affected property owners.

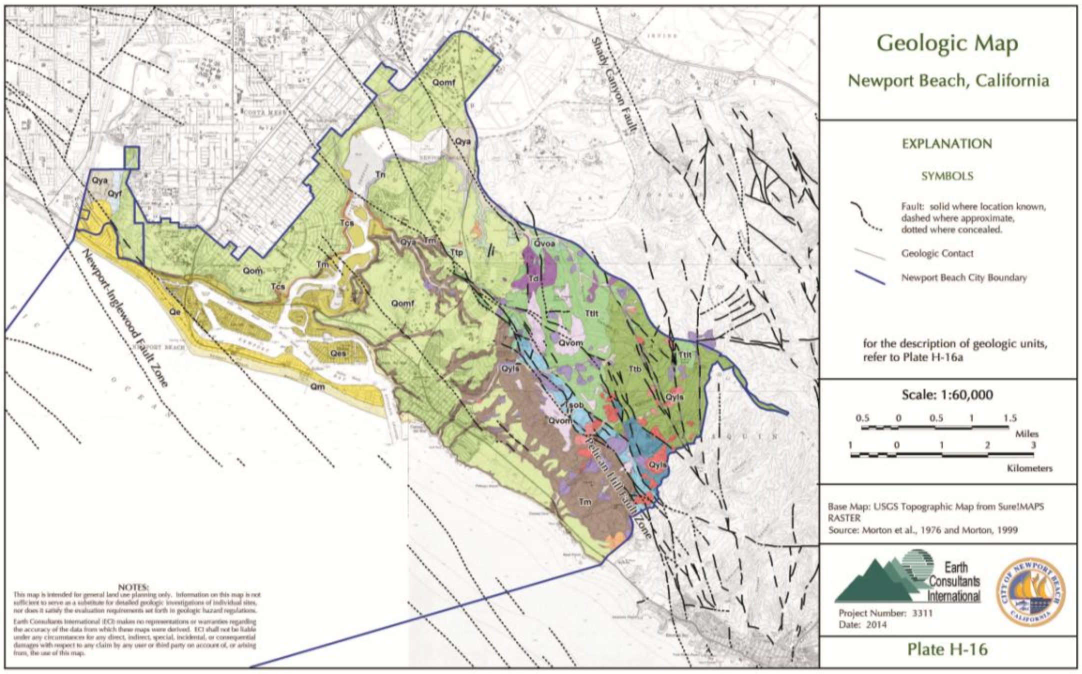
As mentioned before, the San Joaquin Hills contain numerous landslides or suspected landslides composed of highly fragmented, jumbled bedrock debris as well as largely coherent bedrock blocks. Landslides are typically identified by their distinctive morphology, which most often includes a steep, arcuate headscarp, undulating or relatively flat-topped head, and a blocked or diverted drainage at the toe. Most of the slides appear to be rotational failures, occurring in steep natural slopes composed of bedrock weakened by the intense fracturing, shearing and folding in or near the Pelican Hill fault zone. Some of the slides may be block glides associated with the failure of unsupported weak bedding planes. The larger slides are probably more than a hundred feet thick. Landslide materials are commonly porous and very weathered in the upper portions and along the margins. They may also have open fractures and joints. The head of the slide may have a graben (pull-apart area) that has been filled with soil, bedrock blocks and fragments.

Most of the landslides in the San Joaquin Hills are pre-historic in age. The combination of a low sea level in Pleistocene time (when much of the Earth's water was trapped in great ice sheets) and regional tectonic uplift has resulted in the oversteepening of slopes facing small to large stream channels. This, along with the presence of weak bedrock materials, severe deformation associated with the numerous faults that traverse the hills, and a wetter prehistoric climate, have been the major factors contributing to the occurrence of the large number of landslides that cover the hills. Some of these slides have been reactivated in the late Holocene (approximately the past 5,000 years) and, if left untreated, can pose a significant hazard to development.

All the bedrock formations in the San Joaquin Hills have been involved in landsliding, however the most susceptible formations are those that are largely composed of siltstone, claystone, mudstone, and shale, such as the Monterey, Topanga (Los Trancos member), and Vaqueros Formations (see Map 9-1 and Plates H-16 and H-16a). These units are present in the central, southern, and western portions of the hills. The San Onofre Formation, normally resistant to landsliding, occurs as a sheared faulted block within the Pelican Hills fault zone, and as a consequence, has produced several large landslides.

Map 9-1: Geologic Map of Newport Beach

The red zones show areas still undeveloped where landslides have been mapped. Previously mapped landslides in now-graded areas are shown in purple. (For a larger map and an explanation of the geologic units, refer to Plates H-16 and H-16a, respectively.)



The Capistrano siltstone is notorious for large landslides in southern Orange County, where it underlies vast areas of hillside terrain. In Newport Beach, this formation is limited to scattered outcrops along the western bluffs of Newport Bay, and is covered by a protective cap of marine terrace deposits. Consequently, large landslides are not present in this area, and slope instability is generally limited to surficial failures.

Surficial slumps and slides are too small to map at the scale of Map 9-1, however they are common within the hills, typically occurring in the thick soils and deeply weathered bedrock near the base of steep slopes. Soil slips are common throughout the hills during winters of particularly heavy and prolonged rainfall, such as the storms of 1998 that caused several debris flows in the Back Bay Bluffs area.

Much of the accumulated sediment in canyon bottoms, as well as small sediment fans at the mouths of tributary drainages, was probably deposited in mud slurries or debris flows. Catastrophic debris flows, however, have not been reported for the Newport Beach area, probably because most development in the City occurs on elevated areas, rather than vulnerable locations at the base of natural slopes and in canyon bottoms.

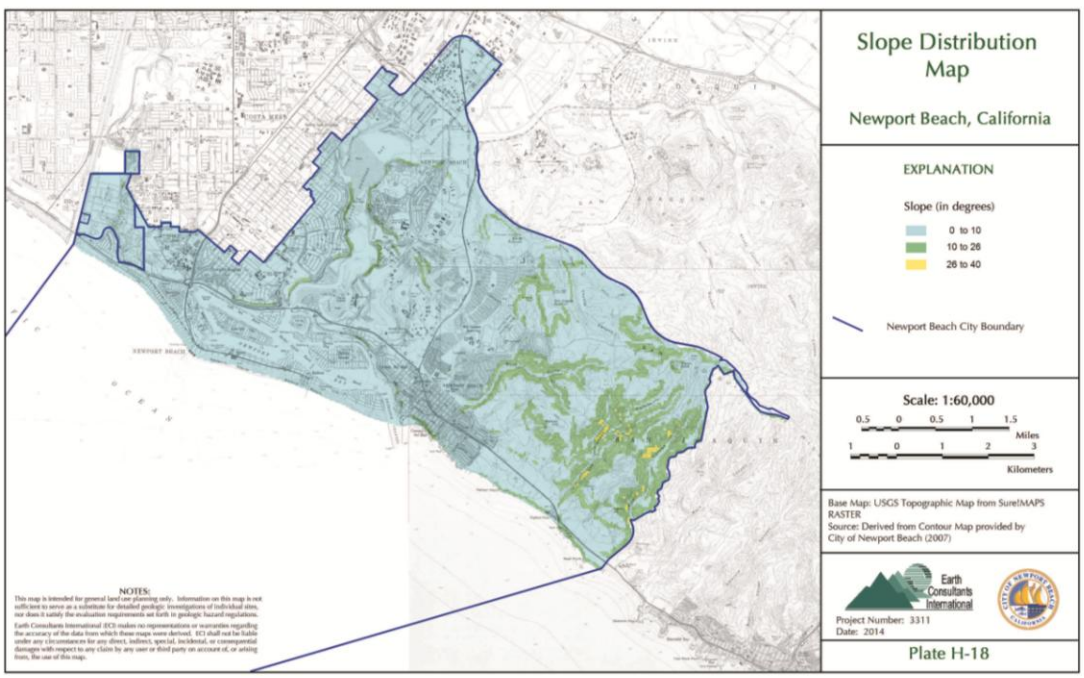
Slopes that are the most susceptible to creep are those composed of weak, fine-grained geologic materials, similar to those that are susceptible to landsliding. Fill slopes constructed with materials excavated from these bedrock units may also show signs of creep over time.

Vulnerability and Risk

A vulnerability assessment for landslides can help predict how different types of property and population groups will be affected by the hazard of unstable slopes. Data that include specific landslide- and debris flow-prone locations in the City can be used to assess the population and total value of property at risk from future landslide occurrences.

The potential for slope failure is dependent on many factors and their interrelationships. Some of the most important factors include slope height, slope steepness, sheer strength, and orientation of weak layers in the underlying geologic units, as well as pore water pressures. [For a map showing steep slopes in the Newport Beach area, refer to Map 9-2 and Plate H-18. This map takes into consideration the grading that has been done in the San Joaquin Hills; the slope height and steepness considered in the analysis is based on a 2007 topographic map provided by the City that shows many of the originally steep slopes have been modified to make them flatter and thus more stable.] Joints and shears, which weaken the rock fabric, allow water to infiltrate deeply into the bedrock, which in turn leads to an increase in the weathering of the rock, increase in pore pressures, increase in the plasticity of weak clays, and an increase in the weight of the landmass. For engineering of earth materials, these factors are combined in calculations to determine if a slope meets a minimum safety standard. The generally accepted standard is a factor of safety of 1.5 or greater (where 1.0 equilibrium, and less than 1.0 is failure).

Map 9-2: Slope Distribution Map of Newport Beach
(for a larger version of this map, refer to Plate H-18 in Appendix H)



Despite the abundance of landslides and relatively recent spread of new development into the San Joaquin Hills, damage from slope failures in Newport Beach has been relatively small compared to other hillside communities, and has more often occurred in older developments. No landslides or slope failures of consequence were reported in Newport Beach during the period between 2008 and 2013.

Some of the areas where landslides have historically been an issue include the Spyglass Hill area, and Galaxy Drive, along the bluffs facing the bay. The limited landslide damage in Newport Beach can probably be attributed to land development fundamentals that have evolved and improved over the last few decades, including stricter hillside grading ordinances, sound project design that avoids severely hazardous areas, soil engineering practices that include detailed preliminary investigations and oversight during grading, and effective agency review of hillside grading projects. The recent trend toward saving biologically rich canyon habitats has the added benefit of keeping developments out of the path of potential slope failures.

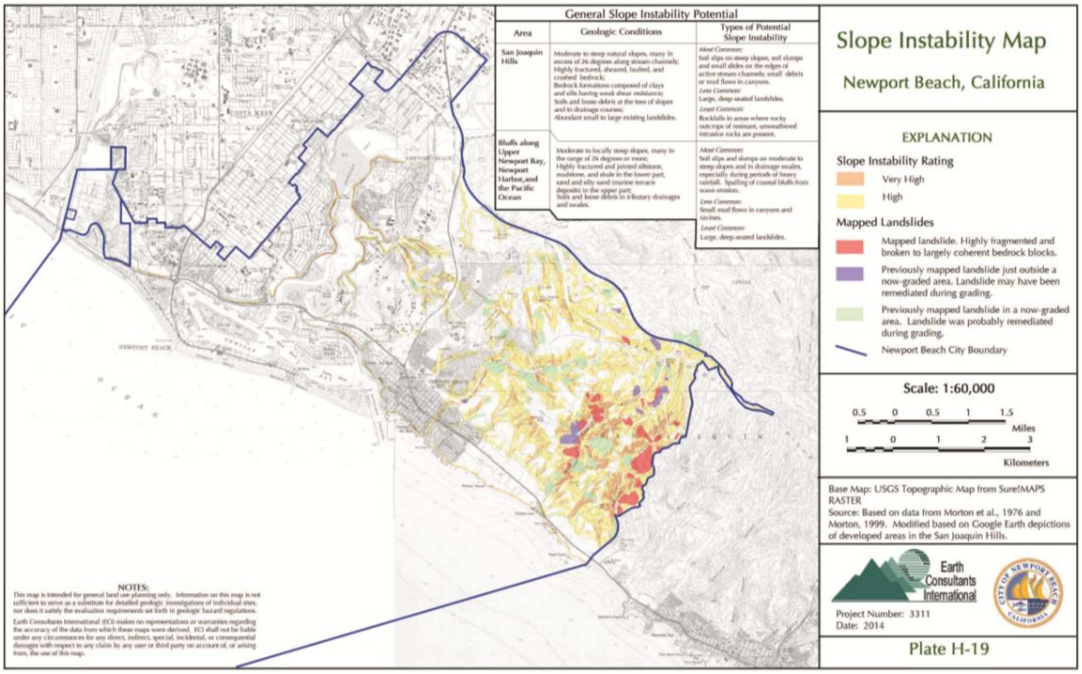
Nevertheless, developments at the top of natural slopes may be impacted by slope failures. Even if a slope failure does not reach the properties above, the visual impact will generally cause alarm to homeowners. The City's remaining natural hillsides and coastal bluff areas are generally vulnerable to the types of slope instability mentioned above. Table 9-1 below is a summary of the geologic conditions in various parts of the City that provide the environment for slope instability to occur. These conditions usually include such factors as terrain steepness, rock or soil type, condition of the rock (such as degree of fracturing and weathering), internal structures within the rock (such as bedding, foliation, faults) and the prior occurrence of slope failures. Catalysts that ultimately allow slope failures to occur in vulnerable terrain are most often water (heavy and prolonged rainfall, or leaky water pipes), erosion and undercutting by streams, man-made alterations to the slope, or seismic shaking. The information in Table 9-1 was used to make the Slope Instability Map (Map 9-3 and Plate H-19).

Table 9-1: General Slope Instability Potential Within the City of Newport Beach

Area	Geologic Conditions	Types of Potential Slope Instability
San Joaquin Hills	Moderate to steep natural slopes, many in excess of 26 degrees along stream channels; Highly fractured, sheared, faulted, and crushed bedrock; Bedrock formations composed of clays and silts having weak shear resistance; Soils and loose debris at the toes of slopes and in drainage courses; Abundant small to large existing landslides.	***Most Common***: Soil slips on steep slopes, soil slumps and small slides on the edges of active stream channels; small debris or mudflows in canyons. ***Less Common:*** Large, deep-seated landslides. ***Least Common***: Rockfalls in areas where rocky outcrops of resistant, unweathered intrusive rocks are present.
Bluffs along Upper Newport Bay, Newport Harbor, and the Pacific Ocean	Moderate to locally steep slopes, many in the range of 26 degrees or more; Highly fractured and jointed siltstone, mudstone, and shale in the lower part, sand and silty sand (marine terrace deposits) in the upper part; Soils and loose debris in tributary drainages and swales.	***Most Common***: Soil slips and slumps on moderate to steep slopes and in drainage swales, especially during periods of heavy rainfall. Spalling of coastal bluffs from wave erosion. ***Less Common***: Small mudflows in canyons and ravines. ***Least Common:*** Large, deep-seated landslides.

Map 9-3: Slope Instability Map of Newport Beach

Red zones are mapped landslides in still mostly undeveloped land; purple and green zones are previously mapped landslides in or near now-graded areas, respectively; orange zones have a very high instability rating, yellow areas have a high slope instability rating.
(For a larger version of this map refer to Plate H-19 in Appendix H.)



Community Landslide Issues

What is Susceptible to Landslides?

The City's hillsides are vulnerable to the types of slope instability mentioned above. Steep-sided slopes in the San Joaquin Hills and along deeply incised drainages may be locally susceptible to slope instability. Table 9-1 above is a general summary of the geologic conditions in various parts of the City that provide the environment for slope instability to occur.

Factors included in assessing landslide risk include population and property distribution in the hazard area, the frequency of landslide or debris flow occurrences, slope steepness, soil characteristics, and precipitation intensity. This type of analysis could generate estimates of the damages to the City due to a specific landslide or debris flow event. At the time of publication of this plan, data were insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available. However, a generalized review of the potentially unstable slope areas in the City, as shown on Map 9-3, and comparison with the location of the City's critical/essential facilities (Plate H-1) shows that most of the essential facilities in the City are not located in an area susceptible to slope instability. Fire Station No. 8 on Ridge Park Road is located in an area of high to very high slope instability susceptibility, and while the fire station site proper is not expected to be impacted by landsliding, some of the areas that it services, including access roads, could be impacted during periods of intense precipitation, or as a result of ground shaking.

Landslides can also affect utility services, transportation systems, and critical lifelines. Communities may suffer immediate damages and loss of service. For example, the road leading to San Joaquin Reservoir is flanked by terrain that in the past has experienced landslide activity, and where the slope instability susceptibility is mapped as high. During an earthquake, or as a result of intense and/or protracted rainfall, the road could be impacted by slope failures. Disruption of infrastructure, roads, and critical facilities may also have a long-term effect on the economy. Utilities, including potable water, wastewater, telecommunications, natural gas, and electric power are all essential to service community needs. Loss of electricity has the most widespread impact on other utilities and on the whole community. Natural gas pipes may also be at risk of breakage from landslide movements as small as an inch or two. Some of these issues are discussed in more detail below.

Roads and Bridges

It is not cost-effective to mitigate all slides because of limited funds and the fact that some historical slides are likely to become active again even with mitigation measures. The City alleviates problem areas by grading slides, and by installing new drainage systems on the slopes to divert water from the landslides. This type of response activity is often the most cost-effective in the short-term, but is only temporary.

Lifelines and Critical Facilities

Lifelines and critical facilities should remain accessible, if possible, during a natural hazard event. The impact of closed transportation arteries may be increased if the closed road or bridge is critical for hospitals and other emergency facilities. Therefore, inspection and repair of critical transportation facilities and routes is essential and should receive high priority. Losses of power, gas, water, communication and sewer services are also potential consequences of landslide events. Due to heavy rains, soil erosion in hillside areas can be accelerated, resulting in loss of soil support beneath high voltage transmission towers in hillsides and remote areas. Flood events can also cause landslides, which can have serious impacts on gas lines that are located in vulnerable soils.

Landslide Mitigation Activities

Landslide mitigation activities feature current mitigation programs and activities that have been and are being implemented by developers, residents, and State and City agencies. All proposed development projects require a site-specific geotechnical evaluation of any slopes that may impact the future use of the property. This includes existing slopes that are to remain, and any proposed graded slopes. The investigation typically includes borings to collect geologic data and soil samples, laboratory testing to determine soil strength parameters, and engineering calculations. Numerous soil-engineering methods are available for stabilizing slopes that pose a threat to development. These methods include designed buttresses (replacing the weak portion of the slope with engineered fill); reducing the height of the slope; designing the slope at a flatter gradient; and adding reinforcements such as soil cement or layers of geogrid (a tough polymeric net-like material that is placed between the horizontal layers of fill). Most slope stabilization methods include a subdrain system to remove excessive ground water from the slope area. If it is not feasible to mitigate the slope stability hazard, building setbacks are typically imposed.

For debris flows, assessment of this hazard for individual sites should focus on structures located or planned in vulnerable positions. This generally includes canyon areas; at the toes of steep, natural slopes; and at the mouth of small to large drainage channels. Mitigation of soil slips, earthflows, and debris flows is usually directed at containment (debris basins), or diversion (impact walls, deflection walls, diversion channels, and debris fences). A system of baffles may be added upstream to slow the velocity of a potential debris flow. Other methods include removal of the source material, placing subdrains in the source area to prevent pore water pressure buildup, or avoidance by restricting building to areas outside of the potential debris flow path.

There are numerous methods for mitigating rock falls. Choosing the best method depends on the geological conditions (i.e., slope height, steepness, fracture spacing, bedding orientation), safety, type and cost of construction repair, and aesthetics. A commonly used method is to regrade the slope. This ranges from locally trimming hazardous overhangs, to completely reconfiguring the slope to a more stable condition, possibly with the addition of benches to catch small rocks. Another group of methods focuses on holding the fractured rock in place by draping the slope with wire mesh, or by installing tensioned rock bolts, tie-back walls, or even retaining walls. Shotcrete is often used on slope faces to prevent raveling in highly fractured rock, but its primary purpose is to offer surface protection only. A third type of mitigation includes catchment devices at the toe of the slope, such as ditches, walls, or combinations of both. Designing the width of the catchment structure requires analysis of how the rock will fall. For instance, the slope gradient and roughness of the slope determines if rocks will fall, bounce, or roll to the bottom. Rock slope stabilization may also include the addition of drains in order to reduce water pressure within the slope (Wyllie and Norrish, 1996).

There are a number of options for management of potential slope instability in developed hillsides.

1. Complete a detailed survey and assessment of existing developments in areas recognized to be vulnerable to potential slope failures (for instance, the San Joaquin Hills).
2. Protect existing development and population where appropriate by physical controls such as drainage, slope-geometry modification, protective barriers, and retaining structures.
3. Implement monitoring or warning systems. For instance, in some recently burned watersheds, the USGS, in cooperation with the National Weather Service, installs and operates a system for real-time warnings for storm-related slope failures (Keefer et al., 1987; http://landslides.usgs.gov/monitoring/). Using a combination of tracking storm systems, measuring actual rainfall with a network of rain gauges, and comparing thresholds for the initiation of debris flows, they are able to issue Flash Flood/Debris Watches during the most intense storms, as necessary.
4. Post warning signs in areas of potential slope instability.
5. Encourage homeowners to use landscaping methods that help stabilize the hillsides.
6. Incorporate recommendations for potential slope instability into geologic and soil engineering reports for additions and new grading.
7. Educate the public about slope stability, including the importance of maintaining drainage devices. USGS Fact Sheet FS-071-00 (May, 2000) and the CGS Note 33 (November, 2001) provide public information on landslide and mudslide hazards. These are available on the internet (see Appendices A and B).

Landslide Resource Directory

City Resources

City of Newport Beach Community Development Department

100 Civic Center Drive
Newport Beach, California 92660
Ph: 949-644-3309

This City department administers the City's land use policies, as well as the City's zoning, building, subdivision, and environmental regulations to ensure the orderly physical growth of the community. The Planning and Building Divisions are responsible for planning, building plan checks, permit issuance, and inspection, among other programs. The City has received the highest grade possible from ISO (the Insurance Services Office) for building code enforcement.

County Resources

Orange County Department of Planning and Development Services

Development Processing Center
300 North Flower, Room 122
Santa Ana, CA 92705
Ph: 714-834-2626

State Resources

California Geological Survey, Southern California Regional Office

320 W. 4th Street, Suite 850
Los Angeles, CA 90013
Ph: 213-239-0877
Fax: 213-239-0894

California Geological Survey, Headquarters

801 K Street, MS 12-30
Sacramento, CA 95814
Ph: 916-445-1923
Fax: 916-445-5718

California Division of Forestry, Headquarters

1416 9th Street
PO Box 944246
Sacramento, CA 94244-2460
Ph: 916-653-5123

California Department of Water Resources

1416 9th Street
Sacramento, CA 95814
Ph: 916-653-6192
Flood Operations Center Ph: 800-952-5530
Fax: 916-653-4684

Governor's Office of Emergency Services (Cal OES)

3650 Schriever Avenue
Mather, CA 95655
Ph: 916-845-8510; Fax: 916-845-8511
www.caloes.ca.gov

California Department of Transportation (Cal Trans) – District 12
3347 Michelson Drive, Suite 100
Irvine, CA 92612
Ph: 949-724-2000

Federal Resources and Programs

Federal Emergency Management Agency (FEMA) – Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052
Ph: 510-627-7100
Fax: 510-627-7112
Southern California Field Office Ph: 626-851-7900

Natural Resource Conservation Service (NRCS)
National Water and Climate Center
1201 NE Lloyd Boulevard, Suite 802
Portland, OR 97232-1274
Ph: 503-414-3031

US Geological Survey, National Landslide Information Center
Mail Stop 966, Box 25046
Denver Federal Center
Denver, CO 80225
Ph: 800-654-4966 or 303-273-8588
Fax: 303-273-8600

National Oceanic and Atmospheric Administration
National Weather Service
San Diego Weather Forecast Office
11440 W. Bernardo Court, Suite 230
San Diego, CA 92127
Ph: 858-675-8700

Publications

(for References, Refer to Appendix I)

Olshansky, Robert B., Planning for Hillside Development (1996) American Planning Association.
This document describes the history, purpose, and functions of hillside development and regulation and the role of planning, and provides excerpts from hillside plans, ordinances, and guidelines from communities throughout the US.

Olshansky, Robert B. & Rogers, J. David, Unstable Ground: Landslide Policy in the United States (1987) Ecology Law Quarterly.
This report discusses the history and policy of landslide mitigation in the US.

Public Assistance Debris Management Guide (July 2000) Federal Emergency Management Agency.
The Debris Management Guide was developed to assist local officials in planning, mobilizing,

organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be compliant with local and city emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The Guide is available in hard copy or on the FEMA website.

<u>USGS Landslide Program Brochure</u>. National Landslide Information Center (NLIC), United States Geologic Survey.

The brochure provides good, general information in simple terminology on the importance of landslide studies and a list of databases, outreach, and exhibits maintained by the NLLC. The brochure also includes information on the types and causes of landslides, rock falls, and earth flows.

SECTION 10: WINDSTORMS

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SECTION 10: WINDSTORMS

Why are Windstorms a Threat to the City of Newport Beach?

Severe windstorms can pose a significant risk to property and life in the region by creating conditions that disrupt essential systems such as public utilities, telecommunications, and transportation routes. High winds can and do occasionally cause damage to local homes and businesses. This section discusses the specific hazards associated with unusual and potentially damaging wind activity based on historic records and scientific data.

Definitions and Setting

Wind is air that is in motion relative to the earth. It generally has both horizontal and vertical components, but the horizontal component generally dominates (National Research Council, Committee on Natural Disasters – NRC, CND, 1993). Due to friction, wind speed drops off at the ground surface, with approximately 50% of the transition in wind speed due to frictional forces exerted by the ground surface occurring in the first six feet above the ground. As a result, "near-surface wind is the most variable of all meteorological events" (NRC, CND, 1993), and it generally consists of a combination of high-frequency oscillations in both speed and direction superimposed on a more consistent flow with a prevailing speed and direction. With an increase in wind speed, the high-frequency oscillations can become more abrupt and of greater amplitude – these are referred to as wind gusts. Because wind speeds vary as a function of height, time and the terrain upwind, it is difficult to obtain a value that is representative of the wind speeds over a large region. The general convention for measuring wind speed is at a height of 33 feet (10 m), in flat, open terrain, such as that provided by an airport field. Temporal variations are taken into account by averaging speed and direction over a given time, typically 1-minute averages for sustained wind, and 2- to 5-second averages for peak or extreme winds. The mean annual wind speed for the contiguous 48 states is 8 to 12 miles per hour (mph), with most areas of the country frequently experiencing 50-mph winds (NRC, CND, 1993).

To better appreciate the impact that wind has on the sea and land, and the wind speeds required to move different objects, refer to the Beaufort scale in Table 10-1. This scale was developed by Sir Francis Beaufort in 1805 to illustrate and measure the effect that varying wind speed can have on sea swells and structures. Note that the highest wind speeds in the Beaufort scale approach the lowest wind speed on the Fujita scale presented in Table 10-2.

Types of High Winds in Southern California

Santa Ana Winds

Most incidents of high wind in southern California are the result of ***Santa Ana wind*** conditions. Santa Ana winds are generally dry, often dust-bearing, winds that blow from the east or northeast toward the coast, and offshore (Figure 10-1). These winds commonly develop when a region of high atmospheric pressure builds over the Great Basin – the arid high plateau that covers most of Nevada and parts of Utah, between the Sierra Mountains on the west and the Rocky Mountains to the east. Clockwise circulation around the center of this high-pressure area forces air downslope from the plateau. As the air descends toward the California coast, it may warm at a rate of about 5 degrees Fahrenheit per 1,000 feet elevation, although this does not always happen. Since the air originates in the high deserts of Utah and Nevada, it starts out already very low in moisture; if heated, it dries out even further. The wind picks up speed as it hits the passes and canyons in the coastal ranges of southern California, blowing with exceptional speed through the Santa Ana Canyon (from where these strong winds derive their name). Forecasters at the National Weather Service usually reserve the use of "Santa Ana" winds for those with sustained speeds over 25 knots (1 knot = 1.15 mph); as they move through passes and canyons, these winds may reach speeds of 35 knots, with gusts of up to 50 to 60 knots (see Table 10-1).

Table 10-1: The Beaufort Scale

Beaufort Force	Wind Speed (mph/ knots)	Wind Description – State of Sea – Effects on Land
0	< 1; <1	Calm – Mirror-like – Smoke rises vertically.
1	1 - 3 / 1 - 3	Light – Scaly ripples; no foam crests – Smoke drifts show direction of wind, but wind vanes do not.
2	4 - 7 / 4 - 6	Light Breeze – Small but pronounced wavelets; crests do not break – Wind vanes move; leaves rustle; you can feel wind on face.
3	8 - 12 / 7 - 10	Gentle Breeze – Large wavelets; crests break; glassy foam; a few whitecaps – Leaves and small twigs move constantly; small, light flags are extended.
4	13 - 18 / 11 - 16	Moderate Breeze – Small (1-4 ft) waves; numerous whitecaps – Wind lifts dust and loose paper; small tree branches move.
5	19 - 24 / 17 - 21	Fresh breeze – Moderate (4-8 ft) waves taking longer to form; many whitecaps; some spray – Small trees with leaves begin to move.
6	25 - 31 / 22 - 27	Strong Breeze – Some large (8-13 ft) waves; crests of white foam; spray – Large branches move; wires whistle.
7	32 - 38 / 28 - 33	Near Gale – Sea heaps up; waves 13-20 ft; white foam from breaking waves blows in streaks with the wind – Whole trees move; resistance felt walking into the wind.
8	39 - 46 / 34 - 40	Gale – Moderately high (13-20 ft) waves of greater length; crests break into spin drift, blowing foam in well-marked streaks; Twigs and small branches break off trees; difficult to walk.
9	47 - 54 / 41-47	Strong Gale – High waves (20 ft) with wave crests that tumble; dense streaks of foam in wind; poor visibility from spray – Slight structural damage; shingles blow off roofs.
10	55 - 63 / 48 - 55	Storm – Very high (20-30 ft) waves with long, curling crests; sea surface appears white from blowing foam; heavy tumbling of sea; poor visibility – Trees broken or uprooted; considerable structural damage.
11	64 – 73 / 56 - 63	Violent Storm – Waves high enough (30-45 ft) to hide small and medium-sized ships; sea covered with patches of white foam; edges of wave crests blown into froth; poor visibility – Seldom experienced inland; considerable structural damage.
12	> 74 / > 64	Hurricane – Sea white with spray; foam and spray render visibility almost non-existent; waves over 45 ft high – Widespread damage; very rarely experienced on land.

Sources: www.spc.noaa.gov/faq/tornado/beaufort.html; http://www.stormfax.com/beaufort.htm

Santa Ana winds are common in the southern California area, occurring on a yearly basis in the region, typically in the fall through early spring. For the most part these winds are a nuisance, bringing dust indoors, breaking tree branches, and causing minor damage. For people with respiratory conditions, however, Santa Ana winds often mean headaches, sinus pain, difficulty breathing, and even asthma attacks. Strong Santa Ana winds can cause extensive damage to trees, utility poles, vehicles and structures, and can even be deadly. In 2003, for example, two deaths were blamed on these strong winds: a downed tree struck and killed a woman in San Diego, and a passenger in a vehicle was struck by a flying pickup truck cover (http://cbsnew.com/ January 8, 2003 article). Wildfires in southern California often occur during Santa Ana wind conditions, when the air humidity is low to very low. Because the winds fan and help spread these fires, Santa Ana wind conditions always are serious concerns to fire fighters.

Thunderstorm-Related Tornadoes

A variety of mechanisms give rise to ***thunderstorms***, but most often these develop when warm, moist air meets a cold front, producing strong winds, and sometimes tornadoes and hail. More than 100,000 thunderstorms occur every year in the United States, and more than 10,000 of these are considered severe, resulting in annual property losses in excess of $1 billion (NRC, CND, 1993). Most of these occur in the central Great Plains and the southeastern coastal states, but thunderstorms do occur in every state. A thunderstorm is officially labeled as severe if: 1) it produces a tornado, 2) has winds in excess of 58 mph, or 3) produces surface hail greater than 0.75 inch in diameter. An exceptionally severe thunderstorm can generate several tornadoes and downbursts.

Tornadoes are "violently rotating columns of air extending from a thunderstorm to the ground (http://www.nssl.noaa.gov/edu/safety/tornadoguide.html; Figure 10-2). Although tornadoes occur in many parts of the world, they are most common in the Central Plains of the United States, east of the Rocky Mountains, where they often occur during the spring and summer months. In the spring, tornadoes often form where warm, moist air from the east meets hot, dry air from the west (this boundary is called a "dryline"). In the winter and early spring, tornadoes can also develop when strong frontal weather systems originating in the central states move eastward. Thunderstorms, and associated tornadoes, also form at the range front, where near-ground air is forced to move "upslope" along the ascending mountain slopes. In California, tornadoes are occasionally generated by strong storms. Although the number of tornadoes reported in California is only a fraction of those reported in the central states, California does get its share of these strong winds. In the 30 years between 1959 and 1988, 133 tornadoes were reported in California, for an average of 4 tornadoes a year (NRC-CND, 1993).

Figure 10-1: View From Space of Smoke from the October 2003 Fires in Southern California, Carried Offshore by Strong Santa Ana Winds

Source: Image by Jacques Descloitres, MODIS Rapid Response Team at NASA/GSFC, obtained from the archives at http://visibleearth.nasa.gov/

Figure 10-2: View of a Tornado

Source:
http://www.photolib.noaa.gov/700s/nssl0123.jpg

Tornadoes can also accompany tropical storms and hurricanes as they move on land, where they usually occur ahead of the path of the storm center as it comes onshore (http://www.nssl.noaa.gov/edu/safety/tornadoguide.html). Weak tornadoes that form over warm water are called ***waterspouts***. Occasionally, waterspouts can move on land and become tornadoes. ***Funnel clouds*** are cone-shaped or needle-like clouds that extend downward from the main cloud base but do not touch the ground surface. If a funnel cloud touches the ground, it becomes a tornado; if it touches or moves across water, it is a waterspout. Waterspouts that have moved onto land are more often reported in southern California in the fall and winter, but some have also been reported in the spring. A few of these have historically caused significant damage. For instance, on April 6, 1926, a waterspout that came on land at National City, near San Diego, unroofed several homes and injured eight people; one on February 12, 1936 unroofed two homes, blew down five oil derricks and injured six people.

To measure the intensity, area and strength of a tornado, in 1973 Dr. Ted Fujita (then with the University of Chicago) and Allen Pearson (at the time director of the National Severe Storm Forecast Center) introduced the Fujita-Pearson Tornado Intensity Scale (see Table 10-2). An improvement over the scale first published by Dr. Fujita in 1971, this scale compared the estimated wind velocity with the corresponding amount of damage to human-built structures and vegetation (a component first introduced by Fujita) and the width and length of the tornado path (the component added by Pearson). The scale classified tornadoes into six levels (from F0 to F5) with larger numbers indicating more damaging and larger tornadoes (the Fujita scale smoothly divided wind speed between the highest Beaufort level and Mach 1.0 into 12 levels – F0 through F12, but recognized that an F6 tornado would be inconceivable, and indeed no tornado above F5 has ever been measured.

Table 10-1: The Fujita-Pearson Tornado Damage Scale

Scale	Wind Speed Estimate (mph)	Average Damage Path Width (feet)	Typical Damage
F0	40 - 72	30 - 150	**Light** damage (gale tornado). Some damage to chimneys and television antennas; twigs and branches break off trees; winds push over shallow-rooted trees; sign boards are damaged.
F1	73 – 112	100 - 500	**Moderate** damage (weak tornado). Winds peel off roofs; windows break; light trailer homes are pushed off their foundations or overturned; some trees are uprooted or snap; moving autos are pushed off the road; attached garages may be destroyed. Hurricane speed starts at 74 mph.
F2	113 – 157	360 - 820	**Considerable** damage (strong tornado). Roofs are torn off frame houses, leaving strong walls upright; weak rural buildings are demolished; trailer homes are destroyed; large trees snap or are uprooted; railroad boxcars are pushed over; light objects become airborne missiles; cars are blown off highways.
F3	158 – 206	650 – 1,650	**Severe** damage (severe tornado). Roofs and some walls are torn off well-constructed frame structures; some rural buildings are completely demolished; trains are overturned; steel-framed hangars and warehouse-type structures are torn; cars are lifted off the ground; most trees are uprooted, snapped or leveled.
F4	207 – 260	1,300 – 3,000	**Devastating** damage (devastating tornado). Well-constructed frame houses are leveled, leaving piles of debris; steel structures are badly damaged; trees are de-barked by small flying objects; cars and trains are thrown some distances or roll considerable distances; large objects become missiles.
F5	261 – 318	~ 3,600	**Incredible** damage (incredible tornado). Strong, whole-frame houses are lifted off their foundations and carried considerable distances; steel-

Scale	Wind Speed Estimate (mph)	Average Damage Path Width (feet)	Typical Damage
			reinforced concrete structures are badly damaged; automobile-sized missiles are generated and carried through the air >100 meters; trees are debarked.
F6	319 –379		**Inconceivable** damage: These winds are unlikely. Should a tornado with maximum speed in excess of F5 occur, the extent and type of damage may not be conceived. A number of airborne missiles, such as refrigerators, water heaters, storage tanks, automobiles, etc. create serious secondary damage on structures.

The Fujita-Pearson scale was used to classify all tornadoes reported after its introduction in 1973, in addition to retroactively classify all tornadoes reported since 1950 that were listed in the National Oceanic and Atmospheric Administration's (NOAA) national tornado database.

Fujita's wind estimates have since been found to be inaccurate, with the original wind speed estimates higher than the wind speeds actually required to incur the damage described in each category, especially for tornadoes classified as F3 or larger. In response to these criticisms, a new **Enhanced Fujita** (EF) **scale** for tornado damage was developed between 2004 and 2006. The EF scale, which was officially implemented in the United States on February 1, 2007, is considered an improvement over the old scale: engineers and meteorologists estimated the wind speeds in the new scale (although actual speed winds have not been empirically measured), and records of past tornadoes were reviewed to better equate the wind speeds with the storm damage reported. The new scale also includes more types of structures and vegetation in the damage assessment, and better accounts for differences in construction quality. Similar to the original Fujita scale, the EF scale has six levels of tornado damage, EF-0 to EF-5 (see Table 10-3). A researcher assigning a level of damage to a tornado using the EF scale needs to refer to a list of 28 different damage indicators (DI) or types of structures and vegetation, and then the degree of damage (DoD) for each. Damage indicators include barns or farm outbuildings, residences, manufactured homes (with distinctions made for single-wide and double-wide), apartments, masonry buildings, strip malls, automobile lots, elementary schools, low-, middle- or high-rise buildings (each a different category of indicator), electrical transmission lines, free-standing towers, and softwoods or hardwood trees. The new scale is likely to be modified or updated as new tornado data become available.

Table 10-3: Enhanced Fujita Scale

Scale	Wind Speed Estimate		Relative Frequency (%)
	mph	Km/h	
EF-0	65 - 85	105 - 137	53.5
EF-1	86 - 110	138 - 178	31.6
EF-2	111- 135	179 – 218	10.7
EF-3	136 – 165	219 – 266	3.4
EF-4	166 – 200	267 – 322	0.7
EF-5	> 200	> 322	< 0.1

Macrobursts and Microbursts

Storm researcher Dr. Ted Fujita first coined the term "***downburst***" to describe a strong, straight-direction surface wind in excess of 39 miles per hour (mph) caused by a small-scale, strong downdraft from the base of a thundershower and thunderstorm cell. Unlike tornadoes, the origin of a downburst is downward-moving air from a thunderstorm's core (as opposed to the upward movement of air associated with tornadoes). Downbursts are further classified into macrobursts and microbursts.

Macrobursts are downbursts with winds up to 117 mph that spread across a path greater than 2.5 miles wide at the surface, and which last from five to 30 minutes. ***Microbursts*** are confined to smaller areas, less than 2.5 miles in diameter from the initial point of downdraft impact. An intense microburst can result in winds near 170 mph but often lasts less than five minutes. Like tornadoes, microbursts can do significant damage: When a microburst hits a tree, the winds strip the limbs and branches off it; a microburst that hits a house has the potential to flatten the structure. After striking the ground, a powerful outward-running gust can generate significant damage along its path. Damage associated with a microburst appears to have been caused by a tornado, except that the damage pattern away from the impact area is characteristic of straight-line winds, rather than the twisted pattern typical of tornado damage.

Microbursts are particularly dangerous to aircraft landing or taking off, and have caused several planes to crash, with resultant loss of life. Microbursts have also been responsible for capsizing and sinking ships, causing structural damage in many communities, lifting roofs off structures, downing electrical lines, and generally causing millions of dollars in damage. Most of the microbursts reported have occurred in the northeastern and central parts of the United States, including New York, New Jersey, Massachusetts, Ohio, and Kansas, but microbursts have also been reported in Arizona and Utah (http://en.wikipedia.org/wiki/Microburst#Danger_to_aircraft), and in southern California. On March 29, 1998, in a Lake Elsinore neighborhood, an apparent microburst uprooted a tree and ripped two 20-foot sections of roofing tiles from a home. A funnel cloud was also spotted that afternoon near Dulzura, to the east-southeast of San Diego. On August 12, 2012, also in the Lake Elsinore area, a microburst knocked down several power poles and trees, and damaged the roofs of several houses (http://latimesblogs.latimes.com/lanow/2012/08/microburst-blamed-tornado-type-activity-riverside-county.html; http://www.pe.com/localnews/riversidecounty/riverside/riverside-headlines-index/20120812-lake-elsinore-tornado-touches-down-more-expected.ece?ssimg=677704#ssStory677446).

Historic Southern California Windstorms

As mentioned above, Santa Ana winds are common in the southern California area, with Santa Ana conditions expected yearly in the region, generally in the fall through early spring. Some of the strong winds in the winter are associated with storms emanating from Alaska and Canada. The desert areas are also subject to high winds associated with short-duration tropical thunderstorms emanating from the south. These storms typically occur in the summer months, between July and September.

Some of the most severe windstorms reported in southern California between 1858 and November 2013 (the more recent entries in the NOAA database as of the writing of this document) are listed in Table 10-4 below (http://www.ncdc.noaa.gov/stormevents/listevents.jps; http://www.wrh.noaa.gov/sgx/document/weatherhistory.pdf). Some of these events are also discussed in other sections of the report because they were accompanied by other hazards, such as flooding or wildfires. Those winds that are clearly Santa Ana windstorms are highlighted in yellow, whereas strong winds that specifically impacted the Newport Beach area and vicinity are in **bold**. Note that many of the Santa Ana windstorm entries mention wildfires. Please note that this list, although extensive, is likely not complete, as it may omit windstorms that caused extensive damage locally.

Table 10-4: Major Southern California Windstorms (1858- November 2013)
(Santa Ana winds are highlighted in yellow;
windstorms that impacted the Newport Beach area, including vicinity, are in bold letters)

Date	Location and Damage
October 2, 1858	Category 1 hurricane hits San Diego. Winds to 75 mph are estimated based on the extensive damage to property reported.
August 11-12, 1873	Tropical storm with strong winds hits San Diego, damaging roofs and felling trees.
November 13, 1880	Severe Santa Ana winds and sandstorms cause extensive damage in southern California.
February 24, 1891	Strong and continuous storm-related winds blowing at 40 mph cause boats to smash on shore and a roof was lifted off a warehouse.
January 27, 1916	Strong winds measured in San Diego, with peak winds at 54 mph; maximum gust to 62 mph, and average wind speeds for the day of 26.2 mph.
January 10, 1918	Strong offshore winds; skies full of dust, with visibility limited to 300 yards. At noon, visibility was only a few miles. Peak wind of 31 mph reported in San Diego at 6:38 am.
November 25, 1918	Strong windstorm produced a 96-mph gust at Mt. Wilson.
May 23, 1932	Strong winds and low humidity; 12 serious brush fires, blackening nearly 2,000 acres in San Diego Count. The biggest fire was in Spring Valley.
March 5, 1933	Strong east winds. A fire that started in the De Luz area spread rapidly westward, impacting more than 800 acres.
September 24-25, 1939	Tropical storm that lost hurricane status shortly before moving onshore at San Pedro had sustained winds of 50 mph. At least 48 people died from sinking boats.
February 11, 1946	Icy cold winds in the mountains of San Diego with gusts to 72 mph.
January 10, 1949	Cold winter storm with gusts to 75 mph in the mountains of San Diego County; gusts to 40 mph in San Diego. Winds cause plane crash near Julian that kills 5 and injures 1.
April 13, 1956	Strong storm-related winds hit Chula Vista causing roof damage to 60 homes and one school. Trees uprooted, TV antennas toppled and windows shattered. Flying glass injures 2. Fish sucked out of San Diego Bay and deposited on the ground. Possible tornado.
November 21-22, 1957	Extremely destructive Santa Ana winds produce a 28,000-acre brush fire west of Crystal Lake.
November 5-6, 1961	Strong Santa Ana winds fan fires in Topanga Canyon, Bel Air and Brentwood; 103 firemen are injured; $100 million in economic losses, including 484 buildings (mostly residential) and 6,090 acres scorched.
September 26, 1963	Santa Ana winds with gusts over 50 mph in the mountains of San Diego County; hottest heat wave on record for the mountains in west San Diego County.
November 19-20, 1963	Strong storm winds topple power lines and hundreds of trees.
December 2-3, 1966	Strong storm winds cause power outages.
January 18-28, 1969	Strong storm winds cause power outages and falling trees; 4 killed by downed trees.
February 20-25, 1969	Strong storm winds cause telephone, power and gas outages.
September 26-29, 1970	Gusts to 60 mph in Cuyamaca Rancho State Park. Fires from Cuyamaca to Alpine, including the Laguna Fire, resulted in 400 homes destroyed, 185,000 acres burned, and 8 killed.
February 10-11, 1973	Strong storm-related winds clocked at 57 mph in Riverside, 46 mph in Newport Beach. More than 200 trees uprooted in the community of Pacific Beach in San Diego County alone.
March 25, 1975	Wind gust of 101 mph measured at Sandberg, a community north of the Los Angeles National Forest.
February 4-10, 1976	Strong storm winds with gusts to 64 mph in Palmdale.

Date	Location and Damage
September 10, 1976	Hurricane Kathleen brought to the SW the highest sustained winds associated with an eastern Pacific tropical cyclone; sustained winds of 57 mph at Yuma, Arizona.
November 30 – December 1, 1982	Widespread strong winds associated with a big storm result in 1.6 million homes without power.
March 26, 1984	Winds to 60-90 mph in the Mojave Desert cause power outages and road closures. Car had its windows blown out; another had a door ripped off. Peak wind of 103 mph at Mojave; 66 mph in Daggett.
March 1, 1985	Strong storm winds struck San Diego County toppling trees and antennas, and causing numerous power outages.
November 23, 1986	Strong Santa Ana winds hit Los Angeles, its foothills and mountains. Gusts to 54 mph recorded; gusts to 70 mph estimated. An unfinished house in Glendale is blown to bits; numerous beach rescues needed for sailors and windsurfers. Two sailboat masts were snapped in a boat race at the Channel Islands.
January 20, 1987	Wind gusts to 80 mph below Cajon Pass, 70 mph in San Bernardino, 60 mph in Mt. Laguna, and 40 mph at El Toro. Winds cause thick dust clouds; trucks blown over; trees toppled. 100 power poles downed in the Inland Empire. Numerous power outages force school closures. Brush fires started.
February 23-24, 1987	Storm winds to 50 mph in Mt. Laguna; gusts to 34 mph in San Diego.
March 15, 1987	Widespread strong storm winds; winds of 25-35 mph sustained all day, gusts to 40 mph in San Diego. Result in power outages all over the San Diego metropolitan area; motor homes toppled in the desert; light standard fell over onto cars in Coronado; boats flipped over in harbors; a 22-foot boat turned over at Mission Beach jetty; Catalina cruise ships delayed, stranding 1,200 tourists there.
November 18, 1987	Strong Pacific storm brought gale-force winds along the coast with winds exceeding 40 mph; downed trees and caused power outages.
December 12-13, 1987	Strong Santa Ana winds in San Bernardino, with 60-80 mph gusts there. 38-mph winds recorded in San Diego. 80 power poles blown down within ½-mile stretch in Fontana and Rancho Cucamonga; downed tree limbs damaged cars, homes and gardens; 1 injured when tree fell on truck; power poles and freeway signs damaged; parked helicopter blown down a hillside in Altadena; trees downed and power outages in San Diego County. In Spring Valley, 1 dead when eucalyptus tree fell on truck.
December 15, 1987	Strong storm winds of 100 mph at Wheeler Ridge, 80 mph in San Bernardino County; up to 70-mph gusts at Point Arguello; 60-mph gusts in Orange County and the San Gabriel Mountains. One truck overturned.
December 17, 1987	Strong Alaska storm brought strong winds to the area; boats broke free of moorings at Shelter Island in San Diego.
January 17, 1988	Major Pacific storm produced 64-mph gusts in San Diego, with the highest wind on record at Lindbergh Field. Trees uprooted in San Diego; boats damaged in San Diego harbor; apartment windows ripped out in Imperial Beach, where damage was estimated at $1 million. San Diego Zoo closed for first time in 72 years due to damage; kelp beds damaged.
January 21-22, 1988	Strong offshore winds following major Pacific storm with gusts to 80 mph at the Grapevine, 60 mph in Ontario, and 80 mph in San Diego County. Power poles, road signs and big rigs knocked down in the Inland Empire. In San Diego County, 6 injured; roofs blown off houses, trees toppled, and crops destroyed. Barn demolished and garage crushed by tree in Pine Valley; 20 buildings damaged or destroyed at Viejas; avocado and flower crops destroyed at Fallbrook and Encinitas, respectively, with 5 greenhouses damaged in Encinitas.

Date	Location and Damage
February 16-19, 1988	Very strong Santa Ana winds with gusts to 90 mph in Newport Beach, 70+ mph in the San Gabriel Mountain foothills; gusts to 76 mph at Monument Peak – Mt. Laguna; 63 mph at Ontario, and 50 mph at Rancho Cucamonga. Numerous trees and power lines downed resulting in power outages along the foothills of the San Gabriel and San Bernardino Mountains. Mobile home overturned and shingles torn off roofs in Pauma Valley; Fontana schools closed due to wind damage; 3 killed when truck overturned and burned; 1 killed when stepped on downed power line. Power outages impacted 200,000 customers in Los Angeles and Orange Counties. Grass fires. Roof damage widespread in communities around Glendale and Burbank, and at John Wayne Airport. Boats torn from moorings at Newport Harbor.
May 29, 1988	Gale-force winds hit coastline; gusts to 60 mph in the mountains; 45 mph at LAX; 40 mph in San Diego. Power outages; brush fires started; hang glider crashed and killed.
November 30, 1988	Santa Ana winds with gusts to 75 mph in Laguna Peak, Ventura County.
December 8, 1988	Strong Santa Ana winds across southern California, with gusts to 92 mph at Laguna Peak. Winds fanned several major fires; buildings were unroofed; trees and power lines downed. $20 million in estimated damages.
November 28, 1989	Strong Santa Ana winds with gusts to 70 mph at the Rialto Airport. Several tractor-trailer trucks were overturned east of Los Angeles.
December 11, 1989	Strong Santa Ana winds with gusts to 100 mph near the Grapevine. Winds reduced visibility to near zero in the desert areas and closed major interstate highways east of Ontario.
March 18-19, 1991	Storm winds with gusts to 125 mph on Laguna Peak; winds of 60 mph in the San Carlos area of San Diego caused extensive damage (possibly a tornado).
October 26-27, 1993	Strong Santa Ana winds with gusts to 62 mph at Ontario. Twenty fires in the southern California area, including the Laguna Hills Fire. 4 dead, 162 injured, $1 billion in property losses alone; 194,000 acres destroyed.
December 24, 1993	Santa Ana winds with gusts to 75 mph at Ontario.
December 14, 1996	Santa Ana winds with gusts to 111 mph at Fremont Canyon, 92 mph in Rialto. 2 killed from flying debris.
December 21-22, 1996	Storm winds 40 - 50 mph.
January 5-6, 1997	Storm winds with gusts to 99 mph in Fremont Canyon, 58 mph elsewhere.
January 29, 1997	Santa Ana winds with gusts to 100 mph in Fremont Canyon, 87 mph in Rialto cause big rigs to be blown over.
August 20, 1997	The remnants of Tropical Storm Ignacio tracked northward and inland into central California, spawning gale-force winds over portions of the southern California coastal waters.
October 14, 1997	Santa Ana winds with gusts up to 87 mph reported in central Orange County. Large fire in Orange County.
December 10-12, 1997	Santa Ana winds with gusts to 96 mph at Pine Valley; 87 mph in Upland. Flying debris killed 2. Property damage in Sun City; crop damage; boats damaged and sunk at Coronado and Avalon.
December 18-22, 1997	Gusts to 60 mph in Rialto; 67 mph at Idyllwild and below Cajon Pass. 1 killed; fires; downed trees; and widespread wind damage.
December 29, 1997	60+ mph gusts reported in Santa Ana.
February 3-4, 1998	Strong storm winds with gusts to 60 mph at Newport Harbor, 51 mph at San Clemente.
February 23-24, 1998	Strong storm winds 40-60 mph caused widespread damage; trees and power lines knocked down.

Date	Location and Damage
March 28-29, 1998	Strong storm-related winds in Orange County with sustained 30-40 mph winds; 70-mph gusts at Newport Beach; 60-mph gust at Huntington Beach and in the mountains. Trees down, power outages, and damage reported across Orange and San Diego counties. One person died in Jamul.
September 2, 1998	Strong thunderstorm-related winds in Orange County, with 40-mph gusts. Large fires in Orange County.
December 6, 1998	Thunderstorm in Los Alamitos and Garden Grove; gusts of 50 to 60 mph; referred to as "almost a tornado."
December 9-10, 1998	Santa Ana winds with 101-mph gusts at Modjeska Canyon, 93-mph gusts at Fremont Canyon, 52-mph gusts in Santa Ana, and 83-mph gusts at Ontario. Winds toppled trees and power lines, overturned vehicles, and caused property damage.
January 21, 1999	80-mph gust in the Salton Sea area; 70-mph gust in the Coachella Valley; 47-mph gust in Palm Springs; and 36-mph gust in Thermal.
February 10-12, 1999	Santa Ana winds with gusts to 85 mph at Rialto; gusts to 80 mph on the I-8, forcing the closure of the interstate.
May 13, 1999	Strong winds with sustained speeds of 61 mph reported at Borrego Springs, causing roof and tree damage.
November 22,1999	80-mph gust at Highland.
December 3, 1999	Santa Ana winds with gusts to 90 mph at San Bernardino and 68 mph in Fontana.
December 10-11, 1999	Gust to 60 mph in Palm Springs.
December 21-22, 1999	Strong Santa Ana winds; 68-mph gust at Campo, 53-mph gust at Huntington Beach; 44-mph gust in Orange. Property damaged and trees downed along the coast, and in Hemet.
January 5-6, 2000	Santa Ana winds with 93-mph gust at Fremont Canyon; 60-mph gust at Ontario; 58-mph gust at Devore. Winds closed the I-15.
February 19, 2000	Santa Ana winds with gusts to 92-mph at Fremont Canyon.
February 21-23, 2000	Winter storm winds with 75-mph gust along Highway 91; winds downed trees in Lake Arrowhead.
March 5-6, 2000	Strong thunderstorm winds along the coastline; 60 mph-gusts at Huntington Beach; trees downed and property damage reported all along the coast.
April 1, 2000	Strong Santa Ana winds; 93-mph gust reported at Mission Viejo; 67-mph gust at Anaheim Hills.
April 17-18, 2000	Late winter storm brings 68-mph gusts in the mountains of San Diego County.
November 7, 2000	Santa Ana winds with 82-mph gust at Fremont Canyon.
December 25-26, 2000	Santa Ana winds; 87-mph gust at Fremont Canyon. Damage and injuries reported in Mira Loma, and in Orange and Riverside counties. 50-mph winds in northern Orange County toppled utility poles leaving about 25,000 customers in Tustin, Garden Grove, Orange, Santa Ana and Westminster without power for a few hours.
January 2-3, 2001	Winter storm with wind gust to 71 mph at Phelan.
February 7, 2001	Winter storm with gusts to 50 mph at Palm Springs and Thermal, 54 mph gusts at Fish Creek.
February 13, 2001	Thunderstorm with 89-mph gust reported in east Orange.
November 27, 2001	Strong Santa Ana winds extend offshore from the coast causing damage and causing a boating accident off of Newport Beach.
December 7-8, 2001	Santa Ana winds with gust to 87-mph at Fremont Canyon. Potrero Fire.
January 24, 2002	Santa Ana winds.
February 8-10, 2002	Santa Ana winds with 80-mph gust at Descanso, 78-mph gust at Fremont Canyon, and 76-mph gust at San Bernardino. Fire in the Fallbrook area.

Date	Location and Damage
January 6-8, 2003	Strong, widespread Santa Ana winds with 100-mph gust at Fremont Canyon, 90-mph gust at Ontario; 80-mph gust at Upland. Winds toppled power poles in Orange; blew over a mobile derrick in Placentia, crushing two vehicles; and delayed Metrolink rail service. As a result of the winds and toppled poles, thousands of people in northeastern Orange County were without power. 2 dead, 11 injured. Widespread property damage, road closures, wildfires, crop damage.
October 25-27, 2003	Strong Santa Ana winds; 45-mph at Ontario, 43-mph at Fremont Canyon. Extensive wildfires consumed hundreds of thousands of acres; killed more than 20 people, and caused more than $1 billion in damage.
November 21, 2004	Cold storm brought 84-mph wind gusts to Fremont Canyon.
December 16, 2004	Santa Ana winds with sustained speeds of 51 mph and 78-mph gusts at Fremont Canyon; gusts to 69-mph northwest of San Bernardino and 66 mph near Pine Valley. Big rigs were blown over, temporarily closing the freeway; other property damage reported.
December 29, 2004	Storm brings 60-65 mph wind gusts to the Inland Empire and 69-mph wind gusts at Julian. Widespread wind damage reported along the coast and valleys.
January 7, 2005	Wind gusts in excess of 50 mph combined with very saturated soils knocked down hundreds of large trees in the Orange County coastal plain. The felled trees knocked out power, blocked roads, and damaged many cars and other property. A woman was injured when an eucalyptus tree fell on her car as she drove in Vista. About $75K in property damage.
February 3, 2005	Strong storm-related winds to 70-mph impact the region. Homes in Idyllwild are damaged by felled trees; downed power lines in the Inland Empire; big rig was overturned on the I-8.
February 19, 2005	Strong thunderstorm winds blew down fences, trees, and damaged the roof of a mobile home in Laguna Hills.
February 22, 2005	Thunderstorm winds to 59 knots caused about $15K in property damage in Newport Beach.
April 7, 2005	Strong winds in the Coachella Valley with gust to 52-mph in Thermal; stronger wind likely in the region. Winds led to reduced visibility in La Quinta, which led to a 12-car pileup.
April 28, 2005	A squall line produced strong straight-line winds as it came onshore in Orange County. The strong winds, to 60 knots, damaged 8 to 12 homes in Dana Point and knocked down several trees. In San Clemente, strong winds blew over a chimney, a large motel sign, and numerous tree limbs. Wind damage was also reported in San Juan Capistrano and Newport Beach. About $45K in property damage.
January 2, 2006	Post-frontal 50+-mph winds widespread throughout the region. Winds downed trees, power lines, and power poles onto houses and cars. In Crestline, 20 houses were so damaged as to be uninhabitable. In San Diego Bay, boats broke loose from their moorings. $25K in property damage.
January 5, 2006	Gusty Santa Ana winds caused minor damage to trees, utility lines and other property.
January 22-24, 2006	Santa Ana winds; peak winds of 71 mph at Fremont Canyon on the 24th; gusts exceeded 60 mph on 19 hourly observations. 7 big rigs overturned in Fontana; downed power lines and trees caused power outages and property damage. Dust storm closed the Ramona Expressway.
February 6-7, 2006	Santa Ana winds blew and the Sierra Fire in east Orange burned nearly 11,000 acres. 8 minor injuries.
October 26, 2006	Offshore winds blew to 40-mph in the Banning Pass. An arsonist started the Esperanza Fire; it burned 40,200 acres from Cabazon to San Jacinto, destroyed 43 homes, and killed 5 firefighters.
November 29, 2006	Offshore winds with sustained speeds of 54 mph and 73-mph gust at

Date	Location and Damage
	Fremont Canyon; 58-mph gust at Ontario, caused widespread property damage and power outages as a result of downed power lines, poles and trees.
December 3, 2006	Offshore winds gusted to 92 mph with seven gusts over 75 mph in northwest San Bernardino. Gusts to 75-mph in Fremont Canyon. Winds downed power lines that sparked a small fire in the Inland Empire; 16 power poles were downed in Valley Center.
December 27, 2006	Strong storm winds hit the coast; 54-mph gust at La Jolla; 49-mph gust at Huntington Beach. Winds downed numerous trees, damaging several vehicles.
March 27, 2007	Strong onshore flow and isolated thunderstorms produced a damaging microburst that removed a roof laminate from the Orange County Fire Authority's aviation building at the Fullerton Municipal Airport. Pieces of the roof landed on four cars. A 60-foot eucalyptus fell over three cars in Encinitas, causing two minor injuries. A funnel cloud was reported off the La Jolla coast.
January 19, 2010	A line of thunderstorms moved through Orange County, with a peak wind gust of 93 mph measured at Newport Beach pier, and several gusts in excess of 70 mph reported. Several boats in the Newport Beach harbor broke free. A building on 17th Avenue, in Costa Mesa, sustained moderate damage – 2/3rds of the top layer of its roof blew off, with pieces of the roofing material, some over 15 feet long, littering the parking lot. In a mobile home park across the street, metal awnings were ripped off by the wind and pieces of wood were seen flying through the air. Strong winds also blew open the door to a business and shattered a window near the intersection of Harbor Blvd. And Victoria Street. $350K in property damage. Wind damage was also reported in San Clemente, Seal Beach, Laguna Beach, and in San Diego.
April 11-13, 2012	An upper-level trough swung through southern California bringing gusty winds and moderate to heavy precipitation to the area on the 12th. A deeper upper low developed behind it. Instability ahead of the cold front set off several waterspouts and thunderstorms on the afternoon of the 13th. Lightning strikes and wind caused roof damage and downed power lines and trees. A spotter reported downed trees, bark peeled off trees and a flipped post office box near Weir Canyon and the 91 freeway. The area was surveyed for possible tornado damage, but only evidence of straight line wind was observed. About $4K in property damage.

Although most tornado activity in the United States occurs in the Midwest states, tornadoes can occur anywhere. The Tornado Project, a company that researches, compiles and makes tornado information available on the web at www.tornadoproject.com, indicates that 41 tornadoes have been reported in Los Angeles County between 1918 and 2000. In Orange County, The Tornado Project list includes 28 tornadoes between 1958 and 1998; whereas the National Weather Service in San Diego adds a few more to the same time period, plus at least 25 more tornadoes, waterspouts, or funnel clouds between February 1998, where The Tornado List ends, and July 2013. The tornadoes reported in Orange County are listed in Table 10-5 below. Those in Newport Beach are in bold.

Table 10-5: Tornadoes Reported in Orange County between 1958 and 2013
(tornadoes that impacted Newport Beach are in **bold** letters)

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
April 1, 1958, Laguna Beach	09:30	F1	0	0
February 19, 1962, Irvine	03:30	F0	0	0
April 8, 1965, Costa Mesa	11:00	F1	0	0
November 7, 1966, Newport Beach and Costa Mesa	09:09	F1 (property damage)	0	0
March 16, 1977, skipped from Fullerton to Brea	18:30	F1 (damaged 80 homes)	0	4
January 5, 1978, Costa Mesa	21:00	F1 (trees fell, roofs damaged, downed power lines)	0	0
February 9, 1978, Irvine	NA	NA	0	0
February 10, 1978, Huntington Beach	01:55	F2 ($3 million property damage)	0	6
March 5, 1978, El Toro Marine Base		Funnel cloud		
January 31, 1979, Santa Ana and possibly elsewhere	11:30	F1 (numerous power outages)	0	0
November 9, 1982, Garden Grove	13:00	F0	0	0
November 9, 1982, Mission Viejo	13:00	F1	0	0
January 13, 1984, Huntington Beach	18:19	F0 (property damage)	0	0
March 16, 1986, Anaheim near Disneyland	05:30	F1 (property damage)	0	0
February 22-24, 1987, Huntington Beach area	NA	Tornadoes and waterspouts	0	0
January 18, 1988, Mission Viejo and San Clemente	09:30	F0 (property damage)	0	0
February 28, 1991, Tustin	12:45	F0	0	0
March 26, 1991, Huntington Beach	22:35	F1 (cut a 5-mile swath; took roofs off 6 homes; damaged several other homes and 50 mobile homes were severely damaged)	0	0
December 7, 1992, Anaheim	05:30	F1 (property damage)	0	0
December 7, 1992, Westminster	08:30	F1 (property damage)	0	0
December 29, 1992, San Clemente	11:30	F0 (property damage)	0	0
January 14, 1993	01:40	F1	0	0
January 17, 1993	19:30	F0	0	1
January 18, 1993, Orange County	14:05	F0 (property damage)	0	0
February 8, 1993, Brea	10:20	F0 (property damage)	0	0
November 11, 1993, Portola Hills near Tustin	09:30	F0 (property damage)	0	2
February 7, 1994, from	18:15	F0	0	0

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
Newport Beach to Tustin		(roof and window damage; trees blown down)		
December 13, 1994, waterspouts about 0.5 mile off Newport Beach	NA	NA	0	0
December 13, 1995, funnel cloud near Fullerton Airport	NA	NA	0	0
March 13, 1996, funnel cloud in Irvine	NA	NA	0	0
November 10, 1997, waterspout came ashore at Newport Pier and quickly dissipated over western Costa Mesa	NA	F0 (winds 60-70 mph) (minor power outages; blew fisherman from one end of pier to another)		
November 11, 1997, Irvine	12:40	F1 (damage from flying debris; 10 cars thrown a few feet)	0	0
November 30, 1997, waterspout 6 miles south of Newport Beach	NA	NA	0	0
December 21, 1997, Huntington Beach (waterspout and tornado developed from a supercell thunderstorm)	13:40	F1 (considerable damage to boats, houses and city property)	0	0
January 9, 1998, 3 miles off Laguna Beach, waterspout	NA	NA	0	0
February 24, 1998, Huntington Beach	01:30	F0 (property damage, power outage; roof travels ¼ mile)	0	0
March 13-14, 1998, numerous waterspouts between Huntington Beach and Catalina	NA	NA	0	0
March 31 – April 1, 1998, numerous funnel clouds and waterspouts near Orange County coast; one waterspout hit coast south of Huntington Beach pier	NA	NA	0	0
June 6, 1998, two funnel clouds off Dana Point	NA	NA	0	0
January 25, 1999, funnel cloud 1 mile off Costa Mesa	NA	NA	0	0
April 1, 1999, waterspout 6 miles off Newport Beach	NA	NA	0	0
June 3-4, 1999, funnel cloud 1 mile off San Clemente; waterspout off Laguna Beach	NA	NA	0	0
December 31, 1999, funnel clouds in Santa Ana; waterspout off Costa Mesa coast	NA	NA	0	0
February 21, 2000, Anaheim	NA	NA		

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
Hills		(property damage)		
October 28, 2000, funnel clouds around Newport Beach and Costa Mesa	NA	NA	0	0
January 10, 2001, funnel cloud at Orange County Airport, Newport Beach	NA	NA	0	0
February 11, 2001, waterspouts 3 miles off Laguna Beach	NA	NA	0	0
February 24, 2001, Orange	NA	NA (damage to warehouse, 6 structures, fences, and telephone wires)	0	0
March 6, 2001, funnel cloud in Yorba Linda	NA	NA	0	0
May 28, 2001, waterspouts 5 miles west of Laguna Beach	NA	NA	0	0
May 20, 2002, three funnel clouds and one waterspout off Dana Point	NA	NA	0	0
November 1, 2003, large waterspout between Laguna Beach and Catalina Island	NA	NA	0	0
October 20, 2004, several funnel clouds offshore San Clemente	NA	NA	0	0
December 28, 2004, funnel cloud in Fullerton	NA	NA	0	0
January 2, 2005, funnel clouds reported 10 miles west of Huntington Beach pier, and off Dana Point	13:28 - 14:20	NA	0	0
January 3, 2005, funnel clouds reported in Fullerton and Huntington Beach	16:00 – 16:30	NA	0	0
January 4, 2005, funnel cloud in Costa Mesa.	4:30	NA	0	0
February 19, 2005, waterspout moved ashore and became a tornado in Huntington Beach within 100 yards of the pier. Multiple waterspouts reported.	NA	(damaged and downed trees and power poles)	0	0
February 22, 2005, funnel cloud in Dana Point	14:40	NA	0	0
May 6, 2005, funnel cloud near Tustin	8:30	NA	0	0
February 18, 2006, waterspout observed 6 nautical miles off Dana Point	NA	NA	0	0
September 22, 2007, waterspouts and funnel clouds off and in **Newport Beach**, San Clemente and	10:00 – 10:50	NA	0	0

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
Capistrano Beach				
January 19, 2010 in Seal Beach, tornado crossed Pacific Coast Highway and moved northeast	13:59	EF1 (flipped a parked Ford Explorer on its side, and two 35-foot catamarans in Huntington Harbor were lifted out of the water. One landed on another vessel and dock piling. Multiple reports of roof damage; the window in a residential building was blown in.)	0	0
March 6, 2010, multiple funnel clouds off the **Orange County coast**, south of John Wayne Airport and off Crystal Cove	9:47 – 9:50	NA	0	0
December 15, 2011, multiple funnel clouds 10-15 miles east of John Wayne Airport	13:00 – 13:30	NA	0	0
February 14, 2012, three funnel clouds 4 miles offshore Huntington Beach	7:30 – 9:00	NA	0	0

Windstorm Hazard Assessment

Hazard Identification

The previous section describes the high wind events that have impacted the coastal Orange County area. By reviewing the historical record we can better understand the geographic extent of the hazard, the intensity of future events likely to impact the study area, and their probability of occurrence.

Windstorms are significant chronic events that cumulatively cause extensive damage, with property losses in the millions of dollars, in addition to potential injuries, and even loss of life. A windstorm event in the region can range from a short-term microburst or waterspout off the coast lasting only a few minutes, to Santa Ana wind conditions that can last for several days, such as the January 2003, and January and February 2006 events.

The data in Table 10-4 show that high winds can occur in the coastal Orange County area, including Newport Beach, almost any time during the year. However, Santa Ana wind conditions occur most often in the fall and winter months, between September and March. These winds generally impact a large geographic area. Similarly, high winds accompanying winter storms approaching from the north or northeast occur in the fall and winter, most often between November and February, although winter storms can occur as early as August, and as late as May. Tropical storms that make landfall in Baja California and move north into Arizona and California occur primarily in August and September. These summer winds tend to impact primarily the San Diego and desert areas. The data in Table 10-4 show that the only two months not represented in the windstorm historical record are June and July.

The historical record suggests that windstorm events can be expected almost annually across a large portion of the southern California area. The data presented in Tables 10-4 and 10-5 would suggest that windstorm events have increased in frequency over time, with more windstorm events occurring between 1997 and 2013, than between 1858 and 1996. However, the early historical record is often incomplete because 1) there were less people in the area that could be impacted by these natural hazards, and 2) only unusually damaging storms would be recorded in newspapers, journals and other sources. Using the record from the last 15 years only, the southern California region is impacted by windstorms approximately two to eight times a year, but there is significant variability from one year to the next. For example, in 2006, the area was impacted by high winds at least eight separate times, but in 2008, 2009, and 2011, no high wind events were reported in the area.

The records show that tornados, funnel clouds and waterspouts can occur in the coastal Orange County area almost any month of the year, but preferentially between November and March. The tornado numbers also vary significantly from year to year, with substantial tornado activity some years, and none in others. For instance, during the 1997-1998 winter, as many as eight funnel clouds and tornadoes were recorded in the region, whereas in 2008 and 2009, there were none. The frequency of tornadoes seems to increase during El Niño years.

Tornadoes typically impact a relatively small geographic area. Many funnel clouds and waterspouts seem to be recorded offshore, with only a few of these actually making a landfall. The historical record suggests that tornadoes are unpredictable in their geographic occurrence in Orange County, although the cities of Huntington Beach, Newport Beach, Costa Mesa, Tustin and Irvine seem to have historically been impacted the most by these weather phenomena. Although tornado occurrence in southern California is relatively rare compared to the Midwest record, and the tornadoes that do hit this region are generally not as strong as the tornadoes in other parts of the country, the historical record shows that even F0 and F1 tornadoes are capable of causing property damage, injuries, and loss of life. Unlike flooding hazards, which are generally confined to a discrete area that can be mapped, windstorms may travel in any direction, and are only partly affected by topography (with stronger winds usually observed in canyons and passes, where the winds are funneled by the surrounding topographic highs). Given that we cannot predict when or where a windstorm will occur, nor its intensity, the conservative approach is to assume that a windstorm event can take place anywhere in the Newport Beach area anytime during the year, but preferentially in the fall or winter.

Vulnerability and Risk

Vulnerability assessment is the second step of the windstorm assessment process. It combines the geographic extent of the potential hazard (anywhere in Newport Beach for windstorms) with an inventory of City facilities within that geographic area (all City facilities are vulnerable). Santa Ana winds especially have the potential to impact the entire City of Newport Beach area. Given that these winds emanate in the Great Basin and move westward and offshore, especially strong winds often occur in and along the west-trending canyons in the San Joaquin Hills.

As past events show, windstorms in the City of Newport Beach have the potential to impact life, property, utilities, infrastructure and transportation systems, causing damage to trees, power lines, utility poles, road signs, cars, trucks, boats, and building roofs and windows (Figures 10-3, 10-4 and 10-5). Structures and facilities can be impacted directly by high winds and/or can be struck by air-borne debris. Windstorms can disrupt power to facilities and disrupt land-based communications as well. In fact, historically, trees downed during a windstorm have been the major cause of power outages in the southern California area. Uprooted trees and downed utility poles can also fall across the public right-of-way disrupting transportation. These events can be major hindrances to emergency response and disaster recovery. For example, if transportation routes are compromised by fallen debris, and loss of power occurs in the area, emergency response facilities like the hospital, fire stations, and the police station may find it difficult to function effectively. Falling or flying debris, falling trees and downed power lines can also injure or kill motorists and pedestrians. As discussed previously, windstorms, especially

Santa Ana winds, are often also associated with wildfires, which, if they occur in or near a populated area, can result in enormous losses to property, in addition to injuries and loss of life.

A windstorm also has the potential to displace residents, which may require the City to provide short-term and/or long-term shelters to accommodate these individuals, in addition to providing for other emergency response activities such as cleanup and repair. This has the potential to impact the City economically, as City funds would have to be tapped into to respond adequately to the needs of the impacted members of the community.

Community Windstorm Issues

What is Susceptible to Windstorms?

Life and Property

Based on the history of the region, windstorm events can occur in the area on an annual basis. As noted above, a windstorm event may occur anywhere in the City, and windstorm events are not readily predictable. Such an event in Newport Beach may result in the involvement of City maintenance personnel responding to cleanup and repairs during and following such an event. Similarly, maintenance crews may be required to secure certain facilities ahead of a potential windstorm, provided sufficient advanced notice is available, and that City crews are available to respond on short notice.

Depending on its age, condition, and structural design, any structure may be susceptible to damage. However, buildings with weak reinforcements are most susceptible to windstorm damage. Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift suction forces that pull building components and surfaces outward and/or upward. Under extreme wind forces, the roof or entire building can fail or sustain considerable damage. Mobile homes are particularly susceptible to windstorm damage. Debris carried by the wind may also contribute to loss of life and, indirectly, to the failure of building envelopes, sidings or walls. As discussed above, when severe windstorms strike a community, downed trees, power lines and damaged property can be major hindrances to emergency response and disaster recovery.

Structures and boats next to the coastline can also be impacted by winds and swells caused by high winds. For example, during storms, the docks in a harbor can break loose and drift. This has happened infrequently in Newport Beach, especially with some of the older docks, which once they broke loose, drifted in the channels. During Santa Ana wind conditions, vessels on offshore moorings in Newport Beach have the potential to break free and drift when severe wind loads are placed upon them. This can be an extremely hazardous condition, as a freed multi-ton vessel floating aimlessly can bump into other boats and property, causing extensive damage, especially if it occurs at night. Personnel from the City's Harbor Department patrol the area for vessels that have broken free from their moorings and attempt to intervene before significant damage occurs (Chris Miller, Harbor Resources Department, personal communication, 2008). Vessel owners are required to inspect their mooring equipment by a mooring contractor every two years, but even so, mooring failures do occur, although infrequently, most likely in response to the very strong winds that hit the area periodically.

Figure 10-3: Windstorm damage to trees in a residential area of Newport Beach (Narcissus Avenue), caused by the April 28, 2005 storms. The winds felled several trees in the neighborhood, which in turn disrupted traffic, and damaged cars, fences, and sidewalks.

Photo courtesy of Mike Pisani from the General Services Department, City of Newport Beach

Figure 10-4: Wind damage caused by the April 28, 2005 storms to trees in a residential area of Newport Beach (Narcissus Avenue).
Two vehicles were damaged by this toppled tree branch.

Photo courtesy of Mike Pisani from the General Services Department, City of Newport Beach

Lifelines and Critical Facilities

Historically, downed trees have been a major cause of power outages in the region during windstorms. Some tree limbs can break in winds of about 45 mph, and the broken limbs can be carried by the wind more than 75 feet from their source. Thus, overhead power lines can be damaged even in relatively minor windstorm events (Figure 10-5). Downed trees can also bring electric power lines down to the pavement or ground, where they become serious, life-threatening, sources of electric shock. Lifelines and critical facilities should remain accessible, if possible, during a natural hazard event. The impact of closed transportation arteries may be increased if a blocked road or bridge is critical to access the hospital or other emergency facilities. Increased population, and new infrastructure in the region could result in a higher probability for damage to occur from windstorms as more lives and property are exposed to this hazard.

Figure 10-5: Downed power lines (and transformer) in the City of Newport Beach caused by the January 1, 2005 storm.

Photo courtesy of Mike Pisani from the General Services Department, City of Newport Beach

Infrastructure

Windstorms may damage buildings, power lines, and other property and infrastructure due to falling trees and branches. During wet winters, saturated soils cause trees to become less stable and more vulnerable to uprooting from high winds. Windstorms can also result in damaged or collapsed buildings, blocked roads and bridges, damaged traffic signals and streetlights, and damaged park facilities. Roads blocked by fallen trees during a windstorm may severely impact people attempting to access emergency services. Emergency response operations can be compromised when roads are blocked or when power supplies are interrupted. Industry and commerce can suffer losses from interruptions in electric services and from extended road closures. They can also sustain direct losses to buildings, personnel and other vital equipment, all of which have a direct impact on the local economy.

Transportation

In addition to the problems caused by downed trees and electrical wires blocking streets and highways, windstorms can also force the temporary closure of roads to vehicular traffic. This is especially true during extremely strong Santa Ana winds. These closures, however, typically do not pose a hardship to the local economy, as they do not last long.

Windstorm Mitigation Activities

Strong winds can have both short- and long-term impacts on the region's economy, and on the health and wellbeing of residents and visitors. Stronger winds, in part as a result of more severe weather, could be the norm in the not-to-distant future due to global climate change. Although most windstorms are regional in scope, a community can implement measures that can locally help to reduce the effects of severe weather, and that can help the City to respond proactively and effectively when a strong wind event impacts the region.

Windstorm mitigation activities include current mitigation programs and activities that are being implemented by State and City agencies. As discussed extensively in the paragraphs above, one of the most common problems associated with windstorms are power outages resulting from fallen power poles, and downed trees and branches coming in contact with and disrupting nearby distribution power lines. Fallen trees can cause power lines to short-circuit and conductors to overload. Wind-induced damage to the power system can result in power outages that, at best, inconvenience, and at worst, pose a life-threatening situation to customers; incur costs to make repairs; and in some situations, can cold-start a fire. As a result, and in an effort to reduce damage to the power supply, one of the most effective mitigation strategies pertain to tree clearance. Specifically, California law requires utility companies to maintain clearances (specified distances based on the type of voltage running through the line) between electric lines and all vegetation. Enforcement of the following California Public Resources Code Sections provides guidance on tree regulations: 4293 – Power Line Clearance Required; 4292 – Power Line Hazard Reduction; 4291 – Reduction of Fire Hazards Around Buildings; and 4171 – Public Nuisances (www.cpuc.ca.gov/js.asp).

Failure to allow a utility company to comply with the law can result in liability to the homeowner for damages or injuries resulting from a vegetation hazard. Many insurance companies do not cover these types of damages if the policyholder has refused to allow the hazard to be eliminated. Undergrounding of overhead utility lines can help reduce the impact of windstorms on the power system, while improving the aesthetics of the community.

As indicated above, the City of Newport Beach requires that each mooring be inspected at least once every two years by the Harbor Resources Manager or a contractor authorized by the Harbor Resources Manager. If upon inspection, the lifted mooring is found to be defective, it has to be repaired before replaced back in the water (Municipal Code 17.25.020, Section K). Vessels using moorings in Newport Beach also need to be firmly anchored so as to prevent the vessel from swinging, turning or drifting (Municipal Code 17.25.020, Section I.1). These requirements are designed to reduce the potential for wind damage to moorings and vessels, but failure of these facilities sometimes still occurs due to the harsh water environment and often unpredictable weather conditions.

Widespread weather observation stations and networks, in addition to great advancements in computer modeling and a better, if not yet comprehensive understanding of atmospheric processes, have greatly facilitated the forecasting of meteorological events such as winter storms and windstorms. Weather forecasts, combined with an increased use of internet and media resources, permit the wide dissemination of weather warnings in real time, with the potential to greatly reduce the effect of extreme weather events on people and property. Utility companies, relief organizations, and government officials can and should use weather warnings to anticipate a need for an increase in the number of on-call maintenance and emergency response personnel to respond to power outages, downed trees and fallen electric lines, and other damages typical during and following high-wind events.

Windstorm Resource Directory

State Resources

California Division of Forestry and Fire Protection
1416 9th Street
P.O. Box 944246
Sacramento, California 94244-2460
Ph: 916-653-5123

Governor's Office of Emergency Services (Cal OES)
P.O. Box 419047
Rancho Cordova, CA 95741-9047
Ph: 916-845-8911
Fax: 916-845-8910

California Department of Transportation (Cal Trans)
120 S. Spring Street
Los Angeles, CA 90012
Ph: 213-897-3656

Federal Resources and Programs

Federal Emergency Management Agency (FEMA) – Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607
Ph: 510-627-7100
Fax: 510-627-7112

National Weather Service
Los Angeles / Oxnard Weather Forecast Office
520 North Elevar Street
Oxnard, California 93030
Forecast and Weather Information: 805-988-6610
Administrative Issues: 805-988-6615

Publications

American Association for Wind Engineering, 2004, Wind Engineering Research and Outreach Plan to Reduce Losses Due to Wind Hazards (Hurricanes, Tornadoes, and Thunderstorms).

Meade, C. and Abbott, M., 2003, Assessing Federal Research and Development for Hazard Loss Reduction: RAND, Arlington, VA.

National Research Council, 1991, A Safer Future: Reducing the Impacts of Natural Disasters: National Academy Press, Washington, D.C.

National Research Council, 1993, Wind and the Built Environment: U.S. Needs in Wind Engineering and Hazard Mitigation: National Academy Press, Washington, D.C.

National Research Council, 1994, Facing the Challenge: The U.S. National Report to the IDNDR World Conference on Natural Disaster Reduction: National Academy Press, Washington, D.C.

National Research Council, 1999, The Impacts of Natural Disasters: A Framework for Loss Estimation: National Academy Press, Washington, D.C.

APPENDIX A: MASTER RESOURCE DIRECTORY

The Resource Directory provides contact information for local, regional, State, and Federal agencies and organizations that are currently involved in hazard mitigation activities. The Hazard Mitigation Advisory Committee may refer to the organizations on the following pages for resources and technical assistance. The Resource Directory provides a foundation for potential partners in the action item implementation.

The Hazard Mitigation Advisory Committee will maintain and update this master resource directory. This directory may be used by various community members interested in hazard mitigation information and projects.

American Public Works Association			
Level: National	Hazard: Multi	http://www.apwa.net	
2345 Grand Boulevard		Suite 700	
Kansas City, MO 64108-2625		Ph: 800-848-APWA	Fax: 816-472-1610
Notes: The American Public Works Association is an international, educational, and professional association of public agencies, private sector companies, and individuals dedicated to providing high quality public works goods and services.			
Association of State Floodplain Managers			
Level: Federal	Hazard: Flood	www.floods.org	
575 D'Onofrio Drive		Suite 200	
Madison, WI 53719		Ph: 608-828-3000	Fax: 608-828-6319
Notes: The Association of State Floodplain Managers is an organization of professionals involved in floodplain management, flood hazard mitigation, the National Flood Insurance Program, and flood preparedness, warning and recovery.			
Building Seismic Safety Council (BSSC)			
Level: National	Hazard: Earthquake	www.bssconline.org	
1090 Vermont Avenue, NW		Suite 700	
Washington, DC 20005		Ph: 202-289-7800	Fax: 202-289-1092
Notes: The Building Seismic Safety Council (BSSC) develops and promotes building earthquake risk mitigation regulatory provisions for the nation. The BSSC supports advances in building science and technology to improve the built environment.			

California Department of Transportation (CalTrans)			
Level: State and Local	Hazard: Multi	www.dot.ca.gov/; www.dot.ca.gov/dist12/	
3347 Michelson Drive		Suite 100	
Irvine, CA 92612		Ph: 949-724-2000	Fax:
Notes: CalTrans is responsible for the design, construction, maintenance, and operation of the California State Highway System, as well as that portion of the Interstate Highway system within the State's boundaries. Alone and in partnership with Amtrak, Caltrans is also involved in the support of intercity passenger rail service in California. Caltrans – District 12 office serves Orange County.			

California Natural Resources Agency			
Level: State	Hazard: Multi	http://resources.ca.gov/	
1416 Ninth Street		Suite 1311	
Sacramento, CA 95814		Ph: 916-653-5656	Fax: 916-653-8102
Notes: The California Natural Resources Agency restores, protects and manages the state's natural, historical and cultural resources for current and future generations using solutions based on science, collaboration and respect for all the communities and interests involved.			

California Division of Forestry and Fire Protection (CalFire)			
Level: State	Hazard: Multi	http://www.fire.ca.gov/php/index.php	
2524 Mulberry Street (Southern Region Operations)			
Riverside, CA 92501		Ph: 951-782-4140	Fax:
Notes: The California Department of Forestry and Fire Protection serves and safeguards the people and protects the property and resources of California. CDF emphasizes the management and protection of California's natural resources, providing fire prevention and fire protection services.			

California Geological Survey (CGS)			
Level: State	Hazard: Multi	http://www.consrv.ca.gov/CGS/	
801 K Street		MS 12-30	
Sacramento, CA 95814		Ph: 916-445-1923	Fax: 916-445-5718
Notes: The California Geological Survey develops and disseminates technical information and advice on California's geology, geologic hazards, and mineral resources. The Southern California Regional Office is located in the Junipero Serra Building, 320 W. 4th Street, Suite 850, Los Angeles, CA 90013, Ph: 213-239-0877; Fax: 213-239-0894.			

California Environmental Resources Evaluation System (CERES)			
Level: State	Hazard: Multi	http://ceres.ca.gov/	
901 P Street		Suite 350	
Sacramento, CA 95814		Ph: 916-651-0770	Fax:
Notes: CERES is an information system developed by the California Natural Resources Agency to facilitate access to a variety of electronic data describing California's environments. The aim of the program is to facilitate environmental analysis and planning by integrating natural and cultural resource information from multiple contributors and making it available and useful to a wide range of users. It is an excellent website for access to environmental information and links to other websites.			

California Department of Water Resources (DWR)			
Level: State	Hazard: Flood	http://wwwdwr.water.ca.gov	
1416 9th Street			
Sacramento, CA 95814		Ph: 916-653-5791	Fax: 916-653-4684
Notes: The Department of Water Resources manages the water resources of California in cooperation with other agencies, to benefit the State's people, and to protect, restore, and enhance the natural and human environments. The agency was created by the State Legislator to plan, design, construct, and oversee the building of the nation's largest state-built water development and conveyance system. The DWR protects, conserves, develops, and manages much of California's water supply, including the State Water Project.			

California Department of Conservation			
Level: State	Hazard: Multi	www.consrv.ca.gov	
801 K Street		MS-24-01	
Sacramento, CA 95814		Ph: 916-322-1080	Fax: 916-445-0732
Notes: The Department of Conservation provides services and information that promote environmental health, economic vitality, informed land-use decisions and sound management of our State's natural resources. The Department oversees the California Geological Survey, The California Division of Oil, Gas and Geothermal Resources, the Office of Mine Reclamation, the State Mining and Geology Board, the California Farmland Conservancy Program, and the State Watershed Program, among others.			

California Planner's Information Network (CALPIN)		
Level: State	Hazard: Multi	www.calpin.ca.gov
Notes: The Governor's Office of Planning and Research (OPR) State Clearinghouse and Planning Unit publishes basic information on local planning agencies, known as the California Planners' Book of Lists. This local planning information is available on-line with new search capabilities and up-to-the- minute updates.		

California Coastal Commission – South Coast District Office			
Level: State	Hazard: Multi	www.coastal.ca.gov	
200 Oceangate, 10th Floor			
Long Beach, CA 90802-4416		Ph: 562-590-5071	Fax: 562-590-5084
Notes: The Coastal Commission, in partnership with coastal cities and counties, plans and regulates the use of land and water in the coastal zone. Its mission is to protect, conserve, restore and enhance environmental and human-based resources of the California coast and ocean for environmentally sustainable and prudent use by current and future generations. Development activities, such as construction of buildings, divisions of land, and activities that change the intensity of use of land or public access to coastal waters, generally require a permit from either the Coastal Commission or the local government.			

Community Rating System (CRS) (of the National Flood Insurance Program)			
Level: Federal	Hazard: Flood	http://www.fema.gov/national-flood-insurance-program-community-rating-system	
500 C Street, S.W.			
Washington, D.C. 20472		Ph: 202-566-1600	Fax:
Notes: The Community Rating System (CRS) recognizes community floodplain management efforts that go beyond the minimum requirements of the NFIP. Property owners within the County would receive reduced NFIP flood insurance premiums if the County implements floodplain management practices that qualify it for a CRS rating. For further information on the CRS, visit FEMA's website.			

Environmental Protection Agency (EPA), Region 9 (Pacific Southwest)			
Level: Regional	Hazard: Multi	http://www2.epa.gov/aboutepa/epa-region-9-pacific-southwest	
75 Hawthorne Street			
San Francisco, CA 94105		Ph: 415-947-8000	Fax: 415-947-3553
Notes: The mission of the U.S. Environmental Protection Agency is to protect human health and to safeguard the natural environment through the themes of air and global climate change, water, land, communities and ecosystems, and compliance and environmental stewardship. The EPA Southern California Field Office is located at 600 Wilshire Boulevard, Suite 1460, Los Angeles, CA 90017.			

Federal Emergency Management Agency (FEMA), Region IX			
Level: Federal	Hazard: Multi	www.fema.gov	
1111 Broadway		Suite 1200	
Oakland, CA 94607		Ph: 510-627-7100	Fax: 510-627-7112
Notes: The Federal Emergency Management Agency is tasked with responding to, planning for, recovering from and mitigating against disasters. FEMA provides extensive resources to help communities, businesses, and residents prepare for disasters. FEMA is also a major source of funding through grants for hazard mitigation and hazard preparedness.			

Federal Emergency Management Agency (FEMA), Region 9 Mitigation Division			
Level: Federal and State	Hazard: Multi	http://www.fema.gov/fema-region-ix-mitigation-division	
1111 Broadway		Suite 1200	
Oakland, CA 94607-4052		Ph: 510-627-7162	Fax:
Notes: The Mitigation Division manages the National Flood Insurance Program and oversees FEMA's mitigation programs. It has a number of programs and activities that provide for citizens' Protection, with flood insurance; Prevention, with mitigation measures, and Partnerships, with communities throughout the country. The Region 9 Mitigation Division oversees the Risk Analysis Branch, Hazard Mitigation Assistance Branch, and Floodplain Management and Insurance Branch.			

Floodplain Management Association			
Level: Federal	Hazard: Flood	www.floodplain.org	
P.O. Box 712080			
Santee, CA 92072		Ph: 916-231-2134	Fax:
Notes: The Floodplain Management Association is a non-profit educational association established in 1990 to promote the reduction of flood losses and to encourage the protection and enhancement of natural floodplain values. Members include representatives from Federal, State and local government agencies, as well as private firms. The association serves as an unbiased forum for legislature, government, industry and science to advance best practices, technologies, policies, regulations, and legal strategies, with a focus on California, Nevada and Hawaii.			

Governor's Office of Emergency Services (Cal OES)			
Level: State	Hazard: Multi	www.oes.ca.gov; www.calema.ca.gov/	
3650 Schriever Avenue			
Mather, CA 95655		Ph: 916 845- 8510	Fax: 916 845- 8511
Notes: The Governor's Office of Emergency Services coordinates overall State agency response to major disasters in support of local government. The office is responsible for assuring the state's readiness to respond to and recover from natural, man-made, and war-caused emergencies, and for assisting local governments in their emergency preparedness, response and recovery efforts.			

Landslide Hazards Program, USGS (National Landslide Information Center)			
Level: Federal	Hazard: Landslide	http://landslides.usgs.gov/	
NLIC, 1711 Illinois			
Golden, CO 80401-1865		Ph: 800-654-4966 or 303-273-8588	Fax: 303-273-8600
Notes: The Landslide Hazards Program (LHP) provides information that leads to the reduction of losses from landslides and increase public safety through improved understanding of landslide hazards and strategies for hazard mitigation. The LHP conducts landslide hazard assessments, pursues landslide investigations and forecasts, provides technical assistance to respond to landslide emergencies, and engages in outreach activities. Their website provides information on available programs and resources that address landslides. The website includes information on the National Landslide Hazards Program Information Center, a bibliography, publications, and current projects.			

Firewise Communities Program (project of the **National Fire Protection Association)**			
Level: National	Hazard: Wildfire	www.firewise.org/	
1 Batterymarch Park			
Quincy, MA 02169-7471		Ph: 617-984-7486	Fax: 617-770-0700
Notes: Firewise maintains a Website designed for people who live in wildfire- prone areas, but it also can be of use to local planners and decision makers. The site offers online wildfire protection information and checklists, online classes, as well as listings of other publications, videos, and conferences. The program encourages local solutions for safety by involving homeowners in taking individual responsibility for preparing their homes from the risk of wildfire.			

National Resources Conservation Service			
Level: Federal	Hazard: Multi	http://www.nrcs.usda.gov/	
1400 Independence Avenue, SW		Room 5105-A	
Washington, DC 20250		Ph: 202-720-7246	Fax: 202-720-7690
Notes: NRCS assists private property owners to conserve their soil, water, and other natural resources by delivering technical assistance based on sound science and suited to a customer's specific needs. Cost shares and financial incentives are available in some cases.			

National Interagency Fire Center (NIFC)			
Level: Federal	Hazard: Wildfire	www.nifc.gov	
3833 S. Development Avenue			
Boise, Idaho 83705-5354		Ph: 208-387- 5512	Fax:
Notes: The NIFC is the nation's support center for wildland firefighting. Seven federal agencies work together to coordinate and support wildland fire and disaster operations. These agencies include the US Forest Service, Bureau of Land Management, National Weather Service, National Park Service, Bureau of Indian Affairs, US Fish and Wildlife Service, and US Fire Administration-FEMA.			

National Fire Protection Association (NFPA)			
Level: National	Hazard: Wildfire	http://www.nfpa.org/	
1 Batterymarch Park			
Quincy, MA 02169-7471		Ph: 617-770-3000	Fax: 617-770-0700
Notes: The mission of the international, non-profit NFPA is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating scientifically based consensus codes and standards, research, training and education.			

National Floodplain Insurance Program (NFIP)			
Level: Federal	Hazard: Flood	http://www.fema.gov/national-flood-insurance-program	
500 C Street, S.W.			
Washington, D.C. 20472		Ph: 202-646-2500	Fax:
Notes: The Mitigation Division manages the National Flood Insurance Program and oversees FEMA's mitigation programs. It has of a number of programs and activities, including flood insurance for private property owners, mitigation measures to encourage prevention of flood disasters, and partnerships with communities throughout the country.			

National Oceanic and Atmospheric Administration (NOAA)			
Level: Federal	Hazard: Multi	www.noaa.gov	
1401 Constitution Avenue, NW		Room 5128	
Washington, DC 20230		Ph: 202-482-6090	Fax: 202-482-3154
Notes: NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship. Some services provided by NOAA include daily weather forecasts, severe storm warnings and climate monitoring, fisheries management, coastal restoration, and marine commerce support.			

National Weather Service, Office of Hydrologic Development			
Level: Federal	Hazard: Flood	http://www.nws.noaa.gov/oh/	
1325 East West Highway			
Silver Spring, MD 20910		Ph: 301-713-1658	Fax: 301-713-0963
Notes: The Office of Hydrologic Development (OHD) enhances National Weather Service (NWS) products by infusing new hydrologic science, developing hydrologic techniques for operational use, managing hydrologic development by NWS field offices, and providing advanced hydrologic products to meet needs identified by NWS customers. Their products and services improve flood warnings and water resource forecasts.			

National Weather Service (NWS)			
Level: Federal	Hazard: Multi	http://www.wrh.noaa.gov/lox/	
1325 East West Highway			
Silver Spring, MD 20910		Ph:	Fax:
Notes: The National Weather Service is responsible for providing weather service to the nation. It is charged with the responsibility of observing and reporting the weather and with issuing forecasts and warnings of weather and floods in the interest of national safety and economy. Briefly, the priorities for service to the nation are: 1) protection of life, 2) protection of property, and 3) promotion of the nation's welfare and economy. The Western Region Headquarters office is located at 125 South State Street, Salt Lake City, UT 84138-1102.			

Orange County Fire Authority			
Level: County	Hazard: Fire	http://www.ocfa.org	
1 Fire Authority Rd.			
Irvine, CA 92602		Ph: 714-573-6000 Fire Information: 714-573-6200	Fax:
Notes: The Orange County Fire Authority is a regional fire service agency that serves 24 cities in Orange County and all unincorporated areas. The OCFA protects over 1,680,000 residents from its 71 fire stations located throughout Orange County. The OCFA delivers fire, emergency medical and rescue services; provides public education programs to schools, businesses, community associations, childcare providers, and other members of the community; administers a Reserve Firefighter Program; sponsors Fire Explorer posts; adopts and enforces codes and ordinances; maintains and operates firefighting helicopters for emergency response; coordinates the inspection of commercial buildings, investigates all fires; enforces hazardous materials regulations; works with developers and jurisdictional planning departments on development projects that could impact fire protection services; conducts new construction inspections, fire safety inspections, and State Fire Marshal-required inspections; conducts an inventory program of hazardous materials stored, handled and used within the OCFD's jurisdiction; conducts Uniform Fire Code inspections; and develops and maintains a fire-safe corridor between the wildland and community developments through fuel modifications and inspections.			

Orange County Water District			
Level: County	Hazard: Multi	http://www.ocwd.com	
18700 Ward Street			
Fountain Valley, CA 92708		Ph: 714-378-3200	Fax: 714-378-3373
Notes: The Orange County Water District manages the groundwater basin under north and central Orange County that supplies water to 19 municipal and special water districts, serving more than 2.4 million customers. To meet the demands of this arid region, they developed a groundwater replenishment system that provides water supply while preventing seawater intrusion into the groundwater basin.			

Orange County Coastkeeper			
Level: County	Hazard: Multi	http://www.coastkeeper.org	
3151 Airway Avenue		Suite F-100	
Costa Mesa, CA 92626		Ph: 714-850-1965	Fax: 714-850-1592
Notes: Orange County Coast keeper is a non-profit organization dedicated to the protection and preservation of the marine habitats and watersheds of Orange County through programs of education, restoration, enforcement and advocacy. They work collaboratively with diverse groups in the public and private sectors to achieve healthy, accessible, and sustainable water resources for the region.			

Orange County Sanitation District			
Level: County	Hazard: Multi	http://www.ocsd.com	
10844 Ellis Avenue			
Fountain Valley, CA 92708		Ph: 714-962-2411	Fax:
Notes: Orange County Sanitation District collects, treats and disposes of (or reclaims) wastewater generated by 2.5 million people in a 479-square-mile area of central and northwestern Orange County.			

Orange County Health Care Agency Certified Unified Program Agency (CUPA)			
Level: County	Hazard: Multi	http://www.occupainfo.com	
1241 East Dyer Road		Suite 120	
Santa Ana, CA 92705		Ph: 714-433-6000	Fax: 714-433-6423
Notes: The CUPA is the local administrative agency that coordinates six programs regulating hazardous materials and hazardous wastes in Orange County. The six programs include: 1) hazardous materials disclosure, 2) business emergency plans, 3) hazardous waste, 4) underground storage tanks, 5) aboveground petroleum storage tanks, and 6) California accidental release prevention. County and City Fire Agencies within Orange County have joined in partnership with the CUPA as participating agencies. The CUPA provides regulated businesses with a single-point of contact for permitting, billing and inspections; uniformity and consistency in enforcement of regulations, and a single-fee system incorporating all of the applicable fees from the six CUPA programs.			

Orange County Chapter of the American Red Cross			
Level: County	Hazard: Multi	http://www.redcross.org/ca/orange-county	
601 North Golden Circle Drive			
Santa Ana, CA 92705		Ph: 714-481-5300	Fax:
Notes: The American Red Cross of Orange County is the regional headquarters of the Red Cross in Orange, Riverside and San Bernardino Counties. Their staff and volunteers are dedicated to disaster preparedness and response; health, safety and aquatics classes; the Lifeline program for independent seniors; youth service programs, as well as educational and informational presentations to thousands of residents and businesses each year. Their region serves 7.3 million people, responds to a local emergency approximately every 22 hours, trains nearly 50,000 people in first aid and CPR annually, teaches nearly 60,000 residents water safety and lifeguard skills, and participates in a national network of nearly 600 local chapters.			

Orange County Sheriff's Department – Emergency Communications Bureau			
Level: County	Hazard: Multi	http://www.ocsd.org	
2644 Santiago Canyon Road			
Silverado, CA 92676		Ph: 714-647-7000 714-628-7170	Fax:
Notes: The Orange County Sheriff's Emergency Management Department operates the Emergency Operation Center (EOC) in the event of a natural disaster or other emergency to help coordinate emergency response countywide.			

Mesa Water District			
Level: County	Hazard: Multi	http://www.mesawater.org	
1965 Placentia Avenue			
Costa Mesa, CA 92627		Ph: 714-631-1200	Fax:
Notes: Mesa provides domestic and irrigation water and serves more than 108,000 people in an 18-square mile area including parts of Newport Beach, Costa Mesa and John Wayne Airport. 100 percent of the water provided by Mesa Water District is sourced from local water supplies.			

South Coast Air Quality Management District (AQMD)			
Level: Regional	Hazard: Multi	http://www.aqmd.gov/	
21865 Copley Drive			
Diamond Bar, CA 91765 Branch Office: 1500 W. Carson, Suite, 115 Long Beach, CA 90810		Ph: 800-CUT-SMOG (for air quality complaints) 909-396-2000 310-233-7000	Fax: 909-326-2000
Notes: AQMD is a regional government agency that seeks to achieve and maintain healthful air quality through a comprehensive program of research, regulations, enforcement, and communication. The AQMD covers Los Angeles and Orange Counties, and parts of Riverside and San Bernardino Counties.			

Southern California Earthquake Center (SCEC)			
Level: Regional	Hazard: Earthquake	http://www.scec.org/	
3651 Trousdale Parkway		Suite 169	
Los Angeles, CA 90089-0742		Ph: 213-740-5843	Fax: 213-740-0011
Notes: The Southern California Earthquake Center (SCEC) gathers new information about earthquakes in southern California, integrates this information into a comprehensive and predictive understanding of earthquake phenomena, and communicates this understanding to end-users and the general public in order to increase earthquake awareness, reduce economic losses, and save lives.			

Southern California Association of Governments (SCAG)			
Level: Regional	Hazard: Multi	http://www.scag.ca.gov/	
818 W. 7th Street		12th Floor	
Los Angeles, CA 90017		Ph: 213-236-1800	Fax: 213-236-1825
Notes: The Southern California Association of Governments functions as the Metropolitan Planning Organization for six counties: Los Angeles, Orange, San Bernardino, Riverside, Ventura and Imperial. As the designated Metropolitan Planning Organization, the Association of Governments is mandated by the Federal government to research and draw up plans for transportation, growth management, hazardous waste management, and air quality.			

State Fire Marshal (SFM)			
Level: State	Hazard: Wildfire	http://osfm.fire.ca.gov	
1131 "S" Street			
Sacramento, CA 95811		Ph: 916-445-8200	Fax: 916-445-8509
Notes: The Office of the State Fire Marshal (SFM) supports the mission of the California Department of Forestry and Fire Protection (CalFire) by focusing on fire prevention. SFM regulates buildings in which people live, controls substances which may cause injuries, death and destruction by fire; provides statewide direction for fire prevention within wildland areas; regulates hazardous liquid pipelines; reviews regulations and building standards; and trains and educates in fire protection methods and responsibilities.			

United States Geological Survey (USGS)			
Level: Federal	Hazard: Multi	http://www.usgs.gov/	
345 Middlefield Road			
Menlo Park, CA 94025		Ph: 650-853-8300 1-800-ASK-USGS	Fax:
Notes: The USGS provides reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. The Pasadena Field Office is located at 525 South Wilson Avenue, Pasadena, CA 91106-3212, Ph: 626-583-7811.			

US Army Corps of Engineers (USACE), Los Angeles District			
Level: Federal	Hazard: Multi	http://www.spl.usace.army.mil/	
915 Wilshire Boulevard		Suite 1101	
Los Angeles, CA 90017		Ph: 213-452- 3333	Fax: 213-452-4209
Notes: The United States Army Corps of Engineers works in engineering and environmental matters. A workforce of biologists, engineers, geologists, hydrologists, natural resource managers and other professionals provides engineering services to the nation including planning, designing, building and operating water resources and other civil works projects.			

US Department of Agriculture (USDA) Forest Service			
Level: Federal	Hazard: Wildfire	http://www.fs.fed.us	
1400 Independence Ave. SW			
Washington, D.C. 20250-1111		Ph: 202-205-8333 1-800-832-1355	Fax:
Notes: The Forest Service is an agency of the U.S. Department of Agriculture. The Forest Service manages public lands in national forests and grasslands.			

US Geological Survey (USGS) Water Resources			
Level: Federal	Hazard: Multi	http://ca.water.usgs.gov/	
6000 J Street		Placer Hall	
Sacramento, CA 95819-6129		Ph: 916-278-3000	Fax: 916-278-3070
Notes: The USGS Water Resources' mission is to provide water information that benefits the Nation's citizens; this information is presented in the form of publications, data, maps, and applications software. The USGS Water aims to minimize loss of life and property as a result of water-related natural hazards such as floods, drought, and landslides; effectively manage groundwater and surface-water resources for domestic, agricultural, recreational, and ecological uses; protect and enhance water resources for human health, aquatic health, and environmental quality; and contribute to the wise physical and economic development of our resources for the benefit of present and future generations.			

Western States Seismic Policy Council (WSSPC)			
Level: Regional	Hazard: Earthquake	www.wsspc.org/	
801 K Street		Suite 1236	
Sacramento, CA 95814		Ph: 916-444-6816	Fax: 916-444-8077
Notes: WSSPC is a regional earthquake consortium funded mainly by FEMA. Its website is a great resource, with information clearly categorized - from policy to engineering to education. The WSSPC develops seismic policies and shares information to promote programs aimed at reducing earthquake-related losses.			

U.S. Department of Homeland Security (DHS)			
Level: Federal	Hazard: Multi	http://www.dhs.gov/dhspublic/index.jsp	
Department of Homeland Security			
Washington, D.C. 20528		Ph: 202-282-8000	Fax:
Notes: In the event of a terrorist attack, natural disaster or other large-scale emergency, the DHS assumes primary responsibility for ensuring that emergency response professionals are prepared for any situation. This entails providing a coordinated, comprehensive federal response to any large-scale crisis and mounting a swift and effective recovery effort. DHS also prioritizes the important issue of citizen preparedness. Educating America's families on how best to prepare their homes for a disaster and tips for citizens on how to respond in a crisis will be given special attention at DHS.			

U.S. Census Bureau			
Level: Federal	Hazard: Multi	http://www.census.gov/	
4600 Silver Hill Road			
Washington, DC 20233		Ph: 800-992-3530 818-267-1700	Fax: 818-267-1711
Notes: Offers many statistics, some of which are available by metropolitan statistical area or by county. The Census Bureau publications collection also includes many current and historical censuses on population and housing. Older census data, which present data describing the people and the economy of each state and county from 1790 to 1960, are also available. The Los Angeles Regional Office is located at 15350 Sherman Way, Suite 400, Van Nuys, CA 91406-4224.			

Appendix B: PUBLIC PARTICIPATION PROCESS and MEETING MATERIALS

In accordance with requirements from the Federal Emergency Management Agency (FEMA) that public input needs to be considered during the development of mitigation plans, the Newport Beach Local Natural Hazards Mitigation Plan Update (this Plan) is the result of a collaborative effort between various City Departments and their consultant, local citizens, and regional and state organizations. Public participation is a key component to strategic planning processes, with residents offered the chance to voice their ideas, interests, and opinions about natural hazard mitigation in their community.

To accomplish this goal, the Newport Beach Hazard Mitigation Advisory Committee developed a public participation process that integrates a cross-section of citizen input and consisted of four main components: (1) development of a project Steering Committee comprised of knowledgeable individuals from various City departments that are already tasked with natural hazard reduction programs and are knowledgeable of the community; (2) stakeholder interviews to obtain input from specific individuals from City Staff and volunteers from the Community Emergency Response Team with expertise in or knowledgeable about natural hazards and their impact on populations at risk; (3) public workshops and disaster preparedness fairs to identify common concerns and ideas regarding hazard mitigation, and to discuss specific goals and actions of the mitigation plan, and (4) publication of the Draft Plan in the City's Web site with a link that allows for public comment and input regarding the document. Through citizen involvement, the Mitigation Plan reflects community issues, concerns, and new ideas and perspectives on mitigation opportunities and plan action items.

Steering and Advisory Committees

Hazard mitigation in the City of Newport Beach is overseen by the Hazard Mitigation Advisory Committee. This committee includes representatives from various City departments. A smaller group of members from the Advisory Committee form the Steering Committee. These committee members have an understanding of how the community is structured and how residents, businesses, and the environment may be affected by natural hazard events. The Advisory Committee guided the development of the Plan, and assisted in developing plan goals and action items, identifying stakeholders, and sharing local expertise to create a more comprehensive Plan. The Steering Committee provided the resources necessary to prepare the Plan, and is tasked with the implementation and review of the Plan's effectiveness.

The Steering Committee was comprised of representatives from:

- ✓ City of Newport Beach Emergency Services (Ms. Katie Eing)
- ✓ City of Newport Beach Fire Department (Mr. Jim Turner)
- ✓ City of Newport Beach Municipal Operations Department (Mr. Mike Pisani), and
- ✓ City of Newport Beach Public Works Department (Mr. Patrick Arciniega)

The Advisory Committee included members from the departments listed above, plus representatives from these other City departments and organizations:

- ✓ City of Newport Beach Community Development Department, Planning Division
- ✓ City of Newport Beach Community Development Department, Building Division
- ✓ City of Newport Beach Harbor Resources
- ✓ City of Newport Beach Information Services – GIS Division

- ✓ City of Newport Beach Police Department and
- ✓ City of Newport Beach Administrative Services Department

The Final Document was presented to the Mayor, City Council Members and Planning Commissioners for review prior to adoption of the document.

Process Followed

The process followed in preparing the original 2008 Local Hazard Mitigation Plan (Plan) for the City of Newport Beach is described in detail in Appendix B of the 2008 document. Herein we describe only the process followed in completing the 2014 Plan Update.

For the 2014 Update, the consultant was to revise the maps provided in the 2008 Plan to include newly incorporated parcels, and update the maps as needed to reflect new data released since 2008. This included updated FEMA flood maps, and tsunami inundation maps released by the California Emergency Management Agency in cooperation with the University of Southern California Center for Tsunami Research and the California Geological Survey. The mitigation actions section (Section 4) was to be updated to show those tasks the City has chosen to prioritize during the next five years, and action items already implemented would be identified (in Section 5). The Community Profile section (Section 2) was updated by the City's Community Development Department, Planning Division to reflect the Census data from 2010 and population estimates for 2012 and/or 2013 and recent developments in the City. Finally, the Introduction, Table of Contents and Appendices were to be updated as necessary to reflect the new document. All of these changes were made.

In addition, all sections of the Plan were updated to include significant events (earthquakes, teletsunamis, storms, windstorms, and wildfires) that have impacted the Newport Beach and/or Orange County area since 2008. At the request of the Fire Chief, the Fire Hazards section (Section 8) was updated to include new programs and legislation implemented at the Federal, State and local levels to reduce the effects of wildfires. The most recent map of Very High Fire Severity Zones adopted by the City's Fire Department is included in this Plan Update. At the request of a local resident who attended the Public Workshop, the Landslide Hazards section (Section 9) was updated to reflect the significant man-made changes to the topography of the Newport Coast area, where, as a result of grading for development, several landslide masses have been removed, and others have been buttressed. The slope distribution and slope instability maps in that section of the report were updated to show these changes. The Flood Hazards section (Section 7) was also modified and updated to expand the section on sea level rise as a consequence of climate change, and to describe changes made to some of the dams that could impact the City if they failed catastrophically. Finally, the Risk Assessment section (Section 3) now includes an analysis of the critical facilities at risk from the various hazards discussed in the plan.

Public participation played a key role in the development of goals and action items. As described in the previous paragraph, the 2014 Plan Update incorporates feedback received from both City staff and residents. Presentations to various stakeholders were made using both oversized versions of the maps prepared for the Plan and a PowerPoint presentation. The Final Draft version of the Plan was posted on the City's website to allow for, and provide ongoing citizen/stakeholder information and participation. A link to post comments and questions regarding the Draft document was provided on the City's website. This document has also benefited from the input and guidance provided by the members of the Hazard Mitigation Steering and Advisory Committees, whom have guided the process of developing the Plan from its inception.

The mitigation actions presented in Section 4 were developed by the Advisory Committee during several meetings described further below. The public participation process is also described in more detail in the appropriate sub-section below.

The template used for this document was originally prepared by the Office of Disaster Management, Area C. Their permission to use and build upon the original document is herein kindly acknowledged. The information presented in this Plan is a compilation from many different sources (listed in Appendices A and I); however, the following organizations merit special recognition for the wealth of information they provide to the general public. These are resources that the Advisory Committee should rely on both during the implementation of the action items contained in this plan, and in the development of future Plans.

- ✓ California Geological Survey (CGS)
- ✓ U.S. Geological Survey (USGS)
- ✓ Federal Emergency Management Agency (FEMA)
- ✓ Governor's Office of Emergency Services (OES)
- ✓ Southern California Earthquake Center (SCEC)
- ✓ Southern California Association of Governments (SCAG)

Meetings with the Steering and Advisory Committees

The following paragraphs and tables summarize the meetings held with the Steering and Advisory Committees during the process of preparing the Plan, with the participants of those meetings identified in the tables following the meeting summaries.

Meeting #1: Tuesday, July 30, 2013, 9:00 AM to 10:30 AM
The purpose of this kick-off meeting was to set in motion the process to update the Local Hazard Mitigation Plan for the City of Newport Beach, using the 2008 Plan as a basis. The meeting was held in the conference room of the City's Emergency Operations Center in the basement of the new City Hall. The agenda for this meeting included the following items:

1. Welcome and introductions, with emphasis on the City department or agency represented, and the expertise brought to the group by those individuals;
2. PowerPoint presentation describing the Purpose and Scope of a Disaster Mitigation Plan, to introduce the project to new members of the committee who did not participate in the 2008 Plan;
3. Questions and Answers;
4. Task Assignments and Schedule of Future Meetings; and
5. Adjournment

The attendees are listed in Table B-2, below. The PowerPoint presentation made by the consultant described the requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, and the work already accomplished with preparation of the 2003 Hazards Assessment Study, 2006 Safety Element of the General Plan, and the 2008 Local Hazards Mitigation Plan.

Members of the committee were interviewed regarding information on recent hazard events, existing hazard mitigation efforts within their own divisions and organizations, and ideas on how to best conduct the public outreach requirements of this project.

Table B-1: Attendees, Kick-off Meeting on July 30, 2013

Name	Department or Organization
Mike Pisani	Municipal Operations Department
Katie Eing	Fire Department, Emergency Services
Rachell Wilfert	Municipal Operations Department
Jim Turner	Fire Department, Lifeguards
Mike Sinacori	Public Works Department
Patrick Arciniega	Public Works Department
Tania Gonzalez	Consultant – Earth Consultants International

Following the kick-off meeting, the City's consultant proceeded to prepare the First Draft of the Plan Update, using the 2008 Plan as a starting point. Updated maps were prepared and submitted to the City, printed in oversized format, to be used as exhibits during the City's Disaster Preparedness Fair held the weekend of September 14-15, 2013. Additional information on this public outreach effort is summarized later in this document.

Katie Eing, the City's Emergency Services officer held several one-on-one meetings with other committee members in September and October 2013 to obtain information on the action items implemented by the City during the period between 2008-2013. Ideas on new action items to be included in the Plan Update were also discussed. Personnel from the City's Community Development Department worked on updating the Plan's Community Profile.

Meeting No. 2: Thursday October 10, 2013, 8:30AM – 10AM
This meeting of the Newport Beach Hazard Advisory Committee was held in the conference room of the City's Emergency Operations Center in the basement of City Hall. Individuals who attended this meeting are listed in Table B-2 below. The agenda for this meeting included the following topics:

1. Welcome;
2. PowerPoint presentation summarizing the findings of the Draft report and presenting the intent and format of the goals and action items as a discussion item;
3. Feedback on the revised maps and section updates;
4. Task assignments and scheduling of future meetings; and
5. Meeting adjournment.

Table B-2: Attendees, Advisory Committee Meeting on October 10, 2013

Name	Department or Organization
Jim Turner	Fire Department, Lifeguards
Rachell Wilfert	Municipal Operations Department
Mike Pisani	Municipal Operations Department
Patrick Alford	Community Development Dept., Planning
Patrick Arciniega	Public Works Department
Dan Kennedy	Community Development Department
Katie Eing	Fire Department, Emergency Services
Tania Gonzalez	Consultant, Earth Consultants International

Preliminary corrections and suggested additions to the Draft report were provided to the consultant by several of the attendees.

Meeting No. 3: Wednesday, September 24, 2014
This meeting was a one-on-one meeting with the City's Emergency Services officer to work through the last changes to the document requested by the Fire Department. Also at this meeting, we discussed scheduling and submittal of the final document. Consultant requested photographs of recent hazard events that could be used in the cover of the Plan.

Table B-3: Attendees, Meeting on September 24, 2014

Name	Department or Organization
Katie Eing	Fire Department / Emergency Services
Tania Gonzalez	Consultant, Earth Consultants International

Meeting No. 4: Tuesday, October 27, 2014
This meeting of the Newport Beach Hazard Advisory Committee was held in the main room of the Emergency Operations Center in the basement of City Hall. Individuals who attended this meeting are listed in Table B-4.

The purpose of this meeting was to discuss the contents of Section 4 – Goals and Action Items, with emphasis on an analysis of the action items that had been proposed earlier. The committee members discussed the value of several goals being considered. Committee members were asked to prioritize the new proposed action items following the STAPLEE criteria. A tentative list of action items had been proposed several months before, but some of the City departments had not committed to being the coordinating organization in charge of seeing those specific action items being implemented. The consultant requested all City departments to give the action items in the spreadsheet a final look to ensure that all action items had been assigned to the appropriate department or organization. Tentative action items that were not assigned to a responsible department were deleted from the list.

Table B-4: Attendees, Advisory Committee Meeting on October 27, 2014

Name	Department / Organization
Katie Eing	Fire Department, Emergency Services
Mike Pisani	Municipal Operations Department
Patrick Arciniega	Public Works Department
Daniel Kennedy	Community Development Department
Tania Gonzalez	Consultant, Earth Consultants International

Over the next two weeks, City staff from the various departments represented in the Advisory Committee reviewed and completed the prioritization of the action items. Ms. Katie Eing from the Fire Department – Emergency Services facilitated this effort and kept everyone on track. Once this task was completed, Ms. Eing submitted the final spreadsheet to the consultant, who completed Section 4 – Goals and Action Items using the data provided by City staff.

Public Meetings

Presentations to various stakeholders have been made across the City, both as part of the original Safety Element work, and for this project. Once the Final Draft of the Hazards Mitigation Plan Update was completed, the document was posted on the City's website in

November 2014 to allow for, and provide ongoing citizen/stakeholder information and participation. The Final Draft was available for review between November 2014 and January 2015. A link to Ms. Eing's e-mail address to send comments and questions regarding the Draft document was provided on the City's website.

Several events have been held to gain input from the public as part of the Local Hazard Mitigation Plan Update. Ms. Katie Eing was present at all public events; the consultant was present at the Public Workshop on May 7, 2014. The first event was on September 14, 2013, when the City hosted its annual Disaster Preparedness Expo. During the Expo, oversized copies of the maps prepared for the Plan were displayed, and City staff was on hand to answer any questions and provide feedback. Over 700 members from the public attended that event. (A Disaster Preparedness Expo was also held on September 13, 2014 that was attended by 650 people. Information specific to the Natural Hazards Mitigation Plan was not posted at this fair, but information on how to prepare for, and respond to disasters was made available to all participants.) The dates of these meetings are summarized on Table B-5 below.

The City held a public workshop specifically to present the Local Hazard Mitigation Plan update on May 7, 2014. The workshop was announced in the City's website, and in notices posted at various locations throughout City Hall and at the Library branches. The City also used the mass-notification system, E-Select, to send out numerous messages advertising the workshops. At this May meeting, the consultant prepared and gave a PowerPoint presentation that described the purpose and scope of the Hazard Mitigation Plan, the findings of the hazard assessment, and possible mitigation actions. A copy of the PowerPoint presentation given is included here, at the end of this section. Oversized printouts of the most important hazard maps prepared for the Plan were placed around the room, pinned to the wall, to allow for easy viewing by the participants. The consultant was present to answer any questions.

In addition, the City has presented the information contained in the Plan at several Community Emergency Response Team (CERT) meetings. The dates of these meetings are also included in Table B-5. Finally, the City hosted an Earthquake and Tsunami Awareness Workshop where information on the specific earthquake sources and the anticipated impact to the city if and when a tsunami generated by an earthquake on a nearby offshore fault occurs. Mitigation measures implemented by the City, including sirens, signs showing tsunami evacuation routes, and evacuation procedures were discussed. This meeting, held at the Oasis Senior Center, was attended by an estimated 100 people.

Table B-5: Public Workshops and Meetings Held in Support of the Hazard Mitigation Plan

Date	Event
September 14, 2013	Disaster Preparedness Expo
March 11, 2014	CERT class
March 15, 2014	CERT class
March 26, 2014	Earthquake and Tsunami Awareness Workshop
May 7, 2014	Public Workshop on the Local Hazard Mitigation Plan
September 13, 2014	Disaster Preparedness Expo
September 23, 2014	CERT class
September 27, 2014	CERT class

Results from the Workshop and Website Posting of Plan

The public workshop was attended by members of the City's Community Emergency Response Team (CERT) and several City residents, in addition to personnel from the Fire Department and the Newport-Mesa Unified School District. Prior to starting the PowerPoint presentation, the attendees were encouraged to walk around the room and look at the hazard maps pinned to the walls. These maps often elicited comments – most people checked where they live and work (if in the City) in relation to the hazards mapped. The PowerPoint presentation was given in an open forum format, allowing the attendees to interrupt with questions and comments as they wished. Taking advantage of the fact that the public workshop was advertised through various media, the public was also invited to send comments via e-mail to Ms. Eing, especially if they could not attend the public meeting. Comments received through this process are also summarized here.

Questions received during the Public Workshop include:

1. "Can the sirens set for tsunami warnings be used for other hazards?" **Response**: Ms. Eing responded that yes, indeed, the sirens can be used to alert the population of other impending hazards. She also mentioned that the City, in cooperation with the County of Orange, uses a regional public mass notification system to inform residents of emergency situations that could affect the health, safety or welfare of the community. Although not mentioned at the workshop, it is important to note that the system uses the 9-1-1 emergency databases to contact Orange County households. Cell phones, as well as cable and internet-based phone systems, are not part of this database. These numbers need to be self-registered to receive notifications.
2. "Large portions of the Newport Coast area of the City have been developed, in the process mitigating the landslides therein. The City's General Plan and the landslide susceptibility maps in this Plan should be revisited to reflect this." **Response**: As a result of this comment, and with verbal authorization from the City, the consultant re-analyzed the slope gradients in the area using recent topographic maps provided by the City's GIS division. Due to grading conducted as part of the development process, the slope gradients have in many areas decreased. We also reviewed Google Earth images of the area and compared the original geologic map of the area showing mapped landslides with areas now developed to identify those landslide masses that are now presumed to be mitigated. Please note that actual as-graded reports for these areas were not reviewed, as that was beyond the scope of work, and thus, we cannot be certain that the landslides have indeed been mitigated, but the maps and images reviewed suggest that at least surficially, this is the case.
3. "How does the City's Emergency Operations Plan relate to the Local Hazards Mitigation Plan?"
   Response: Ms. Eing and the City's consultant combined explained that the Local Hazards Mitigation Plan and the Emergency Operations Plan are complementary documents with different objectives. The first identifies those hazards that the City is most susceptible to, the population, critical facilities and infrastructure most at risk from these hazards, and action items that the City has identified that can be implemented to reduce the impact of these hazards. The Emergency Operations Plan is used to respond to a disaster by identifying the personnel that will mobilize in the event of an emergency, and by describing the tasks and actions that would be conducted as part of the response and recovery efforts.

Comments and questions received via e-mail during and after the workshop notification was released, and in response to the Final Draft of the Plan being posted on the City's website are transcribed below.

1. “Many of us in the community have serious concerns about the constant exposure to airplane fuel, directly overhead for a large number of Newport Beach residents. I used to live on the beach on Balboa Peninsula, at the corner of C Street, and if I wanted to eat outside on one of our patios, I had to wipe off the furniture (the cleaning cloths would be black afterwards), three times a day. We were all breathing that in every day. A large number of people on the Peninsula at that time developed some form of cancer, including me.
   After living on the Peninsula for 13 years, I relocated to the Baycrest area of Dover Shores, two blocks from the Back Bay. Although we are still exposed to the noise from planes, and can see them, the direct path is a few houses over, so the black soot isn't as bad an issue.
   If I were able to attend your session, this would be the number one issue to be addressed, IMHO.”
   Response: The current Plan only addresses natural hazards. City staff hope that man-made hazards, including issues with air traffic pollution such as those described by this resident, can be addressed in future versions of the plan. We appreciate the input and will keep it mind for future updates of the Plan.

2. Katie, Amazing. Is this your doctoral thesis? How long did this take you to collect and organize? Very well prepared. Some thoughts - you may have covered them. Could (not) do a search in the format it was in: A) Effect of major sewage backup, B) Effect of major air accident, C) Effects of other city hazards (CM, HB, Irvine, Laguna, Santa Ana, etc.). Since NB is a city of status for the country, terrorist activity could cause major issues (ex, major shopping malls, airport, resort areas, etc.). Why is there no updated population data after 2010 (Section 2-8)? Love to get a hard copy of the document, if that is possible. Good luck and thank you for your very hard DETAILED work.
   Response from Ms. Eing to this resident: This plan has taken 15 months to update. We’ve changed quite a few things and we also had many delays. The Hazard Mitigation Plan focused on “natural” hazards only and not man-made which would include the information you provided below. Next time we update I hope to include man-made hazards. The Census only officially does a count every 10 years, so that’s why the numbers are from 2010. I can get you a hard copy of the plan but do you want it now or wait until additional changes are incorporated and the State and FEMA have approved it. Thanks for the interest and comments!

3. From all I can assess, I appears you have done an outstanding job covering all the necessary areas! Good for you.
   Response: Thank you for your interest and comments.

APPENDIX C: ECONOMIC ANALYSIS OF NATURAL HAZARD MITIGATION PROJECTS

Benefit/cost analysis is a key mechanism used by the State Office of Emergency Services (CalOES), the Federal Emergency Management Agency, and other State and Federal agencies in evaluating hazard mitigation projects, and is required by the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288, as amended.

This appendix outlines several approaches for conducting economic analysis of natural hazard mitigation projects. It describes the importance of implementing mitigation activities, different approaches to economic analysis of mitigation strategies, and methods to calculate costs and benefits associated with mitigation strategies. Information in this section is derived in part from: The Interagency Hazards Mitigation Team, State Hazard Mitigation Plan, (Oregon State Police – Office of Emergency Management, 2000), and Federal Emergency Management Agency Publication 331, Report on Costs and Benefits of Natural Hazard Mitigation. There are several useful publications that describe the process of conducting a benefit/cost analysis, including equations, developed by and for FEMA. Several of these publications are listed at the end of this section, in the Resources section. FEMA has also developed a software package, or toolkit, for a variety of natural hazards. For additional information and the most up-to-date software, refer to https://www.fema.gov/benefit-cost-analysis, or do a search for FEMA BCA software.

This section is not intended to provide a comprehensive description of benefit/cost analysis, nor is it intended to provide the details of economic analysis methods that can be used to evaluate local projects. It is intended to (1) raise benefit/cost analysis as an important issue, and (2) provide some background on how economic analysis can be used to evaluate mitigation projects.

Why Evaluate Mitigation Strategies?

Mitigation activities reduce the cost of disasters by minimizing property damage, injuries, and the potential for loss of life. Mitigation activities also reduce emergency response costs, which would otherwise be incurred.

Evaluating natural hazard mitigation provides decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects. Evaluating mitigation projects is a complex and difficult undertaking, which is influenced by many variables. First, natural disasters affect all segments of the communities they strike, including individuals, businesses, and public services such as fire, police, utilities, and schools. Second, while some of the direct and indirect costs of disaster damages are measurable, some of the costs are non-financial and difficult to quantify in dollars. Third, many of the impacts of such events produce "ripple-effects" throughout the community, greatly increasing the disaster's social and economic consequences.

While not easily accomplished, there is value, from a public policy perspective, in assessing the positive and negative impacts from mitigation activities, and obtaining an instructive benefit/cost comparison. Otherwise, the decision to pursue or not pursue various mitigation options would not be based on an objective understanding of the net benefit or loss associated with these actions.

What are Some Economic Analysis Approaches for Mitigation Strategies?

The approaches used to identify the costs and benefits associated with natural hazard mitigation strategies, measures, or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. The distinction between the two methods is the way in which the relative costs and benefits are measured. Additionally, there are varying approaches to assessing the value of mitigation for public sector and private sector activities.

Benefit/Cost Analysis

Benefit/cost analysis is used in natural hazards mitigation to show if the benefits to life and property protected through mitigation efforts exceed the cost of the mitigation activity. Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster related damages later. Benefit/cost analysis is based on calculating the frequency and severity of a hazard, avoided future damages, and risk.

In benefit/cost analysis, all costs and benefits are evaluated in terms of dollars, and a net benefit/cost ratio is computed to determine whether a project should be implemented (i.e., if net benefits exceed net costs, the project is worth pursuing). A project must have a benefit/cost ratio greater than 1 in order to be funded.

Cost-Effectiveness Analysis

Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. This type of analysis, however, does not necessarily measure costs and benefits in terms of dollars. Determining the economic feasibility of mitigating natural hazards can also be organized according to the perspective of those with an economic interest in the outcome. Hence, economic analysis approaches are covered for both public and private sectors as follows.

- **Investing in Public Sector Mitigation Activities**
  Evaluating mitigation strategies in the public sector is complicated because it involves estimating all of the economic benefits and costs regardless of who realizes them, which could potentially be a large number of people and economic entities. Furthermore, some benefits cannot be evaluated monetarily, but still affect the public in profound ways. Economists have developed methods to evaluate the economic feasibility of public decisions that involve a diverse set of beneficiaries and non-market benefits.

- **Investing in Private Sector Mitigation Activities**
  Private sector mitigation projects may occur on the basis of one of two approaches: it may be mandated by a regulation or standard, or it may be economically justified on its own merits. A building or landowner, whether a private entity or a public agency, required to conform to a mandated standard may consider the following options:

  1. Request cost sharing from public agencies;
  2. Dispose of the building or land either by sale or demolition;
  3. Change the designated use of the building or land and change the hazard mitigation compliance requirement; or
  4. Evaluate the most feasible alternatives and initiate the most cost-effective hazard mitigation alternative.

Estimating the costs and benefits of a hazard mitigation plan strategy can be a complex process. Employing the services of a specialist can assist in this process.

The sale of a building or land triggers another set of concerns. For example, real estate disclosure laws can be developed which require sellers of real property to disclose known defects and deficiencies in the property, including earthquake weaknesses and hazards to prospective purchasers. Correcting deficiencies can be expensive and time consuming, but their existence can prevent the sale of the building. Conditions of a sale regarding the deficiencies and the price of the building can be negotiated between a buyer and seller.

How Can an Economic Analysis be Conducted?

Benefit/cost analysis and cost-effectiveness analysis are important tools in evaluating whether or not to implement a mitigation activity. A framework for evaluating alternative mitigation activities is outlined below:

1. **Identify the Alternatives:** Alternatives for reducing risk from natural hazards can include structural projects to enhance disaster resistance, education and outreach, and acquisition or demolition of exposed properties, among others. Different mitigation projects can assist in minimizing the risk to natural hazards, but do so at varying economic costs.

2. **Calculate the Costs and Benefits:** Choosing economic criteria is essential to systematically calculate the costs and benefits of mitigation projects and select the most appropriate alternative. Potential economic criteria to evaluate alternatives include:

    - **Determine the Project Cost.** This may include initial project development costs, and repair and operating costs of maintaining projects over time.

    - **Estimate the Benefits.** Projecting the benefits, or cash flow resulting from a project can be difficult. Expected future returns from the mitigation effort depend on the correct specification of the risk and the effectiveness of the project, which may not be well known. Expected future costs depend on the physical durability and potential economic obsolescence of the investment. This is difficult to project. These considerations will also provide guidance in selecting an appropriate salvage value. Future tax structures and rates must be projected. Financing alternatives, such as retained earnings, bond and stock issues, and commercial loans, must be researched.

    - **Consider Costs and Benefits to Society and the Environment.** These are not easily measured, but can be assessed through a variety of economic tools including existence value or contingent value theories. These theories provide quantitative data on the value people attribute to physical or social environments. Even without hard data, however, impacts of structural projects to the physical environment or to society should be considered when implementing mitigation projects.

- **Determine the Correct Discount Rate.** Determination of the discount rate can refer only to the risk-free cost of capital, but it may also include the decision maker's time preference and also a risk premium. Inflation should also be considered.

3. **Analyze and Rank the Alternatives:** Once costs and benefits have been quantified, economic analysis tools can be used to rank the alternatives. Two methods for determining the best alternative given varying costs and benefits include net present value and internal rate of return.

- **Net Present Value.** Net present value is the value of the expected future return on an investment minus the value of expected future cost expressed in today's dollars. If the net present value is greater than the project's costs, the project may be deemed feasible for implementation.

- **Internal Rate of Return.** Using the internal rate of return method to evaluate mitigation projects provides the interest rate equivalent to the dollar returns expected from the project. Once the rate has been calculated, it can be compared to rates earned by investing in alternative projects. Projects may be feasible to implement when the internal rate of return is greater than the total costs of the project.

Once the mitigation projects are ranked on the basis of economic criteria, decision-makers can consider other factors, such as risk, project effectiveness, and economic, environmental, and social returns in choosing the appropriate project for implementation.

How are the Benefits of Mitigation Calculated?

Economic Returns of Natural Hazard Mitigation

The estimation of economic returns, which accrue to a building or landowner as a result of natural hazard mitigation, is difficult. Owners evaluating the economic feasibility of mitigation should consider reductions in physical damages and financial losses. A partial list follows:

- Building damages avoided
- Content damages avoided
- Inventory damages avoided
- Rental income losses avoided
- Relocation and disruption expenses avoided
- Proprietor's income losses avoided

These parameters can be estimated using observed prices, costs, and engineering data. The difficult part is to correctly determine the effectiveness of the hazard mitigation project and the resulting reduction in damages and losses. Equally as difficult is assessing the probability that an event will occur. The damages and losses should only include those that will be borne by the owner. The salvage value of the investment can be important in determining economic feasibility. Salvage value becomes more important as the time horizon of the owner declines. This is important because most businesses depreciate assets over a period of time.

Additional Costs from Natural Hazards

Property owners should also assess changes in a broader set of factors that can change as a result of a large natural disaster. These are usually termed "indirect" effects, but they can have a very direct effect on the economic value of the owner's building or land. They can be positive or negative, and include changes in the following:

- Commodity and resource prices
- Availability of resource supplies
- Commodity and resource demand changes
- Building and land values
- Capital availability and interest rates
- Availability of labor
- Economic structure
- Infrastructure
- Regional exports and imports
- Local, state, and national regulations and policies
- Insurance availability and rates

Changes in the resources and industries listed above are more difficult to estimate and require models that are structured to estimate total economic impacts. Total economic impacts are the sum of direct and indirect economic impacts. Total economic impact models are usually not combined with economic feasibility models. Many models exist to estimate total economic impacts of changes in an economy.

Decision makers should understand the total economic impacts of natural disasters in order to calculate the benefits of a mitigation activity. This suggests that understanding the local economy is an important first step in being able to understand the potential impacts of a disaster, and the benefits of mitigation activities.

Additional Considerations

Conducting an economic analysis for potential mitigation activities can assist decision-makers in choosing the most appropriate strategy for their community to reduce risk and prevent loss from natural hazards. Economic analysis can also save time and resources from being spent on inappropriate or unfeasible projects. Several resources and models (see list below) are available to help in conducting an economic analysis for natural hazard mitigation activities.

Benefit/cost analysis is complicated, and the numbers may divert attention from other important issues. It is important to consider the qualitative factors of a project associated with mitigation that cannot be evaluated economically. There are alternative approaches to implementing mitigation projects. Many communities are looking towards developing multi-objective projects. With this in mind, opportunity rises to develop strategies that integrate natural hazard mitigation with projects related to watersheds, environmental planning, community economic development, and small business development, among others. Incorporating natural hazard mitigation with other community projects can increase the viability of project implementation.

Resources

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APPENDIX D: ACRONYMS

Federal Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ARC	American Red Cross
ATC	Applied Technology Council
BFE	Base Flood Elevation
BLM	Bureau of Land Management
BSSC	Building Seismic Safety Council
CBRA	Coastal Barrier Resources Act of 1982
CDBG	Community Development Block Grant
CFR	Code of Federal Regulations
CRS	Community Rating System
DOE	Department of Energy
DFE	Design Flood Elevation
EDA	Economic Development Administration
EPA	Environmental Protection Agency
ER	Emergency Relief
EWP	Emergency Watershed Protection (NRCS Program)
FAS	Federal Aid System
FAY	Federal Award Year
FDAA	Federal Disaster Assistance Administration
FEMA	Federal Emergency Management Agency
FIA	Federal Insurance Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance (FEMA Program)
FPI	Fire Potential Index
GSA	General Services Administration
HazUS	Hazards United States (an earthquake damage assessment prediction tool)
HMGP	Hazard Mitigation Grant Program
HMST	Hazard Mitigation Survey Team
HUD	Housing and Urban Development (United States, Department of)
IBHS	Institute for Business and Home Safety
IHMT	Interagency Hazard Mitigation Team
NCDC	National Climate Data Center
NEMIS	National Emergency Management Information System
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Association
NPP	Nuclear Power Plant
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NSF	National Science Foundation
NWS	National Weather Service
OASIS	Operational Area Satellite Information System
OCC	Operations Coordination Center
OCD	Office of Civil Defense
OEP	Office of Emergency Planning
PDA	Preliminary Damage Assessment
PIO	Public Information Office

PPA/CA	Performance Partnership Agreement/Cooperative Agreement (FEMA)
SBA	Small Business Administration
SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
URM	Unreinforced Masonry
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFA	United States Fire Administration
USFS	United States Forest Service
USGS	United States Geological Survey
WSSPC	Western States Seismic Policy Council

California and Local Acronyms

ADDI	American Dream Downpayment Initiative
APEFZ	Alquist-Priolo Earthquake Fault Zone
ARP	Accidental Risk Prevention
ATC20	Applied Technology Council20
ATC21	Applied Technology Council21
BSA	California Bureau of State Audits
CAER	Community Awareness & Emergency Response
CalARP	California Accidental Release Prevention
CalBO	California Building Officials
CalEPA	California Environmental Protection Agency
CalFire	California Department of Forestry and Fire Prevention
Cal OES	California Governor's Office of Emergency Services
CalTRANS	California Department of Transportation
CBO	Community Based Organization
CD	Civil Defense
CDBG	Community Development Block Grant
CDMG	California Division of Mines and Geology (now CGS)
CEC	California Energy Commission
CEPEC	California Earthquake Prediction Evaluation Council
CESRS	California Emergency Services Radio System
CGS	California Geological Survey
CHIP	California Hazardous Identification Program
CHMIRS	California Hazardous Materials Incident Reporting System
CHP	California Highway Patrol
CLETS	California Law Enforcement Telecommunications System
CSTI	California Specialized Training Institute
CUPA	Certified Unified Program Agency
DAD	Disaster Assistance Division (of the state Office of Emergency Services)
DFO	Disaster Field Office
DGS	California Department of General Services
DOC	Department Operations Center
DOF	California Department of Finance
DOJ	California Department of Justice
DPIG	Disaster Preparedness Improvement Grant
DR	Disaster Response
DSA	Division of the State Architect

DSR	Damage Survey Report
DSW	Disaster Service Worker
DWR	California Department of Water Resources
EAS	Emergency Alerting System
EDIS	Emergency Digital Information System
EERI	Earthquake Engineering Research Institute
EMA	Emergency Management Assistance
EMI	Emergency Management Institute
EMMA	Emergency Managers Mutual Aid
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
EPEDAT	Early Post Earthquake Damage Assessment Tool
EPI	Emergency Public Information
EPIC	Emergency Public Information Council
ESC	Emergency Services Coordinator
FEAT	Governor's Flood Emergency Action Team
FIR	Final Inspection Reports
FIRESCOPE	Firefighting Resources of So. Calif Organized for Potential Emergencies
FMA	Flood Management Assistance
HAZMAT	Hazardous Materials
HAZMIT	Hazardous Mitigation
HAD	Housing and Community Development
HEICS	Hospital Emergency Incident Command System
HEPG	Hospital Emergency Planning Guidance
HIA	Hazard Identification and Analysis Unit
HMEP	Hazardous Materials Emergency Preparedness
HMGP	Hazard Mitigation Grant Program
HOME	Home Investment Partnership Program
IFG	Individual & Family Grant (program)
IRG	Incident Response Geographic Information System
IPA	Information and Public Affairs (of state Office of Emergency Services)
LEMMA	Law Enforcement Master Mutual Aid
LEPC	Local Emergency Planning Committee
MARAC	Mutual Aid Regional Advisory Council
MHID	Multi-hazard Identification
OCC	Operations Coordination Center
OCD	Office of Civil Defense
OEP	Office of Emergency Planning
OES	California Governor's Office of Emergency Services (also Cal OES)
OSHPD	Office of Statewide Health Planning and Development
OSPR	Oil Spill Prevention and Response
PTAB	Planning and Technological Assistance Branch
RA	Regional Administrator (OES)
RADEF	Radiological Defense (program)
RAMP	Regional Assessment of Mitigation Priorities
RAPID	Railroad Accident Prevention & Immediate Deployment
RDO	Radiological Defense Officer
RDMHC	Regional Disaster Medical Health Coordinator
REOC	Regional Emergency Operations Center
REPI	Reserve Emergency Public Information

RES	Regional Emergency Staff
RIMS	Response Information Management System
RMP	Risk Management Plan
RPU	Radiological Preparedness Unit (OES)
RRT	Regional Response Team
SAM	State Administrative Manual
SAVP	Safety Assessment Volunteer Program
SCEC	Southern California Earthquake Center
SCO	California State Controller's Office
SEMS	Standardized Emergency Management System
SEPIC	State Emergency Public Information Committee
SHMO	State Hazard Mitigation Officer
SLA	State and Local Assistance
SONGS	San Onofre Nuclear Generating Station
SOP	Standard Operating Procedure
SWEPC	Statewide Emergency Planning Committee
UPA	Unified Program Account
USAR	Urban Search and Rescue
WC	California State Warning Center

Industry and Other Acronyms

A&W	Alert and Warning
AA	Administering Areas
AAR	After Action Report
B/CA	Benefit/Cost Analysis
BCP	Budget Change Proposal
CADD	Computer-Aided Design and Drafting
CMU	Concrete Masonry Unit
FTE	Full Time Equivalent
FSR	Feasibility Study Report
FY	Fiscal Year
GIS	Geographic Information System
IA	Individual Assistance
ICC	Increased Cost of Compliance
IDE	Initial Damage Estimate
LAG	Lowest Adjacent Grade
LAN	Local Area Network
Mmax	Maximum magnitude earthquake
MOU	Memorandum of Understanding
MPE	Maximum Probable Earthquake
MSL	Mean Sea Level
NBC	Nuclear, Biological, Chemical
NGVD	National Geodetic Vertical Datum of 1929
OA	Operational Area
OASIS	Operational Satellite Information System
OSB	Oriented Strand Board
PA	Public Assistance
PC	Personal Computer
PGA	Peak Ground Acceleration
PSA	Public Service Announcement

PTR	Project Time Report
TEC	Travel Expense Claim
UPS	Uninterrupted Power Source
WAN	Wide Area Network

APPENDIX E: GLOSSARY

Acceleration	The rate of change of velocity with respect to time. Acceleration due to gravity at the earth's surface is 9.8 meters per second squared. That means that every second that something falls toward the surface of earth its velocity increases by 9.8 meters per second.
Active fault	According to Alquist-Priolo Earthquake Fault Zoning Act (APEFZA)'s requirements, an active fault is one that shows evidence of, or is suspected of having experienced surface displacement within the last 11,000 years. APEFZA classification is designed for land use management of surface rupture hazards. A more general definition (National Academy of Science, 1988), states "a fault that on the basis of historical, seismological, or geological evidence has the finite probability of producing an earthquake" (see potentially active fault).
Adjacent grade	Elevation of the natural or graded ground surface, or structural fill, abutting the walls of a building. See *highest adjacent grade* and *lowest adjacent grade*.
Aftershocks	Minor earthquakes following a greater one and originating at or near the same place.
Aggradation	The building up of earth's surface by deposition of sediment.
Alluvial	Pertaining to, or composed of alluvium, or deposited by a stream or running water.
Alluvium	Surficial sediments of poorly consolidated gravels, sand, silts, and clays deposited by flowing water.
Amplitude	The height of a wave between its crest (high point) and its mid-point.
Anchor	To secure a structure to its footings or foundation wall in such a way that a continuous load transfer path is created and so that it will not be displaced by flood, wind, or seismic forces.
Apparatus	Fire apparatus includes firefighting vehicles of various types.
Appurtenant structure	Under the *National Flood Insurance Program*, a structure which is on the same parcel of property as the principal *structure* to be insured and the use of which is incidental.
Aquifer	A body of rock or sediment that contains sufficient saturated permeable material to allow the flow of groundwater and to yield economically significant quantities of groundwater to wells and springs.
Argillic	Alteration in which certain minerals of a rock or sediments are converted to clay.
Armor	To protect slopes from *erosion* and *scour* by *flood* waters. Techniques of armoring include the use of riprap, gabions, or concrete.
Artesian	An adjective referring to ground water confined under hydrostatic pressure. The water level in wells drilled into an *artesian* aquifer (also called a confined aquifer) will stand at some height above the top of the aquifer. If the water reaches the ground surface the well is a "flowing" *artesian* well.
Aspect	The direction a slope faces.

Asset	Any man-made or natural feature that has value, including, but not limited to people, buildings, infrastructure like bridges, roads, and sewer and water systems; lifelines like electricity and communication resources; or environmental, cultural, or recreational features like parks, dunes, wetlands, or landmarks.
Attenuation	The reduction in amplitude of a wave with time or distance traveled.
Automatic aid agreement	An agreement between two or more agencies whereby such agencies are automatically dispatched simultaneously to predetermined types of emergencies in predetermined areas.
A zone	Under the *National Flood Insurance Program*, area subject to inundation by the *100-year flood* where wave action does not occur or where waves are less than 3 feet high, designated Zone A, AE, A1-A30, A0, AH, or AR on a *Flood Insurance Rate Map* (FIRM).
Base flood	Flood that has a 1 percent probability of being equaled or exceeded in any given year. Also known as the 100-year flood.
Base Flood Elevation (BFE)	Elevation of the base flood in relation to a specified datum, such as the National Geodetic Vertical Datum of 1929. The Base Flood Elevation is used as the standard for the National Flood Insurance Program.
Basement	Under the *National Flood Insurance Program*, any area of a building having its floor subgrade on all sides. (Note: What is typically referred to as a "walkout basement," which has a floor that is at or above grade on at least one side, is not considered a basement under the *National Flood Insurance Program*.)
Beach nourishment	Replacement of beach sand removed by ocean waters.
Beaufort scale	A scale devised in 1805 by Admiral Francis Beaufort of the British Navy to classify wind speed based on the wind's effect on the seas and vegetation. The scale goes from 0 (calm) to 12 (hurricane).
Bedding	The arrangement of a sedimentary rock in beds or layers of varying thickness and character.
Bedrock	The solid rock that underlies loose material, such as soil, sand, clay, or gravel.
Bench	A grading term that refers to a relatively level step excavated into earth material on which fill is to be placed.
Berm	Horizontal portion of the backshore beach formed by sediments deposited by waves.
Bioregion	A major, regional ecological community characterized by distinctive life forms and distinctive plant and animal species.
Blind thrust fault	A thrust fault is a low-angle reverse fault (top block pushed over bottom block). A "blind" thrust fault refers to one that does not reach the surface.
Breakaway wall	Under the *National Flood Insurance Program*, a wall that is not part of the structural support of the building and is intended through its design and construction to collapse under specific lateral loading forces, without causing damage to the elevated portion of the building or supporting foundation system. Breakaway walls are required by the *National Flood Insurance Program* regulations for any enclosures constructed below the *Base Flood Elevation* beneath elevated buildings in *Coastal High Hazard Areas* (also referred to as *V zones*). In addition, breakaway walls are recommended in areas where *flood* waters flow at high velocities or contain ice or other debris.
Brush	A collective term that refers to stands of vegetation dominated by shrubby, woody plants, or low-growing trees.

Brushfire	A fire burning in vegetation that is predominantly shrubs, brush and scrub growth.
Building	A structure that is walled and roofed, principally above ground and permanently affixed to a site. The term includes a manufactured home on a permanent foundation on which the wheels and axles carry no weight.
Building code	Regulations adopted by local governments that establish standards for construction, modification, and repair of buildings and other structures.
Built-up roof covering	Two or more layers of felt cemented together and surfaced with a cap sheet, mineral aggregate, smooth coating, or similar surfacing material.
Bulkhead	Wall or other structure, often of wood, steel, stone, or concrete, designed to retain or prevent sliding or *erosion* of the land. Occasionally, bulkheads are use to protect against wave action.
Cast-in-place concrete	Concrete that is poured and formed at the construction site.
Cladding	Exterior surface of the building envelope that is directly loaded by the wind.
Clay	A rock or mineral fragment having a diameter less than 1/256 mm (4 microns, or 0.00016 in.). Commonly applied to any soft, adhesive, fine-grained deposit.
Claystone	An indurated clay having the texture and composition of shale, but lacking its fine lamination. A massive mudstone in which clay predominates over silt.
Climate	The average condition of weather over time in a given region.
Coastal A zone	The portion of the *Special Flood Hazard Area* landward of a *V zone* or landward of an open coast without mapped *V zones* (e.g., shorelines of the Great Lakes), in which the principal sources of flooding are astronomical tides, *storm surge*, seiches, or *tsunamis*, not riverine sources. The *flood* forces in coastal A zones are highly correlated with coastal winds or coastal seismic activity. Coastal A zones may therefore be subject to wave effects, velocity flows, *erosion*, *scour*, or combinations of these forces. See *A zone* and *Non-coastal A zone*. (Note: the *National Flood Insurance Program* regulations do not differentiate between coastal A zones and *non-coastal A zones*.)
Coastal barrier	Depositional geologic feature such as a bay barrier, tombolo, barrier spit, or barrier island that consists of unconsolidated sedimentary materials; is subject to wave, tidal, and wind energies; and protects landward aquatic habitats from direct wave attack.
Coastal Barrier Resources Act of 1982 (CBRA)	Act (Pub. L. 97-348) that established the Coastal Barrier Resources System (CBRS). The act prohibits the provision of new flood insurance coverage on or after October 1, 1983, for any *new construction* or *substantial improvements* of structures located on any designated undeveloped coastal barrier within the CBRS. The CBRS was expanded by the Coastal Barrier Improvement Act of 1991. The date on which an area is added to the CBRS is the date of CBRS designation for that area.
Coastal flood hazard area	Area, usually along an open coast, bay, or inlet, that is subject to inundation by storm surge and, in some instances, wave action caused by storms or seismic forces.
Coastal high hazard area	Under the *National Flood Insurance Program*, an area of special flood hazard extending from offshore to the inland limit of a *primary frontal dune* along an open coast and any other area subject to high-velocity wave action from storms or seismic sources. On a *Flood Insurance Rate Map*, the Coastal High Hazard Area is designated Zone V, VE, or V1-V30. These zones designate areas subject to inundation by the *base flood* where *wave heights* or *wave runup depths* are greater than or equal to 3.0 feet.

Code official	Officer or other designated authority charged with the administration and enforcement of the code, or a duly authorized representative, such as a building, zoning, planning, or *floodplain management* official.
Column foundation	Foundation consisting of vertical support members with a height-to-least-lateral-dimension ratio greater than three. Columns are set in holes and backfilled with compacted material. They are usually made of concrete or masonry and often must be braced. Columns are sometimes known as posts, particularly if the column is made of wood.
Community at Risk	Wildland interface community in the vicinity of Federal lands that is at high risk from wildfire.
Community Rating System (CRS)	An NFIP (National Flood Insurance Program) program that provides incentives for NFIP communities to complete activities that reduce flood hazard risk. When the community completes specified activities, the insurance premiums of policyholders in these communities are reduced.
Complex fire	Two or more individual incidents located in the same general area and assigned to a single incident commander or unified command.
Computer-Aided Design And Drafting (CADD)	A computerized system enabling quick and accurate electronic 2-D and 3-D drawings, topographic mapping, site plans, and profile/cross-section drawings.
Concrete Masonry Unit (CMU)	Building unit or block larger than 12 inches by 4 inches by 4 inches made of cement and suitable aggregates.
Conglomerate	A coarse-grained sedimentary rock composed of rounded to subangular fragments larger than 2 mm in diameter set in a fine-grained matrix of sand or silt, and commonly cemented by calcium carbonate, iron oxide, silica or hardened clay. The consolidated equivalent of gravel.
Connector	Mechanical device for securing two or more pieces, parts, or members together, including anchors, wall ties, and fasteners.
Consolidation	Any process whereby loosely aggregated, soft earth materials become firm and cohesive rock. Also the gradual reduction in volume and increase in density of a soil mass in response to increased load or effective compressive stress, such as the squeezing of fluids from pore spaces.
Contour	A line of equal ground elevation on a topographic (contour) map.
Contraction joint	Groove that is formed, sawed, or tooled in a concrete structure to create a weakened plane and regulate the location of cracking resulting from the dimensional change of different parts of the structure. See *Isolation joint*.
Corrosion-resistant metal	Any nonferrous metal or any metal having an unbroken surfacing of nonferrous metal, or steel with not less than 10 percent chromium or with not less than 0.20 percent copper.
Coseismic rupture	Ground rupture occurring during an earthquake but not necessarily on the causative fault.
Critical facility	Facilities that are critical to the health and welfare of the population and that are especially important following hazard events. Critical facilities include, but are not limited to, shelters, police and fire stations, and hospitals.
Dead load	Weight of all materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, *cladding*, and other similarly incorporated architectural and structural items and fixed service equipment. See *Loads*.

Debris	(Seismic) The scattered remains of something broken or destroyed; ruins; rubble; fragments. (Flooding, Coastal) Solid objects or masses carried by or floating on the surface of moving water.
Debris burning	Any fire originally set for the purpose of clearing land or for burning rubbish, garbage, range, stubble or meadow burning.
Debris impact loads	Loads imposed on a structure by the impact of floodborne debris. These loads are often sudden and large. Though difficult to predict, debris impact loads must be considered when structures are designed and constructed. See *Loads*.
Debris flow	A saturated, rapidly moving saturated earth flow with 50 percent rock fragments coarser than 2 mm in size which can occur on natural and graded slopes.
Debris line	Line left on a structure or on the ground by the deposition of debris. A debris line often indicates the height or inland extent reached by *flood* waters.
Deck	Exterior floor supported on at least two opposing sides by an adjacent structure and/or posts, piers, or other independent supports.
Defensible space	An area, either natural or manmade, where material capable of causing a fire to spread has been treated, cleared, reduced, or changed in order to provide a barrier between an advancing wildland fire and the loss to life, property, or resources. In practice, defensible space is defined as an area with a minimum of 100 feet around a structure that is cleared of flammable brush or vegetation. Distance from the structure and the degree of fuels treatment vary with vegetation type, slope, density, and other factors.
Deflected canyons	A relatively spontaneous diversion in the trend of a stream or canyon caused by any number of processes, including folding and faulting.
Deformation	A general term for the process of folding, faulting, shearing, compression, or extension of rocks.
Design flood	The greater of either (1) the *base flood* or (2) the *flood* associated with the *flood hazard area* depicted on a community's flood hazard map, or otherwise legally designated.
Design Flood Elevation (DFE)	Elevation of the *design flood*, or the flood protection elevation required by a community, including wave effects, relative to the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or other datum.
Design flood protection depth	Vertical distance between the eroded ground elevation and the *Design Flood Elevation*.
Design stillwater flood depth	Vertical distance between the eroded ground elevation and the *design stillwater flood elevation*.
Design stillwater flood elevation	Stillwater elevation associated with the *design flood*, excluding wave effects, relative to the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or other datum.
Development	Under the *National Flood Insurance Program*, any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials
Differential settlement	Non-uniform settlement; the uneven lowering of different parts of an engineered structure, often resulting in damage to the structure. Sometimes included with liquefaction as ground failure phenomenon.

Digitize	To convert electronically points, lines, and area boundaries shown on maps into x, y coordinates (e.g., latitude and longitude, universal transverse mercator (UTM), or table coordinates) for use in computer applications.
Dike	A tabular shaped, igneous intrusion that cuts across bedding of the surrounding rock. An embankment to confine or control water, often built along the banks of a river to prevent overflow of lowlands. A levee.
Dispatch	The implementation of a command decision to move a resource or resources from one place to another.
Displacement	The length, measured in kilometers, of the total movement that has occurred along a fault over as long as the geologic record reveals.
Displacement time	The average time (in days) which the building's occupants typically must operate from a temporary location while repairs are made to the original building due to damages resulting from a hazard event.
DMA 2000	Disaster Mitigation Act of 2000. Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by Public Law 106-390, October 30, 2000. DMA 2000 is intended to establish a continuing means of assistance by the Federal Government to State and local governments in carrying out their responsibilities to alleviate the suffering and damage which result from disasters by (1) revising and broadening the scope of existing disaster relief programs; (2) encouraging the development of comprehensive disaster preparedness and assistance plans, programs, capabilities, and organizations by the States and by local governments; (3) achieving greater coordination and responsiveness of disaster preparedness and relief programs; (4) encouraging individuals, States, and local governments to protect themselves by obtaining insurance coverage to supplement or replace governmental assistance; (5) encouraging hazard mitigation measures to reduce losses from disasters, including development of land use and construction regulations; and (6) providing Federal assistance programs for both public and private losses sustained in disasters.
Dune	See *Frontal dune* and *Primary frontal dune*.
Dune toe	Junction of the gentle slope seaward of the dune and the dune face, which is marked by a slope of 1 on 10 or steeper.
Duration	How long a hazard event lasts.
Dynamic analysis	A complex earthquake-resistant engineering design technique (UBC - used for critical facilities) capable of modeling the entire frequency spectra, or composition, of ground motion. The method is used to evaluate the stability of a site or structure by considering the motion from any source or mass, such as that dynamic motion produced by machinery or a seismic event.
Earth flow	Imperceptibly slow-moving surficial material in which 80 percent or more of the fragments are smaller than 2 mm, including a range of rock and mineral fragments.
Earthquake	Vibratory motion propagating within the Earth or along its surface caused by the abrupt release of strain from elastically deformed rock by displacement along a fault.
Earth's crust	The outermost layer or shell of the Earth.
Effective Flood Insurance Rate Map (FIRM)	See *Flood Insurance Rate Map*.

El Niño	Phenomenon that originates, every few years, typically in December or early January, in the southern Pacific Ocean, off of the western coast of South America, characterized by warmer than usual water. This warmer water is statistically linked with increased rainfall in both the southeastern and southwestern United States, droughts in Australia, western Africa and Indonesia, reduced number of earthquakes in the Atlantic Ocean, and increased number of hurricanes in the Eastern Pacific.
Enclosure	That portion of an elevated building below the *Design Flood Elevation (DFE)* that is partially or fully surrounded by solid (including breakaway) walls.
Encroachment	Any physical object placed in a floodplain that hinders the passage of water or otherwise affects the flood flows. To develop at the edge of a forest or otherwise undeveloped lands.
Engineering geologist	A geologist who is certified by the State as qualified to apply geologic data, principles, and interpretation to naturally occurring earth materials so that geologic factors affecting planning, design, construction, and maintenance of civil engineering works are properly recognized and used. An engineering geologist is particularly needed to conduct investigations, often with geotechnical engineers, of sites with potential ground failure hazards.
Epicenter	The point at the Earth's surface directly above where an earthquake originated.
Episodic erosion	Erosion induced by a single storm event. Episodic erosion considers the vertical component of two factors: general beach profile lowering and localized conical scour around foundation supports. Episodic erosion is relevant to foundation embedment depth and potential undermining. See *Erosion*.
Erodible soil	Soil subject to wearing away and movement due to the effects of wind, water, or other geological processes during a flood or storm or over a period of years.
Erosion	Under the *National Flood Insurance Program*, the process of the gradual wearing away of landmasses. In general, erosion involves the detachment and movement of soil and rock fragments, during a flood or storm or over a period of years, through the action of wind, water, or other geologic processes.
Erosion analysis	Analysis of the short- and long-term *erosion* potential of soil or strata, including the effects of wind action, *flooding* or *storm surge*, moving water, wave action, and the interaction of water and structural components.
Erosion hazard area	Area anticipated to be lost to shoreline retreat over a given period of time. The projected inland extent of the area is measured by multiplying the average annual long-term recession rate by the number of years desired.
Essential facility	Elements that are important to ensure a full recovery of a community or state following a hazard event. These would include: government functions, major employers, banks, schools, and certain commercial establishments, such as grocery stores, hardware stores, and gas stations.
Evacuation	Movement of people from an area, typically their homes, to another area considered to be safe, typically in response to a natural or man-made disaster that makes and area unsafe for people.
Expansive soil	A soil that contains clay minerals that take in water and expand. If a soil contains sufficient amount of these clay minerals, the volume of the soil can change significantly with changes in moisture, with resultant structural damage to structures founded on these materials.

Extent	The size of an area affected by a hazard or hazard event.
Extratropical cyclone	Cyclonic storm events like Nor'easters and severe winter low-pressure systems. Both West and East coasts can experience these non-tropical storms that produce gale-force winds and precipitation in the form of heavy rain or snow. These cyclonic storms, commonly called Nor'easters on the East Coast because of the direction of the storm winds, can last for several days and can be very large – 1,000-mile wide storms are not uncommon.
Fault	A fracture in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust, in which adjacent surfaces are differentially displaced parallel to the plane of fracture.
Fault segment	A continuous portion of a fault zone that is likely to rupture along its entire length during an earthquake.
Fault slip rate	The average long-term movement of a fault (measured in cm/year or mm/year) as determined from geologic evidence.
Federal Emergency Management Agency (FEMA)	Independent agency created in 1978 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery.
Federal Insurance Administration (FIA)	The component of the *Federal Emergency Management Agency* directly responsible for administering the flood insurance aspects of the *National Flood Insurance Program*.
Federal Responsibility Area (FRA)	Area within which a Federal governmental agency has the financial responsibility of preventing and suppressing fires.
Fetch	Distance over which wind acts on the water surface to generate waves.
Fill	Material such as soil, gravel, or crushed stone placed in an area to increase ground elevations or change soil properties.
Fire behavior	The manner in which a fire reacts to the influences of fuel, weather and topography.
Fire flow	The flow rate of a water supply expressed in gallons per minute (gpm), measured at 20 pounds per square inch (psi) residual pressure, that is available for fire fighting..
Fire Potential Index (FPI)	Developed by USGS and USFS to assess and map fire hazard potential over broad areas. Based on such geographic information, national policy makers and on-the-ground fire managers established priorities for prevention activities in the defined area to reduce the risk of managed and wildfire ignition and spread. Prediction of fire hazard shortens the time between fire ignition and initial attack by enabling fire managers to pre-allocate and stage suppression forces to high fire risk areas.
Fire regime	The long-term fire pattern characteristic of a region or ecosystem described using a combination of seasonality, fire return interval, size, spatial complexity, intensity, severity, and fire type.
Fire resistant	A characteristic of a plant species that allows individuals to resist damage or mortality during a fire. Also used to describe construction materials that resist damage to fire.
Fire weather	The weather conditions that influence fire behavior, including air temperature, atmospheric moisture, atmospheric instability, clouds and precipitation.
First responders	A group designated by the community as those who may be first to arrive at the scene of a fire, accident, or chemical release.

Five (500)-year flood	*Flood* that has as 0.2-percent probability of being equaled or exceeded in any given year.
Flash flood	A flood event occurring with little or no warning where water levels rise at an extremely fast rate.
Flood	A rising body of water, as in a stream or lake, which overtops its natural and artificial confines and covers land not normally under water. Under the *National Flood Insurance Program*, either (a) a general and temporary condition or partial or complete inundation of normally dry land areas from: (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudslides (i.e., mudflows) which are proximately caused by flooding as defined in (2) and are akin to a river of liquid and flowing mud on the surfaces of normally dry land areas, as when the earth is carried by a current of water and deposited along the path of the current, or (b) the collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood or abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in (1), above.
Flood-damage-resistant material	Any construction material capable of withstanding direct and prolonged contact (i.e., at least 72 hours) with floodwaters without suffering significant damage (i.e., damage that requires more than cleanup or low-cost cosmetic repair, such as painting).
Flood depth	Height of the flood-water surface above the ground surface.
Flood elevation	Height of the water surface above an established elevation datum such as the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or *mean sea level*.
Flood hazard area	The greater of the following: (1) the area of special flood hazard, as defined under the *National Flood Insurance Program*, or (2) the area designated as a flood hazard area on a community's legally adopted flood hazard map, or otherwise legally designated.
Flood insurance	Insurance coverage provided under the National Flood Insurance Program.
Flood Insurance Rate Map (FIRM)	Under the *National Flood Insurance Program*, an official map of a community, on which the *Federal Emergency Management Agency* has delineated both the special hazard areas and the risk premium zones applicable to the community. (Note: The latest FIRM issued for a community is referred to as the *effective FIRM* for that community.)
Flood Insurance Study (FIS)	Under the *National Flood Insurance Program*, an examination, evaluation, and determination of *flood* hazards and, if appropriate, corresponding *water surface elevations*, or an examination, evaluation, and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards in a community or communities. (Note: The *National Flood Insurance Program* regulations refer to Flood Insurance Studies as "flood elevation studies.")
Floodplain	Any land area, including watercourse, susceptible to partial or complete inundation by water from any source.

Floodplain management	Operation of an overall program of corrective and preventive measures for reducing *flood* damage, including but not limited to emergency preparedness plans, flood control works, and *floodplain management regulations*.
Floodplain management regulations	Under the *National Flood Insurance Program*, zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as floodplain ordinance, grading ordinance, and erosion control ordinance), and other applications of police power. The term describes such state or local regulations, in any combination thereof, which provide standards for the purpose of *flood* damage prevention and reduction.
Flood-related erosion area or flood-related erosion prone area	A land area adjoining the shore of a lake or other body of water, which due to the composition of the shoreline or bank and high water levels or wind-driven currents, is likely to suffer *flood*-related *erosion* damage.
Floodway	The channel of a river or other watercourse, and the adjacent land areas that must be kept free of encroachment in order to discharge the base flood without cumulatively increasing the water surface elevation more than a certain height.
Flow failure	A type of liquefaction-induced failure that generally occurs in slopes greater than 3 degrees, and that is characterized by the displacement, often over tens to hundreds of feet, of blocks of soil riding on top of the liquefied substrate.
Footing	Enlarged base of a foundation wall, pier, post, or column designed to spread the load of the structure so that it does not exceed the soil bearing capacity.
Footprint	Land area occupied by a structure.
Freeboard	Under the *National Flood Insurance Program*, a factor of safety, usually expressed in feet above a *flood* level, for the purposes of *floodplain management*. Freeboard tends to compensate for the many unknown factors that could contribute to flood heights greater than the heights calculated for a selected size flood and floodway conditions, such as the hydrological effect of urbanization of the watershed.
Frequency	A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs, on average. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered.
Frontal dune	Ridge or mound of unconsolidated sandy soil, extending continuously alongshore landward of the sand beach and defined by relatively steep slopes abutting markedly flatter and lower regions on each side.
Fuel	The source of heat that sustains the combustion process. In wildland fires, fuel is the combustible plant biomass, including grass, leaves, ground litter, shrubs, plants and trees..
Fuel load	The amount of fuel that is potentially available for combustion.
Functional downtime	The average time (in days) during which a function (business or service) is unable to provide its services due to a hazard event.
Gabion	Rock-filled cage made of wire or metal that is placed on slopes or embankments to protect them from *erosion* caused by flowing or fast-moving water.
Geographic area impacted	The physical area in which the effects of the hazard are experienced.

Geographic Information Systems (GIS)	A computer software application that relates physical features on the Earth to a database to be used for mapping and analysis.
Geomorphology	The science that treats the general configuration of the Earth's surface. The study of the classification, description, nature, origin and development of landforms, and the history of geologic changes as recorded by these surface features.
Geotechnical engineer	A licensed civil engineer who is also certified by the State as qualified for the investigation and engineering evaluation of earth materials and their interaction with earth retention systems, structural foundations, and other civil engineering works.
Grade beam	Section of a concrete slab that is thicker than the slab and acts as a footing to provide stability, often under load-bearing or critical structural walls. Grade beams are occasionally installed to provide lateral support for vertical foundation members where they enter the ground.
Grading	Any excavating or filling or combination thereof. Generally refers to the modification of the natural landscape into pads suitable as foundations for structures.
Granite	Broadly applied, any completely crystalline, quartz-bearing, plutonic rock.
Ground failure	Permanent ground displacement produced by fault rupture, differential settlement, liquefaction, or slope failure.
Ground lurching	A form of earthquake-induced ground failure where soft, saturated soils move in a wave-like manner in response to intense seismic ground shaking, forming ridges or cracks at the surface.
Ground motion	The vibration or shaking of the ground during an earthquake. When a fault ruptures, seismic waves radiate, causing the ground to vibrate. The severity of the vibration increases with the amount of energy released and decreases with distance from the causative fault or epicenter, but soft soils can further amplify ground motions
Ground oscillations	A type of liquefaction-induced failure where liquefaction occurs at depth, in an area where the ground surface is too level to permit the lateral displacement of the overlying soil blocks. The blocks instead separate from one another and oscillate above the liquefied layer. This may result in the opening and closing of fissures or cracks, and the formation of sand boils or volcanoes.
Ground rupture	Displacement of the earth's surface as a result of fault movement associated with an earthquake.
Hazard	A source of potential danger or adverse condition. Hazards in this series will include naturally occurring events such as floods, earthquakes, tornadoes, tsunami, coastal storms, landslides, and wildfires that strike populated areas. A natural event is a hazard when it has the potential to harm people or property.
Hazard event	A specific occurrence of a particular type of hazard.
Hazard identification	The process of identifying hazards that threaten an area.
Hazard mitigation	Sustained actions taken to reduce or eliminate long-term risk from hazards and their effects.
Hazard profile	A description of the physical characteristics of hazards and a determination of various descriptors including magnitude, duration, frequency, probability, and extent. In most cases, a community can most easily use these descriptors when they are recorded and displayed as maps.

Hazards reduction	Any treatment of a hazard that reduces the threat.
HazUS (Hazards U.S.)	A GIS-based nationally standardized earthquake loss estimation tool developed by FEMA.
Highest adjacent grade	Elevation of the highest natural or regarded ground surface, or structural fill, that abuts the walls of a building.
High-velocity wave action	Condition in which *wave heights* or *wave runup depths* are greater than or equal to 3.0 feet.
Holocene	An epoch of the Quaternary period spanning from the end of the Pleistocene to the present time (the past about 11,000 years).
Hurricane	An intense tropical cyclone, formed in the atmosphere over warm ocean areas, in which wind speeds reach 74-miles-per-hour or more and blow in a large spiral around a relatively calm center or "eye." Hurricanes develop over the north Atlantic Ocean, northeast Pacific Ocean, or the south Pacific Ocean east of 160°E longitude. Hurricane circulation is counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.
Hurricane clip or strap	Structural connector, usually metal, used to tie roof, wall, floor, and foundation members together so that they can resist wind forces.
Hydrocompaction	Settlement of loose, granular soils that occurs when the loose, dry structure of the sand grains held together by a clay binder or other cementing agent collapses upon the introduction of water.
Hydrodynamic loads	Loads imposed on an object, such as a building, by water flowing against and around it. Among these loads are positive frontal pressure against the structure, drag effect along the sides, and negative pressure on the downstream side.
Hydrology	The science of dealing with the waters of the earth. A flood discharge is developed by a hydrologic study.
Hydrostatic loads	Loads imposed on a surface, such as a wall or floor slab, by a standing mass of water. The water pressure increases with the square of the water depth.
Hypocenter	The earthquake focus, that is, the place at depth, along the fault plane, where an earthquake rupture started.
Igneous	Type of rock or mineral that formed from molten or partially molten magma.
Ignition point	The location of the ignition.
Ignition source	The origin or source of a fire.
Infiltration	The process by which water seeps into the soil, as influenced by soil texture, soil structure, and vegetation cover.
Infrastructure	Refers to the public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technology such as phone lines or Internet access, vital services such as public water supplies and sewer treatment facilities, and includes an area's transportation system such as airports, heliports; highways, bridges, tunnels, roadbeds, overpasses, railways, bridges, rail yards, depots; and waterways, canals, locks, seaports, ferries, harbors, drydocks, piers and regional dams.
Intensity	A measure of the effects of a hazard event at a particular place.
Invasive plants	Plants that aggressively expand their ranges over the landscape, typically at the expense of native plants that are displaced or destroyed by the newcomers. Invasive species are typically considered a major threat to biological diversity.

ISO	Insurance Services Office. Private organization that formulates fire safety ratings based on fire threat and responsible agency's ability to respond to the threat. ISO ratings from one (excellent) to ten (no fire protection). Many insurance companies use ISO ratings to set insurance premiums. ISO may establish multiple ratings within a community, such as a rating of 5 in the hydranted areas and one of 8 in the non-hydranted areas.
Isolation joint	Separation between adjoining parts of a concrete structure, usually a vertical plane, at a designated location such as to interfere least with the performance of the structure, yet such as to allow relative movement in three directions and avoid formation of cracks elsewhere in the concrete and through which all or part of the bonded reinforcement is interrupted. See *Contraction joint*.
Jet stream	A relatively narrow stream of fast-moving air in the middle and upper troposphere. Surface cyclones develop and move along the jet stream.
Jetting (of piles)	Use of a high-pressure stream of water to embed a pile in sandy soil. See *pile foundation*.
Jetty	Wall built out into the water to restrain currents or protect a structure.
Joist	Any of the parallel structural members of a floor system that support, and are usually immediately beneath, the floor.
ka	Thousands of years before present.
Lacustrine flood hazard area	Area subject to inundation by *flooding* from lakes.
Landslide	A general term covering a wide variety of mass-movement landforms and processes involving the downslope transport, under gravitational influence, of soil and rock material en masse.
Lateral force	The force of the horizontal, side-to-side motion on the Earth's surface as measured on a particular mass; either a building or structure.
Lateral spreads	Lateral movements in a fractured mass of rock or soil which result from liquefaction or plastic flow or subjacent materials.
Left-lateral fault	A strike-slip fault across which a viewer would see the block on the opposite side of the fault move to the left.
Level of service standard (LOS Standard)	Quantifiable measures against which services being delivered by a service provider can be compared. Standards based upon recognized and accepted professional and county standards, while reflecting the local situation within which services are being delivered. Levels-of-service standards for fire protection may include response times, personnel per given population, and emergency water supply. LOS standards can be used to evaluate the way in which fire protection services are being delivered, for use in countywide fire planning efforts.
Lifeline system	Linear conduits or corridors for the delivery of services or movement of people and information (e.g., pipelines, telephones, freeways, railroads).
Lineament	Straight or gently curved, lengthy features of earth's surface, frequently expressed topographically as depressions or lines of depressions, scarps, benches, or change in vegetation.
Liquefaction	Changing of soils (unconsolidated alluvium) from a solid state to weaker state unable to support structures; where the material behaves similar to a liquid as a consequence of earthquake shaking. The transformation of cohesionless soils from a solid or liquid state as a result of increased pore pressure and reduced effective stress.

Litter	Recently fallen plant material that is only partially decomposed, forming a surface layer on some soils.
Littoral	Of or pertaining to the shore, especially of the sea; coastal.
Littoral drift	Movement of sand by littoral (longshore) currents in a direction parallel to the beach along the shore.
Live loads	*Loads* produced by the use and occupancy of the building or other structure. Live loads do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load. See *Loads*.
Load-bearing wall	Wall that supports any vertical load in addition to its own weight. See *Non-load-bearing wall*.
Loads	Forces or other actions that result from the weight of all building materials, occupants and their possessions, environmental effects, differential movement, and restrained dimensional changes. Permanent loads are those in which variations over time are rare or of small magnitude. All other loads are variable loads.
Lowest adjacent grade (LAG)	Elevation of the lowest natural or re-graded ground surface, or structural fill, that abuts the walls of a building. See *Highest adjacent grade*.
Lowest floor	Under the NFIP, the lowest floor of the lowest enclosed area (including basement) of a structure.
Lowest horizontal structural member	In an elevated building, the lowest beam, *joist*, or other horizontal member that supports the building. *Grade beams* installed to support vertical foundation members where they enter the ground are not considered lowest horizontal structural members.
Ma	Millions of years before present.
Magnitude	A measure of the strength of a hazard event. The magnitude (also referred to as severity) of a given hazard event is usually determined using technical measures specific to the hazard.
Main shock	The biggest earthquake of a sequence of earthquakes that occur fairly close in time and space. Smaller shocks before the main shock are called **foreshocks**; smaller shocks that occur after the main shock are called **aftershocks**.
Major earthquake	Capable of widespread, heavy damage up to 50+ miles from epicenter; generally near Magnitude range 6.5 to 7.0 or greater, but can be less, depending on rupture mechanism, depth of earthquake, location relative to urban centers, etc
Manufactured home	Under the *National Flood Insurance Program*, a *structure*, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home" does not include a "recreational vehicle."
Marsh	Wetland dominated by herbaceous or non-woody plants often developing in shallow ponds or depressions, river margins, tidal areas, and estuaries.
Masonry	Built-up construction of combination of building units or materials of clay, shale, concrete, glass, gypsum, stone, or other
Maximum Magnitude Earthquake (Mmax)	The highest magnitude earthquake a fault is capable of producing based on physical limitations, such as the length of the fault or fault segment.

Maximum Probable Earthquake (MPE)	The design size of the earthquake expected to occur within a time frame of interest, for example within 30 years or 100 years, depending on the purpose, lifetime or importance of the facility. Magnitude/frequency relationships are based on historic seismicity, fault slip rates, or mathematical models. The more critical the facility, the longer the time period considered.
Metamorphic rock	A rock whose original mineralogy, texture, or composition has been changed due to the effects of pressure, temperature, or the gain or loss of chemical components.
Mean sea level (MSL)	Average height of the sea for all stages of the tide, usually determined from hourly height observations over a 19-year period on an open coast or in adjacent waters having free access to the sea. See *National Geodetic Vertical Datum*.
Metal roof panel	Interlocking metal sheet having a minimum installed weather exposure of 3 square feet per sheet.
Metal roof shingle	Interlocking metal sheet having an installed weather exposure less than 3 square feet per sheet.
Mitigation	Any action taken to reduce or permanently eliminate the long-term risk to life and property from natural hazards.
Mitigation directorate	Component of *Federal Emergency Management Agency* directly responsible for administering the flood hazard identification and *floodplain management* aspects of the *National Flood Insurance Program*.
Mitigation plan	A systematic evaluation of the nature and extent of vulnerability to the effects of natural hazards typically present in the state and includes a description of actions to minimize future vulnerability to hazards.
Moderate earthquake	Capable of causing considerable to severe damage, generally in the range of Magnitude 5.0 to 6.0 (Modified Mercalli Intensity <VI), but highly dependent on rupture mechanism, depth of earthquake, and location relative to urban center, etc.
National Flood Insurance Program (NFIP)	Federal program created by Congress in 1968 that makes *flood* insurance available in communities that enact and enforce satisfactory *floodplain management regulations*.
National Geodetic Vertical Datum of 1929 (NGVD)	Datum established in 1929 and used as a basis for measuring flood, ground, and structural elevations, previously referred to as Sea Level Datum or *Mean Sea Level*. The *Base Flood Elevations* shown on most of the *Flood Insurance Rate Maps* issued by the *Federal Emergency Management Agency* are referenced to NGVD or, more recently, to the *North American Vertical Datum*.
National Weather Service (NWS)	Prepares and issues flood, severe weather, and coastal storm warnings and can provide technical assistance to Federal and state entities in preparing weather and flood warning plans.
Naturally decay-resistant wood	Wood whose composition provides it with some measure of resistance to decay and attack by insects, without preservative treatment (e.g., heartwood of cedar, black locust, black walnut, and redwood).
Near-field earthquake	Used to describe a local earthquake within approximately a few fault zone widths of the causative fault which is characterized by high frequency waveforms that are destructive to above-ground utilities and short period structures (less than about two or three stories).

New construction	For the purpose of determining flood insurance rates under the *National Flood Insurance Program*, *structures* for which the start of construction commenced on or after the effective date of the initial *Flood Insurance Rate Map* or after December 31, 1974, whichever is later, including any subsequent improvements to such structures. (See *Post-FIRM structure*.) For *floodplain management* purposes, new construction means *structures* for which the *start of construction* commenced on or after the effective date of a *floodplain management regulation* adopted by a community and includes any subsequent improvements to such structures.
Non-coastal A zone	The portion of the *Special Flood Hazard Area* in which the principal source of *flooding* is runoff from rainfall, snowmelt, or a combination of both. In non-coastal A zones, *flood* waters may move slowly or rapidly, but waves are usually not a significant threat to buildings. See *A zone* and *coastal A zone*. (Note: the *National Flood Insurance Program* regulations do not differentiate between non-coastal A zones and *coastal A zones*.)
Non-load-bearing wall	Wall that does not support vertical loads other than its own weight. See *Load-bearing wall*.
Nor'easter	An extra-tropical cyclone producing gale-force winds and precipitation in the form of heavy snow or rain.
North American Vertical Datum (NAVD)	Datum used as a basis for measuring flood, ground, and structural elevations. NAVD is used in many recent *Flood Insurance Studies* rather than the *National Geodetic Vertical Datum*.
Oblique – reverse fault	A fault that combines some strike-slip motion with some dip-slip motion in which the upper block, above the fault plane, moves up over the lower block.
Offset ridge	A ridge that is discontinuous on account of faulting.
Offset stream	A stream displaced laterally or vertically by faulting
(One) 100-year flood	See *Base flood*.
Oriented strand board (OSB)	Mat-formed wood structural panel product composed of thin rectangular wood strands or wafers arranged in oriented layers and bonded with waterproof adhesive.
Outflow	Follows water inundation creating strong currents that rip at structures and pound them with debris, and erode beaches and coastal structures.
Paleoseismic	Pertaining to an earthquake or earth vibration that happened decades, centuries, or millennia ago.
Peak Ground Acceleration (PGA)	The greatest amplitude of acceleration measured for a single frequency on an earthquake accelerogram. The maximum horizontal ground motion generated by an earthquake. The measure of this motion is the acceleration of gravity (equal to 32 feet per second squared, or 980 centimeter per second squared), and generally expressed as a percentage of gravity.
Peak flood	The highest discharge or stage value of a flood.
Pedogenic	Pertaining to soil formation.
Perched ground water	Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.
Planimetric	Describes maps that indicate only man-made features like buildings.
Planning	The act or process of making or carrying out plans; the establishment of goals, policies and procedures for a social or economic unit.
Plutonic	Pertaining to igneous rocks formed at great depth.

Plywood	Wood structural panel composed of plies of wood veneer arranged in cross-aligned layers. The plies are bonded with an adhesive that cures on application of heat and pressure.
Pore pressure	The stress transmitted by the fluid that fills the voids between particles of a soil or rock mass.
Post foundation	Foundation consisting of vertical support members set in holes and backfilled with compacted material. Posts are usually made of wood and usually must be braced. Posts are also known as columns, but columns are usually made of concrete or masonry.
Post-FIRM structure	For purposes of determining insurance rates under the *National Flood Insurance Program*, structures for which the *start of construction* commenced on or after the effective date of an initial *Flood Insurance Rate Map* or after December 31, 1974, whichever is later, including any subsequent improvements to such structures. This term should not be confused with the term *new construction* as it is used in *floodplain management*.
Potentially active fault	A fault showing evidence of movement within the last 1.6 million years (750,000 years according to the U.S. Geological Survey) but before about 11,000 years ago, and that is capable of generating damaging earthquakes.
Precast concrete	Structural concrete element cast elsewhere than its final position in the structure. See *Cast-in-place concrete*.
Pressure-treated wood	Wood impregnated under pressure with compounds that reduce the susceptibility of the wood to flame spread or to deterioration caused by fungi, insects, or marine borers.
Primary frontal dune	Under the *National Flood Insurance Program*, a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.
Probability	A statistical measure of the likelihood that a hazard event will occur.
Project	A development application involving zone changes, variances, conditional use permits, tentative parcel maps, tentative tract maps, and plan amendments.
Quaternary	The second period of the Cenozoic era, consisting of the Pleistocene and Holocene epochs; covers the last approximately two million years.
Recurrence interval	The time between earthquakes of a given magnitude, or within a given magnitude range, on a specific fault or within a specific area.
Reinforced concrete	Structural concrete reinforced with steel bars.
Repetitive loss property	A property that is currently insured for which two or more National Flood Insurance Program losses (occurring more than ten days apart) of at least $1000 each have been paid within any 10-year period since 1978.
Replacement value	The cost of rebuilding a structure. This is usually expressed in terms of cost per square foot, and reflects the present-day cost of labor and materials to construct a building of a particular size, type and quality.
Resonance	Amplification of ground motion frequencies within bands matching the natural frequency of a structure and often causing partial or complete structural collapse; effects may demonstrate minor damage to single-story residential structures while adjacent 3- or 4-story buildings may collapse because of corresponding frequencies, or vice versa.

Response spectra	The range of potentially damaging frequencies of a given earthquake applied to a specific site and for a particular building or structure.
Retrofit	Any change made to an existing structure to reduce or eliminate damage to that structure from flooding, *erosion*, high winds, earthquakes, or other hazards
Revetment	Facing of stone, cement, sandbags, or other materials placed on an earthen wall or embankment to protect it from *erosion* or *scour* caused by *flood* waters or wave action.
Richter scale	A numerical scale of earthquake magnitude devised by seismologist C.F. Richter in 1935. Seismologists no longer use this magnitude scale because of limitations in how it measures large earthquakes, and prefer instead to use moment magnitude as a measure of the energy released during an earthquake.
Right-lateral fault	A strike-slip fault across which a viewer would see the block on the opposite side of the fault move to the right.
Riprap	Broken stone, cut stone blocks, or rubble that is placed on slopes to protect them from *erosion* or *scour* caused by *flood* waters or wave action.
Risk	The estimated impact that a hazard would have on people, services, facilities, and structures in a community; the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate or low likelihood of sustaining damage above a particular threshold due to a specific type of hazard event. It also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.
Riverine	Of or produced by a river.
Roof deck	Flat or sloped roof surface not including its supporting members or vertical supports.
Sand boil	An accumulation of sand resembling a miniature volcano or low volcanic mound produced by the expulsion of liquefied sand to the sediment surface. Also called sand blows, and sand volcanoes.
Sand dunes	Under the *National Flood Insurance Program*, natural or artificial ridges or mounds of sand landward of the beach.
Sandstone	A medium-grained, clastic sedimentary rock composed of abundant rounded or angular fragments of sand size set in a fine-grained matrix and more or less firmly united by a cementing material.
Saturated	Said of the condition in which the interstices of a material are filled with a liquid, usually water.
Scale	A proportion used in determining a dimensional relationship; the ratio of the distance between two points on a map and the actual distance between the two points on the earth's surface.
Scarp	A steep slope. A line of cliffs produced by faulting or by erosion. The term is an abbreviated form of escarpment.
Scour	Removal of soil or fill material by the flow of floodwaters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence.
Seawall	Solid barricade built at the water's edge to protect the shore and to prevent inland *flooding*.

Sediment	Solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, ice, or that accumulates by other natural agents, such as chemical precipitation from solution, and that forms in layers on the Earth's surface in a loose, unconsolidated form.
Seiche	A free or standing-wave oscillation of the surface of water in an enclosed or semi-enclosed basin (such as a lake, bay, or harbor), that is initiated chiefly by local changes in atmospheric pressure, aided by winds, tidal currents, and earthquakes, and that continues, pendulum-fashion, for a time after cessation of the originating force.
Seismicity	Describes the likelihood of an area being subject to earthquakes.
Seismogenic	Capable of producing earthquake activity.
Seismograph	An instrument that detects, magnifies, and records vibrations of the Earth, especially earthquakes. The resulting record is a seismogram.
Shearwall	*Load-bearing wall* or *non-load-bearing wall* that transfers in-plane lateral forces from lateral *loads* acting on a structure to its foundation.
Shoreline retreat	Progressive movement of the shoreline in a landward direction caused by the composite effect of all storms considered over decades and centuries (expressed as an annual average *erosion* rate). Shoreline retreat considers the horizontal component of *erosion* and is relevant to long-term land use decisions and the siting of buildings.
Shutter ridge	That portion of an offset ridge that blocks or "shutters" the adjacent canyon.
Silt	A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 1/256 to 1/16 mm (4-62 microns, or 0.00016-0.0025 in.). An indurated silt having the texture and composition of shale but lacking its fine lamination is called a siltstone.
Single-ply membrane	Roofing membrane that is field-applied with one layer of membrane material (either homogeneous or composite) rather than multiple layers.
Sixty (60)-year setback	A state or local requirement that prohibits new construction and certain improvements and repairs to existing coastal buildings located in an area expected to be lost to *shoreline retreat* over a 60-year period. The inland extent of the area is equal to 60 times the average annual long-term recession rate at a site, measured from a reference feature.
Slope ratio	Refers to the angle or gradient of a slope as the ratio of horizontal units to vertical units. For example, in a 2:1 slope, for every two horizontal units, there is a vertical rise of one unit (equal to a slope angle, from the horizontal, of 26.6 degrees).
Slump	A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface.
Soil horizon	A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color, or texture.
Special Flood Hazard Area (SFHA)	Under the *National Flood Insurance Program*, an area having special *flood*, mudslide (i.e., mudflow) and/or flood-related erosion hazards, and shown on a Flood Hazard Boundary Map or *Flood Insurance Rate Map* as Zone A, AO, A1-A30, AE, A99, AH, V, V1-V30, VE, M or E.

Stafford Act	The Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-107 was signed into law November 23, 1988 and amended the Disaster Relief Act of 1974, PL 93-288. The Stafford Act is the statutory authority for most Federal disaster response activities, especially as they pertain to FEMA and its programs.
Start of construction	Under the *National Flood Insurance Program*, date the building permit was issued, provided the actual start of construction, repair, reconstruction, rehabilitation, addition placement, or other improvement was within 180 days of the permit date. The actual start means either the first placement of permanent construction of a structure on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns, or any work beyond the stage of excavation; or the placement of a manufactured home on a foundation. Permanent construction does not include land preparation, such as clearing, grading, and filling; nor does it include the installation of streets and/or walkways; nor does it include excavation for a basement, footings, piers, or foundations or the erection of temporary forms; nor does it include the installation on the property of accessory buildings, such as garages or sheds not occupied as dwelling units or not part of the main structure. For a *substantial improvement*, the actual start of construction means the first alteration of any wall, ceiling, floor, or other structural part of a building, whether or not that alteration affects the external dimensions of the building.
State Coordinating Agency	Under the *National Flood Insurance Program*, the agency of the state government, or other office designated by the Governor of the state or by state statute to assist in the implementation of the *National Flood Insurance Program* in that state.
State Hazard Mitigation Officer (SHMO)	The representative of state government who is the primary point of contact with FEMA, other state and Federal agencies, and local units of government in the planning and implementation of pre- and postdisaster mitigation activities.
Stillwater elevation	Projected elevation that flood waters would assume, referenced to the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or other datum, in the absence of waves resulting from wind or seismic effects.
Storage capacity	Dam storage measured in acre-feet or decameters, including dead storage.
Storm surge	Rise in the water surface above normal water level on the open coast due to the action of wind stress and atmospheric pressure on the water surface.
Storm tide	Combined effect of *storm surge*, existing astronomical tide conditions, and breaking *wave setup*.
Strike-slip fault	A fault with a vertical to sub-vertical fault surface that displays evidence of horizontal and opposite displacement.
Structural concrete	All concrete used for structural purposes, including *plain concrete* and *reinforced concrete*.
Structural engineer	A licensed civil engineer certified by the State as qualified to design and supervise the construction of engineered structures.
Structural fill	Fill compacted to a specified density to provide structural support or protection to a *structure*. See *Fill*.

Structure	Something constructed, such as a building, or part of one. For *floodplain management* purposes under the *National flood Insurance Program*, a walled and roofed building, including a gas or liquid storage tank, that is principally above ground, as well as a manufactured home. For insurance coverage purposes under the NFIP, structure means a walled and roofed building, other than a gas or liquid storage tank, that is principally above ground and affixed to a permanent site, as well as a *manufactured home* on a permanent foundation. For the latter purpose, the term includes a building while in the course of construction, alteration, or repair, but does not include building materials or supplies intended for use in such construction, alteration, or repair, unless such materials or supplies are within an enclosed building on the premises.
Subsidence	The sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal motion.
Substantial damage	Damage of any origin sustained by a structure in a Special Flood Hazard Area whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage.
Substantial improvement	Under the *National Flood Insurance Program*, any reconstruction, rehabilitation, addition, or other improvement of a *structure*, the cost of which equals or exceeds 50 percent of the market value of the structure before the *start of construction* of the improvement. This term includes structures, which have incurred *substantial damage*, regardless of the actual repair work performed. The term does not, however, include either (1) any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions, or (2) any alteration of a "historic structure," provided that the alteration will not preclude the structure's continued designation as a "historic structure."
Super typhoon	A typhoon with maximum sustained winds of 150 mph or more.
Surface faulting	The differential movement of two sides of a fracture – in other words, the location where the ground breaks apart. The length, width, and displacement of the ground characterize surface faults.
Surge	See *Storm surge*.
Swale	In hillside terrace, a shallow drainage channel, typically with a rounded depression or "hollow" at the head.
Tectonic plate	Torsionally rigid, thin segments of the earth's lithosphere that may be assumed to move horizontally and adjoin other plates. It is the friction between plate boundaries that cause seismic activity.
Thirty (30)-year erosion setback	A state or local requirement that prohibits new construction and certain improvements and repairs to existing coastal buildings located in an area expected to be lost to *shoreline retreat* over a 30-year period. The inland extent of the area is equal to 30 times the average annual long-term recession rate at a site, measured from a reference feature.
Thrust fault	A fault, with a relatively shallow dip, in which the upper block, above the fault plane, moves up over the lower block.
Topographic	Characterizes maps that show natural features and indicate the physical shape of the land using contour lines. These maps may also include manmade features.

Tornado	A violently rotating column of air extending from a thunderstorm to the ground.
Transform system	A system in which faults of plate-boundary dimensions transform into another plate-boundary structure when it ends.
Transpression	In crustal deformation, an intermediate stage between compression and strike-slip motion; it occurs in zones with oblique compression.
Tropical cyclone	A generic term for a cyclonic, low-pressure system over tropical or subtropical waters.
Tropical depression	A tropical cyclone with maximum sustained winds of less than 39 mph.
Tropical disturbance	Tropical cyclone that maintains its identity for at least 24 hours and is marked by moving thunderstorms and with slight or no rotary circulation at the water surface. Winds are not strong. It is a common phenomenon in the tropics and is the first discernable stage in the development of a *hurricane*.
Tropical storm	A tropical cyclone with maximum sustained winds greater than 39 mph and less than 74 mph.
Tsunami	Great sea wave produced by a submarine earthquake, landslide, or volcanic eruption.
Typhoon	A special category of tropical cyclone peculiar to the western North Pacific Basin, frequently affecting areas in the vicinity of Guam and the North Mariana Islands. Typhoons whose maximum sustained winds attain or exceed 150 mph are called super typhoons.
Unconfined aquifer	Aquifer in which the upper surface of the saturated zone is free to rise and fall.
Unconsolidated sediments	A deposit that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either at the surface or at depth.
Underlayment	One or more layers of felt, sheathing paper, non-bituminous saturated felt, or other approved material over which a steep-sloped roof covering is applied.
Undermining	Process whereby the vertical component of erosion or scour exceeds the depth of the base of a building foundation or the level below which the bearing strength of at the foundation is compromised.
Unreinforced Masonry (URM) Structure	Structures in which there is no steel reinforcement within the masonry walls. The definition of an unreinforced masonry building can vary among jurisdictions. Some cities classify unreinforced infill walls within a reinforced frame as a URM while others classify unreinforced exterior veneers on to a wood frame as URMs.
Uplift	Hydrostatic pressure caused by water under a building. It can be strong enough lift a building off its foundation, especially when the building is not properly anchored to its foundation.
Upper bound earthquake	Defined as a 10% chance of exceedance in 100 years, with a statistical return period of 949 years.
V zone	See *Coastal High Hazard Area*.
Variance	Under the *National Flood Insurance Program*, grant of relief by a community from the terms of a *floodplain management regulation*.

Violation	Under the *National Flood Insurance Program*, the failure of a structure or other development to be fully compliant with the community's *floodplain management regulations*. A *structure* or other *development* without the elevation certificate, other certifications, or other evidence of compliance required in Sections 60.3(b)(5), (c)(4), (c)(10), (d)(3), (e)(2), (e)(4), or (e)(5) of the NFIP regulations is presumed to be in violation until such time as that documentation is provided.
Vulnerability	Describes how exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power – if an electric substation is flooded, it will affect not only the substation itself, but a number of businesses as well. Often, indirect effects can be much more widespread and damaging than direct ones.
Vulnerability assessment	The extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability assessment should address impacts of hazard events on the existing and future built environment.
Watershed	A topographically defined region draining into a particular water course.
Water surface elevation	Under the *National Flood Insurance Program*, the height, in relation to the *National Geodetic Vertical Datum* of 1929 (or other datum, where specified), of *floods* of various magnitudes and frequencies in the *floodplains* of coastal or riverine areas.
Water table	The upper surface of groundwater saturation of pores and fractures in rock or surficial earth materials.
Wave	Ridge, deformation, or undulation of the water surface.
Wave crest elevation	Elevation of the crest of a wave.
Wave height	Vertical distance between the wave crest and wave trough.
Wave runup	Rush of wave water up a slope or structure.
Wave runup depth	Vertical distance between the maximum wave runup elevation and the eroded ground elevation.
Wave runup elevation	Elevation, referenced to the *National Geodetic Vertical Datum* or other datum, reached by *wave runup*.
Wave setup	Increase in the stillwater surface near the shoreline, due to the presence of breaking waves.
Wildfire	An uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures.
X zone	Under the *National Flood Insurance Program*, areas where the *flood* hazard is less than that in the *Special Flood Hazard Area*. Shaded X zones shown on recent *Flood Insurance Rate Maps* (B zones on older maps) designate areas subject to inundation by the *500-year flood*. Un-shaded X zones (C zones on older *Flood Insurance Rate Maps*) designate areas where the annual probability of flooding is less than 0.2 percent.
Zone	A geographical area shown on a Flood Insurance Rate Map (FIRM) that reflects the severity or type of flooding in the area.

APPENDIX F: CALIFORNIA DISASTERS SINCE 1950

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
Floods	OCD 50-01	1950	Statewide	11/21/50	9		$32,183,000
Fire, Flood, and Erosion	DR-28	1954	Los Angeles, San Bernardino	2/5/54			Not Avail
Floods	DR-47	1955	Statewide	12/22/55	74		$200,000,000
Fires	DR-65	1956	Los Angeles (Malibu area), Ventura		1	Several hundred	$70,000,000
Unseasonal and Heavy Rainfall		1957	Cherry producing areas of Northern California	5/20/57		2	$6,000,000
Fires	CDO 58-01	1958	Los Angeles	1/3/58	1	23	Not available
High Tides	CDO 58-02	1958	City of Imperial Beach, San Diego County	1/31/58			Not available
Storm & Flood Damage	CDO 58-03	1958	Northern California (Southern boundaries of Santa Cruz, Santa Clara, Stanislaus, Tuolumne, Alpine counties to the Oregon border)	2/26/58			Not available
Storm & Flood Damage	N/A	1958	Statewide	4/2/58	13		$24,000,000
Potential Flood Damage and Landsides as a Result of Fires	CDO 59-01	1959	Los Angeles	1/8/59			Not applicable
Unseasonal and Heavy Rainfall	N/A	1959	Tokay grape producing areas of Northern California	9/17/59	2		$100,000
Major and Widespread Fires	N/A	1960	Los Angeles, San Bernardino	7/21-22/60		12	$10,000,000
Major and Widespread Fires	N/A	1960	Lassen Plumas, Shasta, Sierra, Tehama	8/16/60			$3,075,000
Bel Air Fires	DR-119	1961	Los Angeles			103	Between $50,000,000 - $100,000,000
Widespread Fires	N/A	1961	Amador, Butte, El Dorado, Napa, Nevada, Placer, San Diego, Sonoma, Tehama	9/8/61			$5,696,813
High Tides and Waves Caused By Storms At Sea	N/A	1961	Ventura	1/16/61			Not available
Flood and Rainstorm	DR-122	1962	Los Angeles, Ventura	2/16/62 & 2/23/62			Not available
Fires and Explosions	N/A	1962	Alameda	9/14/62	1	12	$500,000
Flood and Rainstorm		1962	Alameda, Butte, Contra Costa, Modoc, Napa San Mateo, Sierra, Sutter, Yuba, Placer, Trinity, Lassen	10/17/62, 10/25/62, 10/30,62, & 11/4/62			$4,000,000
Baldwin Hills Dam Failure	DR-161	1963	Los Angeles	12/16/63			$5,233,203
High Tides and Heavy Surf	N/A	1963	Orange, City of Redondo Beach		5		$500,000
Abnormally Heavy and Continuous Rainfall	N/A	1963	Northern California (boundaries of San Luis Obispo, Ventura, Los Angeles, and San Bernardino counties to the Oregon State Line	2/14/64			Not Available
Flood and Rainstorm	Unknown	1963	Alpine, Nevada, Placer, Plumas, Sierra, Amador, Colusa, El Dorado, Glenn, Lake, Lassen, Tehama, Santa Clara, Santa Cruz, Siskiyou, Yolo, Tulare, Mono, Trinity, Yuba	2/7/63, 2/26/63, 2/29/63, & 4/22/63			Not available
Major Widespread Fires (Weldon Fire)	N/A	1964	Los Angeles	3/16/64			$2,000,000

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
Major and Widespread Fires and Excessively High Winds	N/A	1964	Napa, Sonoma, Santa Barbara	9/22/64, 9/23/64, & 9/25/64			$16,500,000
Storms	N/A	1964	Los Angeles	4/3/64			1,610,300
Abnormally Heavy and Continuous Rainfall	N/A	1964	Humboldt	2/10/64			$1,407,000
Tsunami Caused by 1964 Earthquake in Alaska	N/A	1964	Marin	9/15/64			Not applicable
1964 Late Winter Storms	Unknown	1964	Del Norte, Humboldt, Shasta, Mendocino, Colusa, Glenn, Lassen, Plumas, Sierra, Siskiyou, Sonoma, Sutter, Tehama, Trinity, Amador, Butte, El Dorado, Modoc, Nevada, Placer, Yuba, Alpine, Lake, Sacramento, Yolo, Marin	12/22/64, 12/23/64, 12/28/64, 1/5/65, & 1/1/65			$213,149,000
Tsunami Caused by Alaska Earthquake	Unknown	1964	Del Norte	3/28/64	12		$10,000,000
Riots	N/A	1965	Los Angeles	8/14/65	32	874	$44,991,000
Major and Widespread Fires	N/A	1965	Marin, Napa, Placer, Solano, Sonoma	9/18/65			Not available
Flooding and Hill Slides Caused by Heavy Rains	N/A	1965	City of Burbank, Los Angeles	1/5/65			Not Available
Slide Damage	N/A	1965	City of Los Angeles	6/21/65			$6,488,600
1965 Heavy Rainfall		1965	Riverside, San Bernardino, Ventura, San Diego	11/24/65, 11/26/65, 12/23/65			$21,843,739
Continuous Rainfall	DR-211	1966	Humboldt	1/14/66			$6,918,000.00
Riots	N/A	1966	San Francisco	9/27/66		42	Not available
Earth slides	N/A	1966	Redwood City	12/16/66			$100,000
1966 Winter Storms	Unknown	1966	Kern, Riverside, Tulare, San Bernardino, San Luis Obispo, Monterey, City of Escondido, Inyo	12/9/66, 12/13/66, 12/16/66, 12/16/66, & 12/23/66			$28,761,041.00
Major and Widespread Fires	N/A	1967	Los Angeles, Orange, San Diego, Ventura	1/7/67			$11,345,000
Riots and Other Conditions	N/A	1968	City of Richmond	8/2/68			Not applicable
Riots	N/A	1969	City of Berkeley	2/5/69	0	20	Not available
Extremely Severe Weather; Freezing	N/A	1969	San Diego	2/5/69			$10,000,000
Major Oil Spill	N/A	1969	Coastal Areas of Southern California				Not available
1969 Storms	Unknown	1969	Los Angeles, San Luis Obispo, Fresno, Inyo, Riverside, San Bernardino, Santa Barbara, Tulare, Ventura, Amador, El Dorado, Kern, Kings, Madera, Modoc, Mono, Monterey, Orange, Placer, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Tuolumne, Mariposa, Merced, Calaveras, San Benito, Sierra, Contra Costa, Humboldt, Mendocino, Sonoma, Plumas, Tehama, Yuba, Butte, Marin, Yolo	1/23/69, 1/25,69, 1/28/69, 1/29/69, 2/8/69, 2/10/69, 2/16/69, 3/12/69	47	161	$300,000,000
Heavy Snow Runoff		1969	Kings	1/28/96			$2,812,500.00
Riots and Disorders	N/A	1970	Santa Barbara	2/26/70		12+	$300,000
Large Fire	N/A	1970	City of Sonora, Tuolumne	2/26/70			$2,300,000
Widespread Fires	N/A	1970	Riverside	12/22/70			$3,200,000

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
Storms and Floods	N/A	1970	Contra Costa	4/10/70			Not available
Freezing Conditions	N/A	1970	Napa, Sonoma, Mendocino, San Joaquin, Lake	5/1/70, 5/19/70, 6/8/70, 6/10/70, 7/24/70			$19,749,200
Slide Damage Caused by Heavy Rains and Storms	N/A	1970	City of Oakland	2/10/70			$11,500,000
Slide Damage Caused by Heavy Rains and Storms	N/A	1970	City of Los Angeles	3/10/70			$8,500,000
Northern California Flooding	Unknown	1970	Butte, Colusa, Glenn, Lake, Lassen, Marin, Modoc, Plumas, Shasta, Siskiyou, Tehama, Trinity, Sutter, Yuba, Del Norte, Alameda, El Dorado, Mendocino	1/26/60, 2/3/60, 2/10/60, 3/2/60			$27,657,478
Statewide Fires		1970	City of Oakland, Los Angeles, Ventura, San Diego, Kern, San Bernardino, Monterey, Riverside	9/24/70, 9/28/70, 10/1/70, 10/2/70, 10/20/70, 11/14/70	19		$223,611,000
San Fernando Earthquake	DR-299	1971	Los Angeles	2/9/71	58	2,000	$483,957,000
Widespread Fires	N/A	1971	Santa Barbara	10/13/71	4		$9,000,000
High Ocean Tides and Wind-driven Waves	N/A	1971	Ventura	5/19/71			$250,000
1972 Storms	DR-316	1972	Santa Barbara	1/3/72			$2,660,000
Andrus island Levee Break	DR-342	1972	Sacramento	6/21/72			$23,681,630
Exotic Newcastle Disease Epidemic	N/A	1972	Los Angeles, Orange, Riverside, San Bernardino, San Diego, Ventura, Santa Barbara	4/10/72, 5/22/72			$10,000,000
Drought Conditions	N/A	1972	Glenn, San Benito, Santa Clara	7//73			$8,000,000
Heavy Rains and Mud Slides	N/A	1972	Monterey	10/24/72			$720,000
Severe Weather Conditions	N/A	1972	Sutter	9/3/72			$2,004,300
Freeze and Severe Weather Conditions	N/A	1972	Fresno, Kings, Tulare, Merced, Kern, Madera, San Benito, Stanislaus, El Dorado, Tehama, Placer, Nevada, San Joaquin, Colusa, Siskiyou, Modoc, Santa Clara	4/17/72, 5/22/72, 5/22/72, 5/31/72			$111,517,260
1972 Continuing Storms		1972	Del Norte, Humboldt	2/28/72			$6,817,618
Coastal Flooding	DR-364	1973	Marin, San Luis Obispo, City of South San Francisco, Santa Barbara, Solano, Ventura	1/23/73, 1/30/73, 2/8/73, 2/28/73			$17,998,250
Southern Pacific Railroad Fires and Explosions (Roseville)	N/A	1973	Sacramento, placer	4/30/73	0	37	$2,925,000
Boulder Fire	N/A	1973	San Diego	12/12/73	0		$215,700
High Ocean Tides and Wind-driven Waves	N/A	1973	Ventura	2/1/73			$1,027,000
Storms and Floods	N/A	1973	Colusa, Glenn, Napa, Placer, Sutter, Yuba	2/28/73			$1,864,000
Storms and Floods	N/A	1973	Mendocino	3/15/73			$1,523,200
Storms and Floods	N/A	1973	City of Pacifica	4/11/73			$700,000
Freeze	N/A	1973	Butte	2/28/73			$300,000
Eucalyptus Tree	Unknown	1973	Alameda, Contra Costa	4/4/73			$8,000,000 to $10,000,000

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
Freeze							
Fires	N/A	1973	Los Angeles	7/16/73			$1,300,000
Storms	DR-412	1974	Humboldt, Shasta, Siskiyou, Trinity, Glenn, Mendocino, Tehama	1/17/74, 1/18/74			$35,192,500
Storms	DR-432	1974	Mendocino	4/23/74			$4,475,900
Gasoline Purchasing Problems	N/A	1974	Alameda, Contra Costa, Los Angeles, Orange, Riverside, San Mateo, Solano, Santa Clara, Ventura	2/28/74, 3/4/74, 3/10/74			
Storms	N/A	1974	Santa Cruz	2/28/74			$763,267
Fires	N/A	1975	Los Angeles	11/24/75			$19,486,960
Drought	N/A	1976	Alpine, Calaveras, Colusa, Fresno, Glenn, Madera, Merced, San Diego, San Joaquin, Solano, Stanislaus, Sutter, Tuolumne, Alameda, Butte, Contra Costa, Kings, Los Angeles, Riverside, San Luis Obispo, Tulare, Yolo, Amador, Monterey, Napa, Nevada, San Benito, San Bernardino, Tehama, San Mateo, Marin	2/9/76, 2/13,76, 2/24/76, 3/26/76, 7/6/76			$2,664,000,000
1976 High Winds and Flooding	DR-521	1976	Imperial, Riverside, San Bernardino, San Diego	9/13/76, 9/22/76			$120,132,771
Sycamore Fire	N/A	1977	Santa Barbara	7/27/77	0		$25,540,755
Imperial County Flooding	N/A	1977	Imperial	8/23/77			$28,498,469
Threat of Floods/Mud Slides	N/A	1977	Monterey, Riverside	9/8/77			$6,110,000
Storms	N/A	1977	San Diego, Kern, Humboldt, City of Arvin	1/10/78, 12/23/77, 1/22/77, 12/21/77			$38,009,035
Laguna Landslide	DR-566	1978	City of Laguna Beach	10/5/78			$16,595,000
1978 Los Angeles Fire	EM-3067	1978	Los Angeles	10/24/78	1		$61,279,374
Santa Barbara Earthquake	N/A	1978	Santa Barbara	8/15/78	0	65	$12,987,000
PSA Air Crash	N/A	1978	City of San Diego	1/15/79	150		
Storms	N/A	1978	Humboldt, Mendocino, Santa Cruz	1/27/78, 1/20/78			$6,126,409
Storms	Unknown	1978	Inyo, Mono, San Diego, San Luis Obispo, Kings, Monterey, Kern, Los Angeles, Orange, Riverside, San Bernardino, Santa Barbara, Tulare, Ventura	3/9/78, 2/27,78, 2/13/78	14	21	$117,802,785
Severe Storms	DR-594	1979	Riverside	7/26/80			$25,867,100
Imperial Earthquake	DR-609	1979	Imperial	10/16/79	0	91	$21,197,250
Gasoline Shortage Emergency	N/A	1979	Alameda, Contra Costa, Los Angeles, Marin, Monterey, Orange, Riverside, San Francisco, San Diego, Santa Clara, Santa Cruz, San Mateo, Ventura, San Bernardino, Sonoma, Contra Costa, Los Angeles, Orange, Santa Clara	5/8/79 - 11/13/79			
Fires	N/A	1979	Santa Barbara, Ventura, Los Angeles, El Dorado	9/28/79, 9/21/79, 9/20/79			$9,970,119
1980 Winter Storms	DR-615	1980	Santa Barbara, Los Angeles, Orange, Riverside, Ventura, San Bernardino, San Diego	2/21/80, 2/7/80			
Jones Tract Levee Break	DR-633	1980	San Joaquin	9/30/80			$21,510,956
Southern California Fires	DR-635	1980	San Bernardino, Los Angeles, Orange, Riverside	11/18/80			$64,795,200
Delta Levee Break	EM-3078	1980	Contra Costa, Sacramento, San Joaquin	1/23/80			$17,388,013

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
Owens Valley Earthquake	N/A	1980	Mono	5/28/80	0	9	$2,000,000
Storms	N/A	1980	Stanislaus, Monterey, Solano, Santa Cruz	3/5/80			$316,640,817
Mediterranean Fruit Fly Infestation	N/A	1981	Contra Costa, Los Angeles, San Benito, Stanislaus, Santa Cruz, San Mateo	8/8/81 - 9/25/81			$22,000,000
Atlas Peak Fire	N/A	1981	Napa	6/24/81	0		$31,000,000
1982 Winter Storms	DR-651	1982	Alameda, Santa Clara, Solano, San Joaquin, Contra Costa, Humboldt, Marin, San Mateo, Santa Cruz, Sonoma	1/5/82 - 1/9/82	33	481	$273,850,000
Orange Fire	DR-657	1982	Orange, City of Redondo Beach	4/21/82			$50,877,040
McDonald Island Levee Break	DR-669	1982	MacDonald Island	8/24/82			$11,561,870
1982-83 Winter Storms	DR-677	1982	Contra Costa, San Joaquin, Sacramento, Marin, San Mateo, Los Angeles, San Diego, Alameda, Orange, San Benito, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Sonoma, Ventura, Trinity, Colusa, Lake, Mendocino, Monterey, San Luis Obispo, Solano, Yolo, Butte, Glenn, Kern, Kings, San Bernardino, Sutter, Tehama, Merced, Del Norte, Fresno, madera, Napa, Placer, Riverside, Stanislaus, Tulare, Humboldt, Mariposa, Nevada, Yuba	1982, 1983	0	0	$523,617,032
Rains Causing Agricultural Losses	N/A	1982	Fresno, Madera, Merced, Monterey, kenr Tulare, Sacramento, San Joaquin, Solano, Stanislaus, Yolo	10/26/82			$345,195,974
Dayton Hills Fire	N/A	1982	Los Angeles, Orange, Ventura	10/10/82	0		$19,277,102
High Tides, Strong Winds, and Rains	N/A	1982	Contra Costa, Sacramento, San Joaquin	12/8/82			$6,964,998
Heavy Rains/ Flooding	N/A	1982	Inyo	9/27/82			$6,161,320
Winter Storms	Unknown	1982	Contra Costa, San Joaquin, Sacramento, Marin, San Mateo, Los Angeles, San Diego, Alameda, orange, San Benito, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Sonoma, Ventura, Trinity, Colusa, Lake Mendocino, Monterey, San Luis Obispo, Solano, Yolo, Butte, Glenn, Kern, Kings, San Bernardino, Sutter, Tehama, Merced, Del Norte, Fresno, Madera, Napa, Placer, Riverside, Stanislaus, Tulare, Humboldt, Mariposa, Nevada, Yuba	12/8/82-3/21/83			$523,617,032
Coalinga Earthquake	DR-682	1983	Fresno	5/2/83	0	47	$31,076,300
Colorado River Flooding	DR-682	1983	Riverside, San Bernardino, Imperial	6/23/83, 6/28/83			$4,640,315
1983 Summer Storms	DR-690	1983	Inyo, Riverside, San Bernardino	8/29/83	3		$34,689,155
Mexican Fruit Fly	N/A	1983	Los Angeles	11/4/83			
Levee Failure, High Winds, High Tides, Floods, Storms, Wind Driven Water	N/A	1983	Contra Costa, Alameda	12/9/83, 1/18/84			$10,909,785
Morgan Hill Earthquake	EM-4043	1984	Santa Clara		0	27	$7,265,000
Storms	N/A	1984	Kern, Riverside, Tulare, San Bernardino, San Luis Obispo, Monterey, City of Escondido, Inyo				$1,600,000
Statewide Fires	DR-739	1985	San Diego, City of Lost Angeles, San	7/1/85 -	3	470	$64,845,864

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
			Luis Obispo, Monterey, Santa Clara, Santa Cruz, Ventura	7/11/85			
Wheeler Fire	N/A	1985	Ventura	10/14/85	1	2	
Hydrilla Proliferation	N/A	1985	Shasta	9/13/85			
Storms	DR-758	1986	Humboldt, Napa, Sonoma, Glenn, Lake, Marin, Modoc, Sacramento, Santa Clara, Santa Cruz, Solano, Yuba, Alpine, Amador, Butte, Calaveras, Colusa, El Dorado, Lassen, Mendocino, Nevada, Placer, Plumas, San Joaquin, Sierra, Sutter, Tehama, Tuolumne, Yolo, Fresno, Madera, San Mateo, Alameda, Contra Costa, Del Norte, Trinity, Mono, San Benito, Shasta	2/18-86 - 3/12/86	13		$407,538,904
Heavy Rains	N/A	1986	Monterey, Siskyou	3/26/86			$400,000
Plane Crash	N/A	1986	City of Cerritos	8/31/86	67	2	
Whittier Earthquake	DR-799	1987	Monterey park, City of Whittier, Los Angeles, Orange	10/2/87 - 10/5/87	9	200	$358,052,144
Imperial County Earthquake	N/A	1987	Imperial	11/23/87	0	94	$2,638,833
Mediterranean Fruit Fly	N/A	1987	Los Angeles	8/25/87			
Forest Fire - Del Norte Fire, Pebble Beach	N/A	1987	Monterey		0	8	$15,000,000
Acorn Fire	N/A	1987	Alpine	8/3/87	0	3	$8,500,000
Wildland Fires	N/A	1987	Colusa, Del Norte, Butte, Fresno, Humboldt, Inyo, Kern, Lake, Lassen, Mariposa, Mendocino, Modoc, Mono, Nevada, Placer, Plumas, Riverside, San Bernardino, Shasta, Sierra, Siskiyou, Trinity, Tulare, Tuolumne	9/10/87, 9/3/87	3	76	$18,000,000
Wildfires/ Flooding/ Mud Slides	N/A	1987	San Diego	11/19/87			$5,371,150
Coastal Storms	DR-812	1988	Los Angeles, Orange, San Diego	1/21/88	0		
Fires - 49er, Miller, and Fern	DR-815	1988	Shasta, Solano, Yuba, Nevada	9/11/88-9/20/88	0		$31,247,534
Mediterranean Fruit Fly	N/A	1988	Los Angeles	7/21/88			
Wildland Fires	N/A	1988	Calaveras	7/21/88			
Fire and Wind Driven Waves	N/A	1988	City of Redondo Beach	6/15/88	0		$25,000,000
Fires/ High Winds	N/A	1988	Los Angeles	12/9/88	0	2	$12,400,000
Storms	N/A	1988	Santa Barbara, City of San Buenaventura	1/26/88			$49,416,200
Loma Prieta Earthquake	DR-845	1989	Alameda, Monterey, San Benito, San Mateo, Santa Clara, Santa Cruz, San Francisco, Contra Costa, Marin, City of Isleton, City of Tracy, Solano	10/18/89 - 10/30/89	63	3,757	$5,900,000,000
Mediterranean Fruit Fly	N/A	1989	Los Angeles	8/9/89			
Mediterranean Fruit Fly	N/A	1989	Santa Clara	9/6/89			
Mediterranean Fruit Fly	N/A	1989	San Bernardino	10/3/89			
Mediterranean Fruit Fly	N/A	1989	Orange	11/20/89			
Santa Barbara Fires	DR-872	1990	Los Angeles, Santa Barbara, Riverside, San Bernardino	6/28/90, 6/29/90	3	89	$300,000,000
Freeze	DR-894	1990	Santa Cruz, Fresno, Glenn, imperial, Kern, Mendocino, Monterey,	12/19/90-1/18/91			$856,329,675

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
			Riverside, San Benito, San Bernardino, San Diego, San Mateo, Santa Barbara, Santa Clara, Solano, Sonoma, Tulare, Ventura, Alameda, Butte, Colusa, Los Angeles, Madera, Marin, Merced, Napa, San Joaquin, San Luis Obispo, Sutter, Yolo, Yuba, Stanislaus, Tehama				
Drought	N/A	1990	City of Santa Barbara	7/17/90			
Drought	N/A	1990	Santa Barbara	11/13/90			
Upland Earthquake	N/A	1990	Los Angeles, San Bernardino	3/9/90, 3/13/90	0	38	$12,034,150
Mediterranean Fruit Fly	N/A	1990	Riverside	4/18/90			
Mexican Fruit Fly	N/A	1990	Los Angeles, San Diego	5/14/90			
Finley Fire/ Yosemite Fire	N/A	1990	Mariposa, Kern, Tehama	8/13/90, 8/14/90	1	84	$548,000,000
Severe Storms	N/A	1990	Butte, Nevada	2/22/90	1	17	$11,500,000
East Bay Hills Fire	DR-919	1991	Alameda County	10/20/91	25	150	$1,700,000,000
Sweet potato Whitefly	N/A	1991	Imperial, Riverside				$120,567,949
Cantara Spill	N/A	1991	Shasta, Siskyou			300	$38,000,000
1992 Winter Storms	DR-935	1992	Los Angeles, Ventura, City of Los Angeles, kern, orange, San Bernardino	2/12/92, 2/19/92	5		$123,240,531
Los Angeles Civil Disorder	DR-942	1992	Los Angeles	4/29/92	53	2,383	$800,000,000
Cape Mendocino Earthquakes	DR-943	1992	Humboldt	4/25/92	0	356	$48,271,137
Big Bear - Landers Earthquakes	DR-947	1992	Riverside, San Bernardino	6/28/92	1	$402	$91,079,376
Shasta/Calaveras Fire	DR-958	1992	Calaveras, Shasta	8/21/92	0	$8	$54,108,500
1992 Late Winter Storms	DR-979	1992	Alpine, Los Angeles, Humboldt, Napa, Santa Barbara, Culver City, City of Los Angeles, Contra Costa, Mendocino, Sonoma, Fresno, imperial, Madera, Monterey, San Bernardino, Sierra, Tehama, Trinity, Tulare, Modoc, Orange, Riverside, Lassen, Siskiyou, Plumas, San Diego	1/7/93 - 2/19/93	20	10	$600,000,000
Sewage Spill	N/A	1992	San Diego, City of Chula Vista, City of Coronado, San Diego	2/6/92, 2/7/92			
Southern California Firestorms	DR-1005	1993	Los Angeles, Ventura, San Diego, Orange, Riverside, San Bernardino	10/27/93, 10/28/93	4	162	$1,000,000,000
Mediterranean Fruit Fly	N/A	1993	Riverside	5/21/94			
Tijuana River Pollution	N/A	1993	San Diego	9/10/93			
New River Pollution	N/A	1993	Imperial	10/6/93			
Northridge Earthquake	DR-1008	1994	Los Angeles, Ventura, Orange	1/17/94, 1/24/94	57	11,846	$40,000,000,000
Salmon fisheries	DR-1038	1994	Del Norte, Humboldt, Mendocino, Sonoma	5/20/94			$28,300,000
Humboldt Earthquake	N/A	1994	Humboldt	12/29/94			$1,300,000
Mediterranean Fruit Fly	N/A	1994	Ventura	10/7/94			
San Luis Obispo Fire - Hwy 41	N/A	1994	San Luis Obispo	8/24/94		12	$6,382,235
Severe Winter Storms	DR-1044	1995	Los Angeles, Orange, Humboldt, Lake , Sonoma, Butte, Colusa, Contra Costa, Del Norte, Glenn, Kern, Lassen, Mendocino, Modoc, Monterey, Napa, placer, Plumas,	1/6/95 - 3/14/95	11		$741,400,000

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
			San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Tehama, Ventura, Yolo, Yuba, Alpine, Amador, Nevada, Riverside, Sacramento, San Bernardino, San Mateo, Shasta, Sutter, Trinity, San Diego, Alameda, Marin, Fresno, Kings, El Dorado, Madera, Solano, Siskiyou				
Late Winter Storms	DR-1046	1995	All counties except Del Norte		17		$1,100,000,000
Southern California Firestorms	EM-3120	1996	Los Angeles, Orange, San Diego	10/1/96		5	$40,000,000
January 1997 Floods		1997	Alpine, Amador, Butte, Colusa, Del Norte, El Dorado, Glenn, Humboldt, Lake, Lassen, Modoc, Napa, Nevada, Plumas, Sacrament, San Joaquin, Sierra, Siskiyou, Solano, Sonoma, Sutter, Tehama, Trinity, Yuba, Calaveras, Madera, Mono, Monterey, Placer, San Benito, San Luis Obispo, San Mateo, Santa Cruz, Shasta, Stanislaus, Tuolumne, Yolo, Contra Costa, Fresno, Marin, Tulare, Mariposa, Merced, Santa Clara, Alameda, San Francisco, Kings,	1/2/97 - 1/31/97	8		$1,800,000,000
El Nino		1998	Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, Fresno, Glenn Humboldt, Kern, Kings, Lake, Los Angeles, Marin, Mendocino, Merced, Monterey, Napa, Orange, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Francisco, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Siskiyou, Solano, Sonoma, Stanislaus, Sutter, Tehama, Trinity, Tulare, Ventura, Yolo, Yuba		17		$550,000,000
Freeze		1998	Fresno, Kern, Kings, Madera, Merced, Monterey, Tulare, Ventura	2/9/99			
Fire		1999	Various Counties	8/26/99			
Road Damage		1999	Sonoma	3/29/99			
Earthquake		2000	Napa	9/6/00			
Water Shortage		2001	City of Rio Dell	3/16/01			
Sierra Madre Earthquake	N/A	2003	Los Angeles	7/5/91	1	30	$33,500,000
Widespread Fires	N/A	2003	Madera		2		Not available
Freeze and Snow Conditions	N/A	2003	Lake	7/13/72			$357,000
Drought		2003	Modoc, Siskiyou	5/4/01			
Exotic Newcastle Disease Epidemic		2003	15 Northern Counties	2/21/03			
Bark Beetle Infestation		2003	San Bernardino, San Diego, Riverside	3/7/03			
Wildfire		2003	Calaveras	9/10/01			
Southern California Wildfires	DR-1498	2003	Ventura, Los Angeles, San Bernardino, Riverside, San Diego	10/24-26/03			$317,000,000
San Simeon Earthquake	DR-1505	2003	San Luis Obispo, Santa Barbara	12/23/03			$21,100,000
Levee Break	DR-1529	2004	San Joaquin	6/4/04			$53,000,000
La Conchita Mudslide		2005	La Conchita, Ventura County	1/12/05	10	22	
Southern California Severe Storm	DR-1577	2005	Kern, Los Angeles, Orange, Riverside, San Bernardino, San	1/6/05, 1/15/05	28	8	$200,000,000

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
			Diego, Santa Barbara, Ventura				
Southern California Severe Storm	DR-1585	2005	Kern, San Bernardino and San Diego	1/15/05			
Flood		2005	Los Angeles Region		9		$250,000,000
California Severe Storms, Flooding, Mudslides and Landslides	DR-1628	2006	Alpine, Amador, Butte, Colusa, Contra Costa, Del Norte, El Dorado, Humboldt, Lake, Lassen, Marin, Mendocino, Napa, Nevada, Placer, Plumas, Sacramento, San Joaquin, San Luis Obispo, San Mateo, Santa Cruz, Sierra, Siskiyou, Solano, Sonoma, Sutter, Trinity, Yolo, and Yuba		3		$245,000,000
California Severe Storms, Flooding, Landslides	DR-1646	2006	Alameda, Amador, Calaveras, El Dorado, Lake, Madera, Marin, Merced, Napa, Nevada, Placer, San Joaquin, San Mateo, Santa Cruz, Sonoma, Stanislaus, and Tuolumne		1		$259,000,000
		2006	Throughout California	7/9-7/14/06	1	17	$16,000,000
		2006	Riverside County	10/26-27/06	4	1	
		2006	Ventura County	12/3-6/06			
Freeze	DR-1689	2007	Fresno, Imperial, Kern, Los Angeles, Monterey, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Tulare, and Ventura	1/11-11/17/07	65 (US)	220 (US)	$23,000,000
Island Fire	FM-2694	2007	Santa Catalina	5/10/07 - 5/15/07			
Forest Fires		2007	Lake Tahoe Region, Nevada	6/25/07			
Forest Fires	DR-1731	2007	Los Angeles, Orange, Riverside, San Bernardino, San Diego, Santa Barbara and Ventura counties	10/21/07-03/31/08	10		$114,000,000
Santa Anita Fire	FM-2763	2008	Los Angeles County	4/26/08 – 5/2/08			
Summit Fire	FM-2766	2008	Santa Clara and Santa Cruz Counties	5/22/08 – 5/28/08		16	$16,100,000
Ophir Fire	FM-2770	2008	Butte County	6/10/08 – 6/13/08		1	
Humboldt Fire	FM-2771	2008	Butte County	6/11/08 – 6/18/08		10	$20,500,000
Martin Fire	FM-2772	2008	Santa Cruz County	6/11/08 – 6/17/08		4	$5,400,000
Wildfires	EM-3287	2008	Butte, Mendocino, Monterey, Santa Clara, Santa Cruz, Shasta, and Trinity counties	6/20/08			
Sayre Fire	DR-1810	2008	Los Angeles County	11/13/08 – 11/14/08			
Jesusita Fire	FM-2817	2009	Santa Barbara County	5/5/09 – 5/18/09			$20,000,000
Lockheed Fire	FM-2824	2009	Santa Cruz County	8/12/09 - 8/23/09		10	$26,600,000
Yuba Fire	FM-2825	2009	Yuba County	8/14/09 – 8/23/09		41	$12,100,000
PV Fire	FM-2828	2009					
Station Fire	FM-2830	2009	Los Angeles County	8/26/09 – 10/16/09			
49er Fire	FM-2832	2009	Placer County	8/30/09 – 9/2/09			$1,000,000
Oak Glen Fire	FM-2833	2009	San Bernardino County	8/30/09 – 9/8/09		4	$6,900,000
Pendleton Fire	FM-2836	2009	San Bernardino County	8/31/09 – 9/4/09		1	$1,490,000
Guiberson Fire	FM-2839	2009	Ventura County	9/22/09 –		10	$9,800,000

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
				9/27/09			
Sheep Fire	FM-2841	2009	San Bernardino County	10/3/09 – 10/10/09			
Bull Fire	FM-2849	2010					
West Fire	FM-2850	2010	Fresno County				
Crown Fire	FM-2851	2010	Los Angeles County				
Post Fire	FM-2852	2010	Kern County				
Glenview Fire	FM-2856	2010	San Mateo County				
Canyon Fire	FM-2858	2010	Kern County				
Flooding	DR-1884	2010	Imperial, Siskiyou, Los Angeles, Riverside, San Bernardino and Calaveras counties				$50,000,000
Easter Sunday EQ	DR-1911	2010	Imperial County				$90,000,000
Flooding	DR-1952	2011	Inyo, Kern, Kings, Madera, Mariposa, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Tulare counties	12/10/10 to 01/04/2011; declared 01/26/2011			163 residences impacted; 2 destroyed. Total individual assistance cost estimate of nearly $2 million, and total public assistance cost estimate exceeding $75.4 million
Tsunami	DR-1968	2011	Tsunami wave surge as result of earthquake in Japan on 3/11/11. Del Norte and Santa Cruz counties.	3/12/2011	1		$70 million in damages in California. Minor to major damage to harbors from Crescent City to San Diego.
Hill Fire	FM-2955	2011	San Bernardino County	9/2/2014;			Burned 1,158 acres; threatened more than 1,000 structures; approximately 1,000 people were evacuated.
Canyon Fire	FM-2961	2011	Kern County – due to plane crash	9/4/2011;		7	Burned 14,585 acres; destroyed 32 residences and 30 outbuildings. >$10.3 million in costs.
Keene Fire Complex	FM-2970	2011	Southeastern Kern County near Tehachapi	9/10/2011		4	$ 7.2 million in costs; burned 10,470 acres
Comanche Fire Complex	FM-2971	2011	Kern County, 5 miles south east of Arvin	9/10/2011		6	Burned 29,338 acres; complex consisted of 4 fires.
Wye Fire	FM-5004	2012	Lake and Colusa Counties, East of Clearlake Oaks	8/12/2012		3	Burned 7,934 acres; destroyed 2 structures and 1 outbuilding, and damaged 2 structures.
Ponderosa Fire	FM-5007	2012	Tehama & Shasta Counties, Southeast of Manton	8/18/2012		7	27,676 acres burned; 52 residences and 81 outbuildings destroyed; 1 residence and 5 outbuildings damaged.
Shockey Fire	FM-5021	2012	San Diego County, East of Campo	9/23/2012	1	3	2,556 acres burned; 11 residences, 14 outbuildings and 11 vehicles destroyed; 2 residences damaged.
Summit Fire	FM-5023	2013	Riverside County, Banning and Beaumont	5/1/2013		2	3,166 acres burned; 1 structure destroyed.
Springs Fire	FM-5024	2013	Ventura County; southbound Highway 101 at Camarillo Springs Road in Camarillo	5/2/2013		10	24,251 acres burned; 10 outbuildings destroyed; 6 commercial properties and 6 outbuildings damaged.
Powerhouse Fire	FM-5025	2013	North Los Angeles County, within the Angeles National Forest	6/2/13			30,274 acres burned
Falls Fire	FM-5040	2013	Riverside County; within the Cleveland National Forest; off Ortega Highway, west of Lake Elsinore	8/6/2013			1,383 acres burned
Silver Fire	FM-5041	2013	Riverside County, Poppet Flats Rd. near Hwy. 243, south of Banning	8/8/2013		13	20,292 acres burned; 48 structures destroyed; 8 structures damaged. Estimated cost about $10 million,
Rim Fire	DR-4158 FM-5049	2013	Tuolemne County; 3 miles east of Groveland, along Highway 20, within the Stanislaus National Forest / Yosemite National Park Administrative area.	8/17/2013 to 10/25/2013; declared 12/13/13			257,314 acres burned
Clover Fire	FM-5050		Shasta County; about 10 miles SW of Redding	9/10/2013		6	8,073 acres burned; 68 residences and 128 outbuildings destroyed; 5 residences and 10 outbuildings damaged.
Colby Fire	FM-5051	2014	Los Angeles County; near Morris Reservoir north of Glendora, within the Angeles National Forest	1/16/2014			1,952 acres burned; 7 residences damaged, 5 destroyed. 1 outbuilding damaged, 10 destroyed.

Disaster Name	Disaster #	Year	Counties and Cities Declared	State Declaration	# of Deaths	# of Injuries	Cost of Damage
Poinsettia Fire	FM-5054	2014	San Diego County; off Poinsettia Land and Alicante Road in Carlsbad	5/14/2014	1		600 acres burned; 5 homes destroyed; 18 apartment units and 1 commercial unit destroyed; 4 homes, 1 commercial building damaged; 22 homes with minor damage. Cost to structures: $12 million; costs to fight fire: $12 million.
Cocos Fire	FM-5055	2014	San Diego County; at Village Drive and Twin Oaks Road, San Marcos	5/14/2014		3	1,995 acres burned; 40 structures destroyed.
Butts Fire	FM-5057	2014	Napa and Lake Counties; NW of lake Berryessa	7/2/2014		4	4,300 acres burned; 2 residences and 7 outbuildings destroyed.
Eiler Fire	FM-5067	2014	Shasta County; 12 miles SE of Burney, near Old Station	8/2/2014		11	32,416 acres burned; 7 residences, 2 commercial and 12 outbuildings destroyed
Oregon Gulch Fire	FM-5068	2014	Siskiyou County (Jackson and Klamath Counties in Oregon); part of the Beaver Fire Complex; in the community of Copco south of Oregon border	8/2/2014			35,302 acres burned; 9,464 in California. Total costs to fight fire estimated at greater than $22 million.
Bald Fire	FM-5069	2014	Shasta County; 8 miles SE of Fall River Mills	8/3/2014			39,736 acres burned
Day Fire	FM-5070	2014	Modoc County; north of the community of Day	8/3/2014		7	13,153 acres burned; 6 structures destroyed.
Junction Fire	FM-5074	2014	Madera County; off Road 425A, near the junction of Hwys. 41 and 49 at Oakhurst	8/19/2014		3	612 acres burned; 47 structures destroyed.
Way Fire	FM-5075	2014	Kern County; north of Hwy 55, NW of Wofford Heights	8/19/2014			4,045 acres burned
Napa Earthquake	DR-4193	2014	Napa and Solana Counties	8/24/2014; declared 9/11/2014			>$2.4 million in Federal assistance
Oregon Fire	FM-5076	2014	Trinity County; off Hwy 299 at Oregon Mountain Summit, near Weaverville	8/25/2014		2	580 acres burned; 1 structure destroyed.
Bridge Fire	FM-5077	2014	Mariposa County; Highway 49 at Harris Road, 10 miles E of Mariposa	9/5/2014		3	300 acres burned.
Courtney Fire	FM-5078	2014	Madera County; on Courtney Lane and 7 Hills Road, at Oakhurst	9/14/2014		4	320 acres burned; 30 residences, 19 outbuildings and 17 vehicles destroyed; 4 homes, 3 outbuildings and 2 vehicles damaged.
Boles Fire	FM-5079	2014	Siskiyou County; in the city of Weed	9/15/2014		1	516 acres burned; 157 residences and 8 commercial properties destroyed; 4 homes and 3 commercial structures damaged. 1,000 homes and 100 commercial structures threatened.
King Fire	FM-5081	2014	El Dorado County; near Pollock Pines	Started 9/13/14; declared 9/17/2014		12	97,717 acres burned; 12 residences and 68 other minor structures destroyed.
Applegate Fire	FM-5082	2014	Placer County; on the east side of I-80, near the Applegate area	10/8/2014		2	459 acres burned; 6 homes and 4 outbuildings destroyed.

Sources: California Governor's Office of Emergency Services (http://www.oes.ca.gov); FEMA (http://www.fema.gov/news/disasters.fema); EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels – Belgium.

APPENDIX G: MAJOR DAMS IN ORANGE COUNTY

Dam Name	Dam No.	National ID	Owner	Latitude, Longitude	Stream	Year Built	Capacity (Ac-Ft)	Res. Area (Acres)	Drainage Area (mi^2)	Crest Elev. (ft)	Free Board (ft)	Height (Ft)	Length (ft)	Width (ft)	Type	Volume (yd^3)	Comments	Hazard
Agua Chinon	1012-017	CA01361	County of Orange	33.688, -117.7	Agua Chinon Wash	1998	256	16	2.17	636	10.5	41	480	20	ERTH	176,000		Significant
Bee Canyon Retention Basin	1012-009	CA01360	County of Orange	33.708, -117.71	Bee Canyon Wash	1994	243	14	1.29	581	11.5	62	570	25	ERTH	66,000		High
Big Canyon	1058-000	CA00891	City of Newport Beach	33.61, -117.86	Tributary Big Canyon Cr	1959	600	22	0.04	308	5.5	65	3824	20	ERTH	508,000		High
Bonita Canyon	793-004	CA00747	The Irvine Company	33.632, -117.848	Bonita Creek	1938	323	50	4.2	151	8	51	331	20	ERTH	43,000		
Brea Dam (Brea Reservoir)		CA10016	Federal - USCOE	33.8917, -117.925	Brea Creek	1942	4,018	162.7	22.0	295	16	87	1,765	20	ERTH	680,472		
Carbon Canyon		CA10017	Federal - USCOE	33.915 -117.6433	Carbon Canyon Creek	1961	7,033	221	19.3	499	24	99	2,610	20	ERTH	150,000		
30 MG Central Reservoir	1087-000	CA01113	City of Brea		Offstream	1924	92	5	0	392		30	1596		ERTH			
Diemer No. 8	35-009	CA00220	Metropolitan Water District of SoCal	33.912, -117.82	Offstream	1968	18	1	0.007	828	0.6	172	1004	9	RECT			
Diemer Ozone Contact Basin	35-022	CA01492	Metropolitan Water District of SoCal	33.9115, -117.82	Offstream	2011	23	0.27	0	840.25	1.7	32	1012	1	RECT	152,000		
Diemer Reservoir	35-010	CA00221	Metropolitan Water District of SoCal	33.91, -117.82	Offstream	1963	80	5	0	811.4	3.7	22	1880		RECT			
Dove Canyon	790-000	CA01248	Dove Canyon Master Assoc.	33.638, -117.57	Dove Creek	1989	415	16	0.96	1100	10	88	700	55	ERTH	463,000		
East Hicks Canyon Retarding Basin	1012-015	CA01415	County of Orange	33.735, -117.72	Hicks Canyon Wash	1997	75	6	0.54	571	9.5	49	1168	25	ERTH	339,400		

Dam Name	Dam No.	National ID	Owner	Latitude, Longitude	Stream	Year Built	Capacity (Ac-Ft)	Res. Area (Acres)	Drainage Area (mi^2)	Crest Elev. (ft)	Free Board (ft)	Height (Ft)	Length (ft)	Width (ft)	Type	Volume (yd^3)	Comments	Hazard
Eastfoot Retarding Basin	1799-000	CA01496	City of Irvine	33.7525, -117.75	Peters Canyon Wash	2007	213	9.7	0.51	421	8.2	38.5	1,000	25	ERTH	300,000		
El Toro Reservoir	1041-000	CA00875	El Toro Water District	33.623, -117.67	Tributary Oso Creek	1967	877	21	0.04	632	9	106	900	30	ERTH	550,000		
Fullerton		CA10018	Federal – USCOE	33.898, -117.88	East Fullerton Creek	1941	706	60	5.0	307	17	47	575	15	ERTH	160,000		
Galivan Retarding Basin	1012-012	CA01427	County of Orange	33.566, -117.68	Oso Creek	2000	169	17	13.4	273	5.3	14	600	1	ERTH	6,000		
Harbor View	1012-002	CA00830	County of Orange	33.603, -117.87	Jasmine Gulch	1964	28	3	0.39	190	20	65	330	60	ERTH	63,000		
Hicks Canyon Retention Basin	1012-014	CA01414	County of Orange	33.735, -117.72	Hicks Canyon Wash	1997	110	8	0.83	690	9.5	60	806	25	ERTH	367,800		
Lower Peters Canyon Retarding Basin	1012-005	CA01207	County of Orange	33.755, -117.77	Peters Canyon Wash	1990	206	14	2.15	325.3	4.8	52	1166	16	ERTH	175,000		
Marshburn Retarding Basin	1012-011	CA01426	County of Orange	33.694, -117.73	Tributary Marshburn Channel	1998	282	26	5.8	378	11.5	27	2456	20	ERTH	204,000		
Mission Viejo, Lake	1794-000	CA01122	Lake Mission Viejo Assn. Inc.	-117.65	Oso Creek	1976	4,300	150	3.6	711	9	123	1,750	104	ERTH	1,376,200		
Orange County Reservoir	35-007	CA00218	Metropolitan Water District of SoCal	33.937, -117.88	Tributary Fullerton Creek	1941	217	7	0.01	662.5	3	103	655	88	ERTH	298,200		
Orchard Estates Retarding Basin	1012-016	CA01436	County of Orange	33.738, -117.75	Tributary Rattlesnake Canyon	1999	138	11	0.63	408	8	21	810	25	ERTH	63,500		
Palisades Reservoir	1022-002	CA00843	South Coast Water District	33.463, -117.65	Tributary Prima Deshecha	1963	147	6	0.03	436	6	146	620	20	ERTH	300,000		
Peters Canyon	1012-006	CA00746	County of Orange	33.7, -117.768	Peters Canyon Wash	1932	1090	65	1.5	547.8	5	54	580	10	ERTH	111,100		
Portola	2013-002	CA01183	Santa Margarita Water District	33.633, -117.58	Canada Gobernadora	1980	586	20	0.18	946	10	53	1,200	20	ERTH	206,500		

Dam Name	Dam No.	National ID	Owner	Latitude, Longitude	Stream	Year Built	Capacity (Ac-Ft)	Res. Area (Acres)	Drainage Area (mi^2)	Crest Elev. (ft)	Free Board (ft)	Height (Ft)	Length (ft)	Width (ft)	Type	Volume (yd^3)	Comments	Hazard
Rattlesnake Canyon	1029-003	CA00855	Irvine Ranch Water District	33.728, -117.74	Rattlesnake Canyon	1959	1,480	60	2.02	418	6	79	980	15	ERTH	445,600		
Rossmoor No 1	1041-002	CA00753	El Toro Water District	33.618, -117.73	Tributary San Diego Creek	1964	43	3	0.23	320	3.5	36	305	15	ERTH	22,000		
Rossmoor Retarding Basin	1012-013	CA01443	County of Orange	33.787, -118.09	Los Alamitos Channel	2002	175	25	2.7	14.2	4.2	14	95	13	ERTH	12,000		
Round Canyon Retarding Basin	1012-010	CA01378	County of Orange	33.698, -117.69	Round Canyon Wash	1994	286	16	1.698	665	10.5	98	750	25	ERTH	149,000		
San Joaquin Reservoir	1029-000	CA00853	Irvine Ranch Water District	33.62, -117.64	Tributary Bonita Creek	1964	380	24	19.9	245	15	65	385	34	ERTH	116,000		
Sand Canyon	1029-002	CA00854	Irvine Ranch Water District	33.648, -117.6	Sand Canyon	1912	960	51	6.76	202	8.5	58	861	10	ERTH	134,787		
Santiago Creek	75-000	CA00298	Serrano Water District & Irvine Ranch WD	33.785 -117.72	Santiago Creek	1933	25000	650	63.1	810	20	136	1425	10	ERTH	789,000		
Sulphur Creek	1012-007	CA00873	County of Orange	33.55, -117.71	Sulphur Creek	1966	520	40	4.8	202	10	42	485	25	ERTH	150,000		
Syphon Canyon	793-009	CA00749	The Irvine Company	33.71, -117.73	Tributary Newport Bay	1949	500	27	0.29	385	7	59	843	10	ERTH	145,000		
Trabuco	2030-002	CA01241	Trabuco Canyon Water District	33.643, -117.56	Tributary Dove Creek	1984	138	5	0.05	1280	5.5	108	620	20	ERTH	166,000		
Trabuco Retarding Basin	1012-008	CA01399	County of Orange	33.695, -117.76	San Diego Creek	1996	390	22.25	3.17	201	3.5	18	2250	20	ERTH	14,160		
Trampas Canyon	1795-006	CA01123	Oglebay Norton Ind. Sands	33.498, -117.59	Trampas Canyon	1975	5700	96	0.91	600	5	183	1300	20	ERTH	1,900,000		
Upper Chiquita	2013-3	CA01553	Santa Margarita Water District	33.5883, -117.62	Tributary to San Juan Creek	2012	753.5	15.65	0.035	867.5	7.5	177.2	965	23.75	ERTH	1,377,500		
Upper Oso	2013-000	CA01145	Santa Margarita Water District	33.658, -117.63	Oso Creek	1979	3,700	115	1.13	962	7	142	800	60	ERTH	1,109,000		

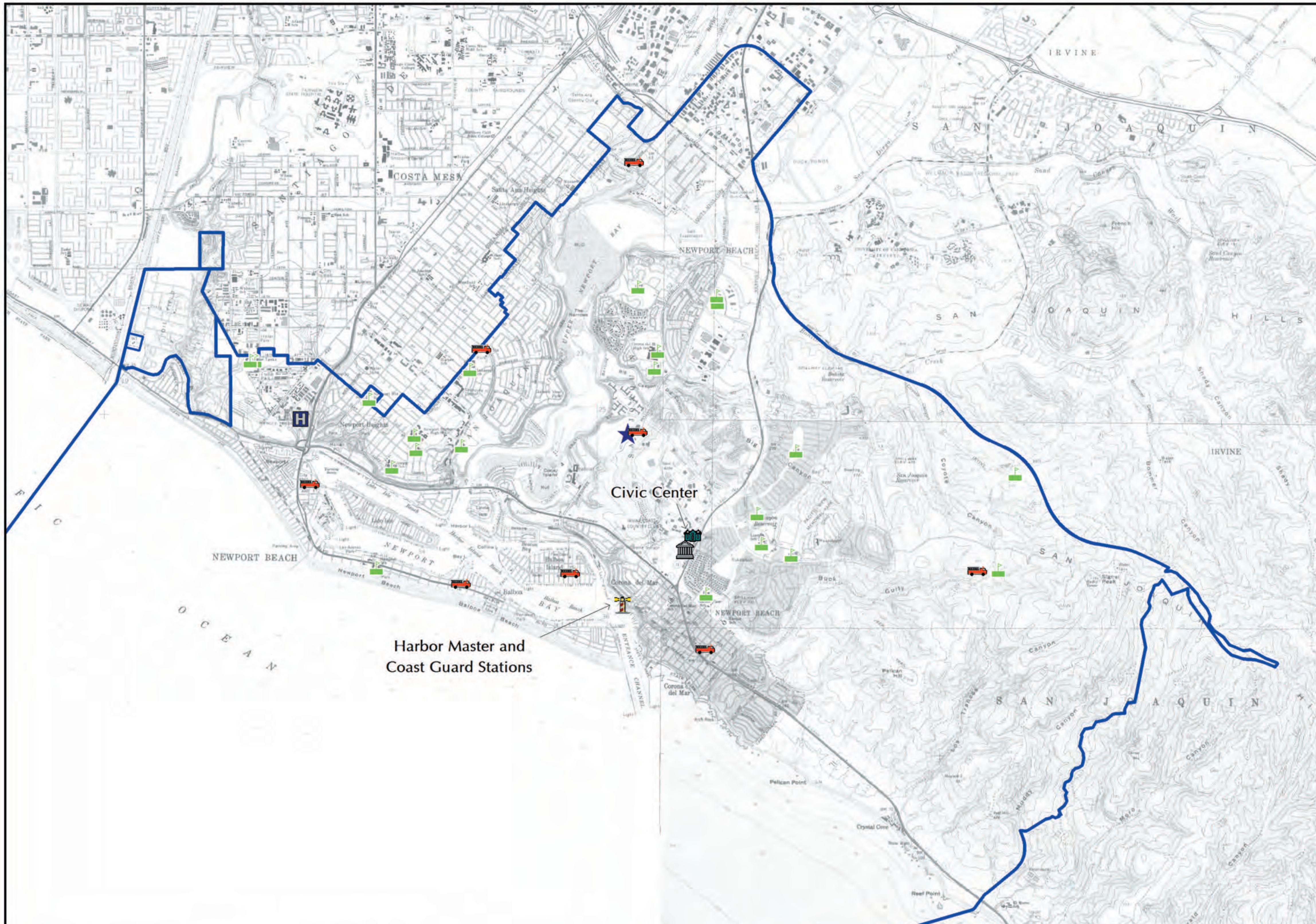
Dam Name	Dam No.	National ID	Owner	Latitude, Longitude	Stream	Year Built	Capacity (Ac-Ft)	Res. Area (Acres)	Drainage Area (mi^2)	Crest Elev. (ft)	Free Board (ft)	Height (Ft)	Length (ft)	Width (ft)	Type	Volume (yd^3)	Comments	Hazard
Veeh	796-000	CA00750	Lake Hills Community Church	33.625, -117.73	Tributary San Diego Creek	1936	185	16	1.7	287	6.3	37	417	14	ERTH	22,060		
Villa Park	1012-000	CA00829	County of Orange	33.815, -117.77	Santiago Creek	1963	15,600	480	83.4	584.3	18.3	118	119	20	ERTH	835,000		
Walnut Canyon	1037-000	CA00869	City of Anaheim	33.842, -117.75	Walnut Canyon	1968	2570	47	0.33	847	6	187	930	30	ERTH	957,000		
Yorba	1012-003	CA00831	County of Orange	33.872, -117.61	Tributary Santa Ana River	1907	1,200	87	1	311	5.4	45	920	12	HYDF	110,000	Drained in 1969.	
Prado Dam	9000-022	CA10022	Federal	33.890, -117.64	Santa Ana River	1941	383,500	6,695	2,255	566	23	106	2,280	30	ERTH	3,389,000	Being improved.	

APPENDIX H: PLATES

Table of Contents

Essential Facilities

Newport Beach, California



NOTES:

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EXPLANATION

- Schools
- Police Station
- Fire Station
- City Hall
- Hospital
- Harbor Master and Coast Guard Stations
- Civic Center
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

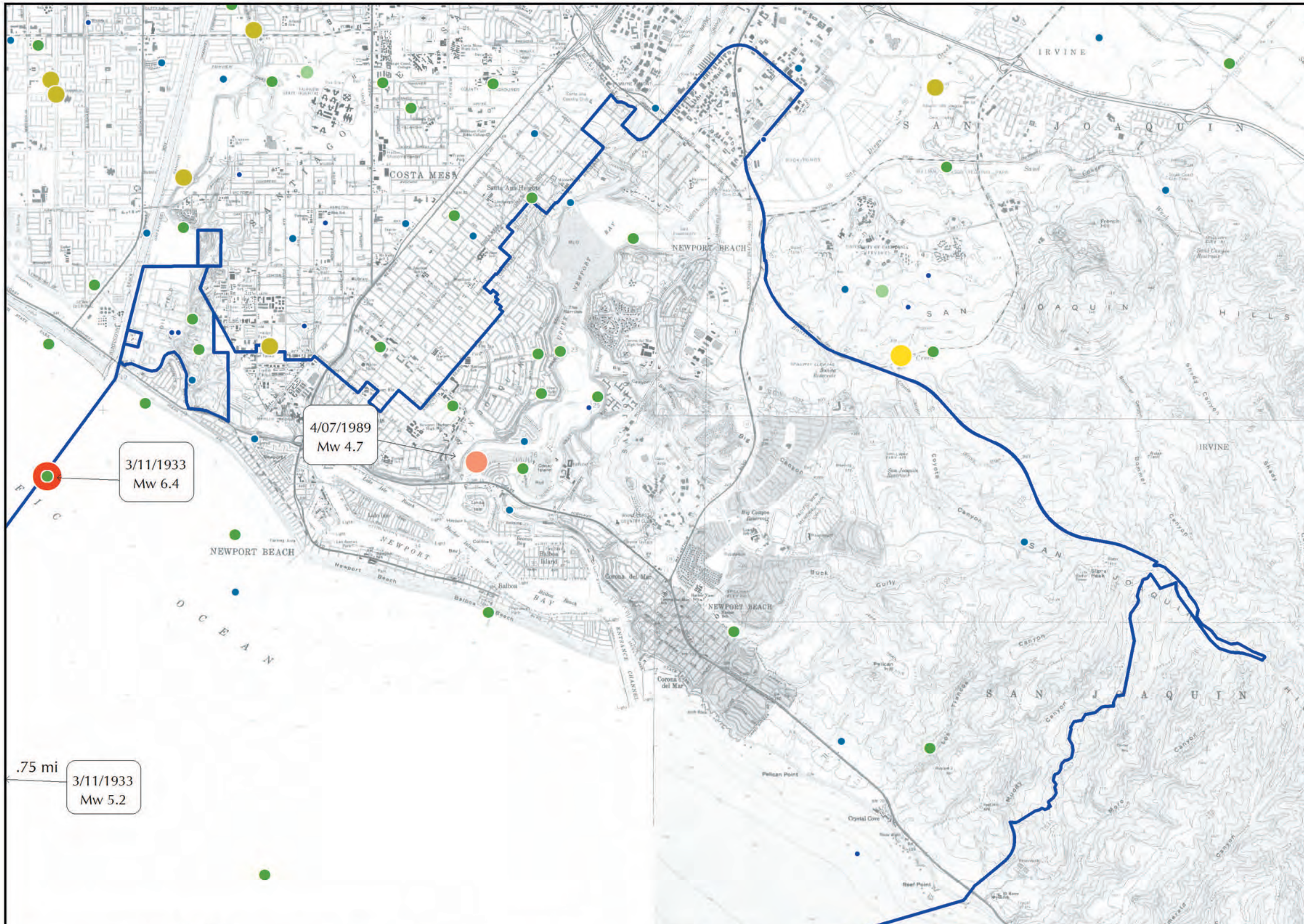
Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: City of Newport Beach and Google Maps

Earth Consultants International

Project Number: 3311
Date: 2014

City of Newport Beach California

Plate H-1



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Historical Seismicity (1855-2014)

Newport Beach, California

EXPLANATION

Earthquake Magnitude

- 5 to 6.4
- 4 to 5
- 3 to 4
- 2 to 3
- 1 to 2

Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Sources: Southern California Earthquake Center (January 1932 to April 2014); National Earthquake Information Center (1855 to 1931).

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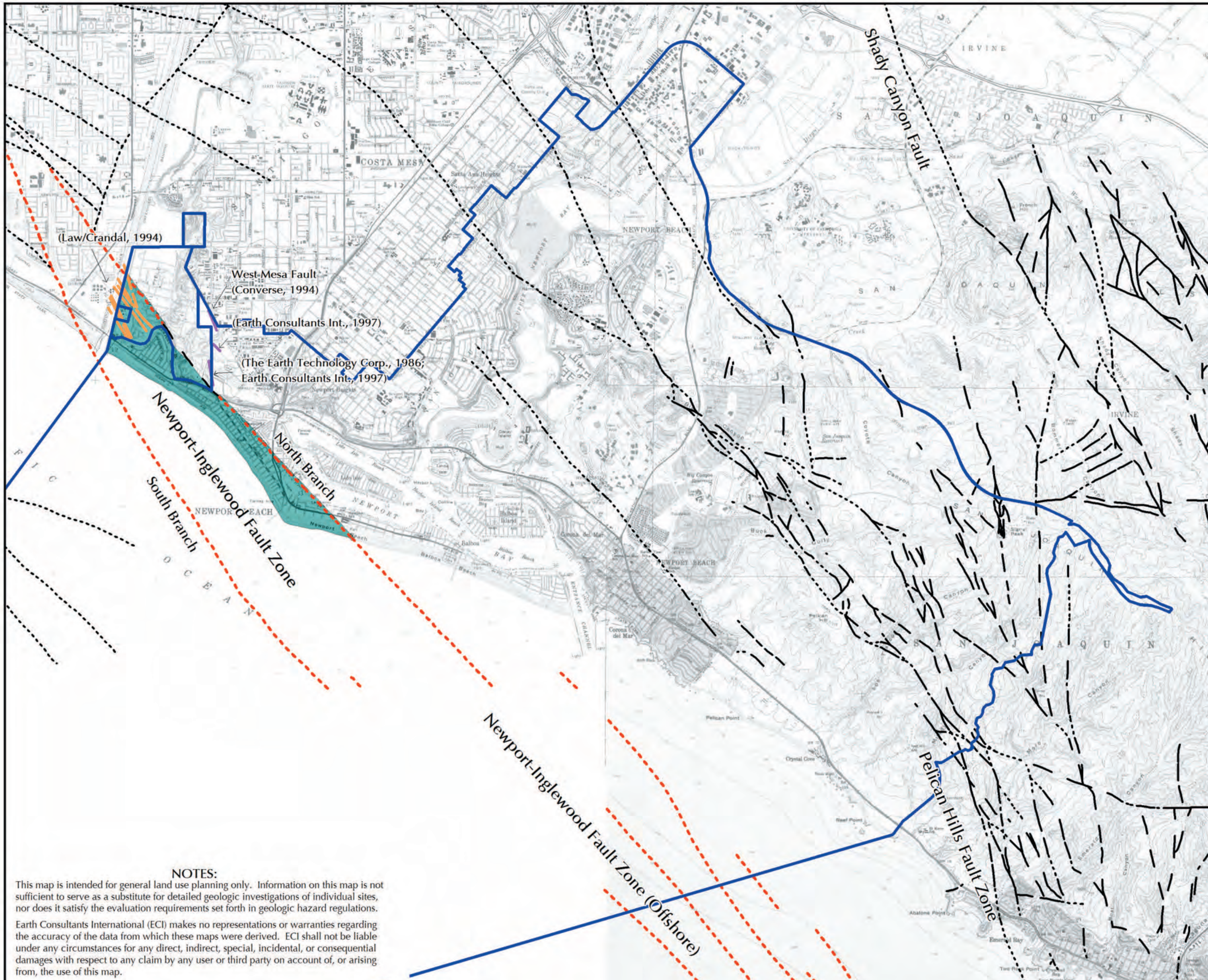
Project Number: 3311
Date: 2010

Plate H-2



Fault Map

Newport Beach, California

EXPLANATION

Fault: solid where location known, long dashed where approximate, dotted where inferred.

- Major fault traces as mapped by Morton, 1999. Presumed active, except where shown otherwise based on geological studies.
- Southward projection of active fault traces based on a subsurface study on the west bank of the Santa Ana River.
- Secondary fault traces that have been shown to have moved at least once during the Holocene.
- Faults that are not active.
- Fault Hazard Management Zone for real-estate disclosure purposes (refer to text).
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER

Source: Earth Technology Corp., 1986; Converse,1994; Law/Crandall, 1994; Earth Consultants Int., 1997; Morton, 1999.

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Project Number: 3311
Date: 2014

Plate H-3

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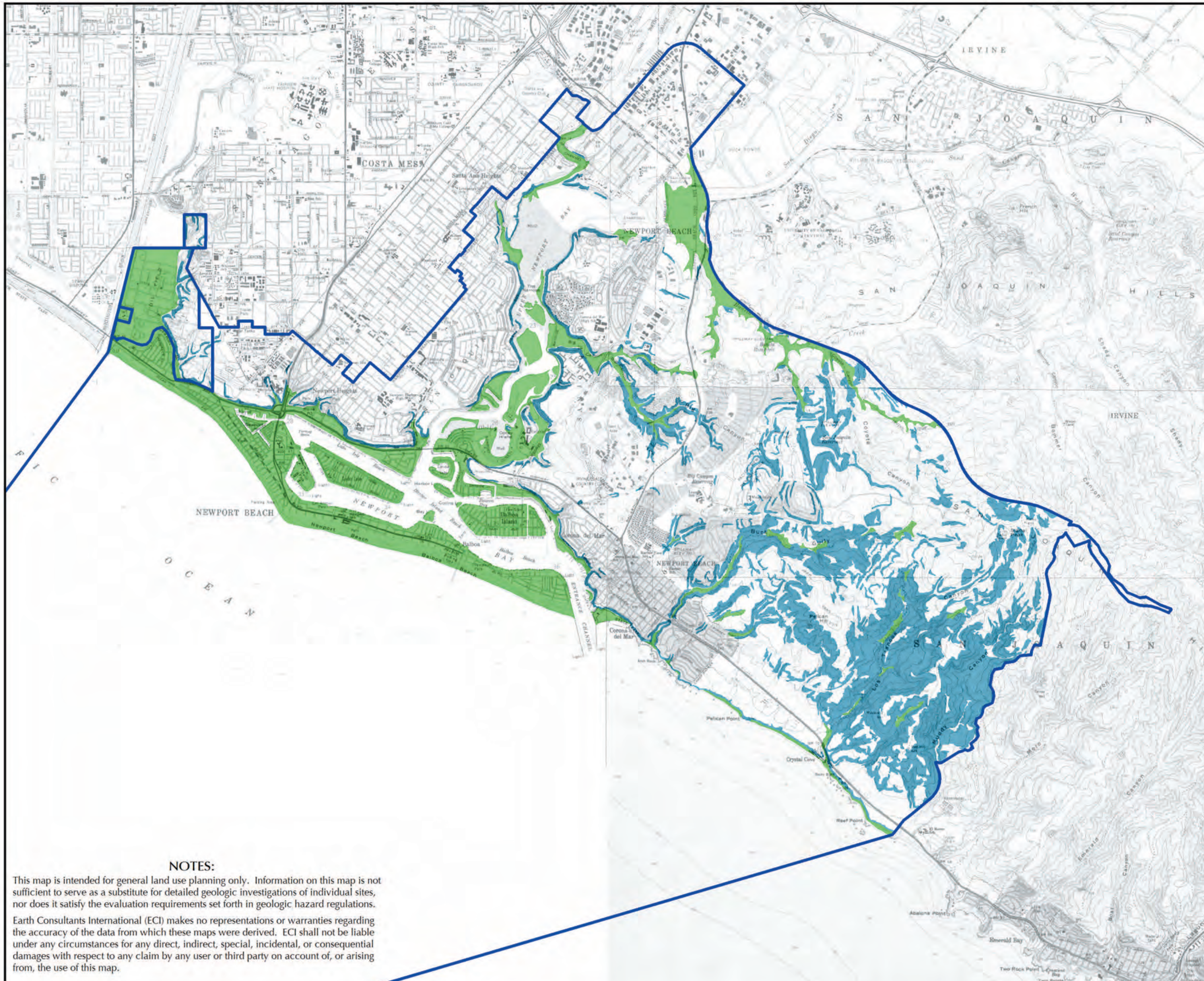

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Seismic Hazards Map

Newport Beach, California

EXPLANATION

- (Green) Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693c would be required.
- (Blue) Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693c would be required.
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: California Geological Survey, 1997; Revised 2001 (Newport, Tustin and Laguna Beach Quadrangles).

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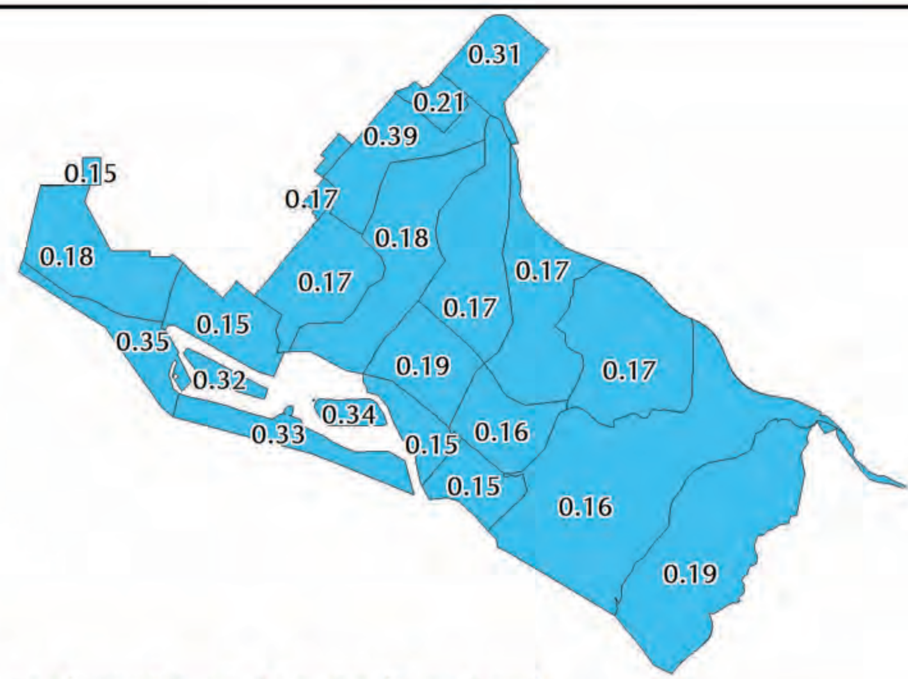
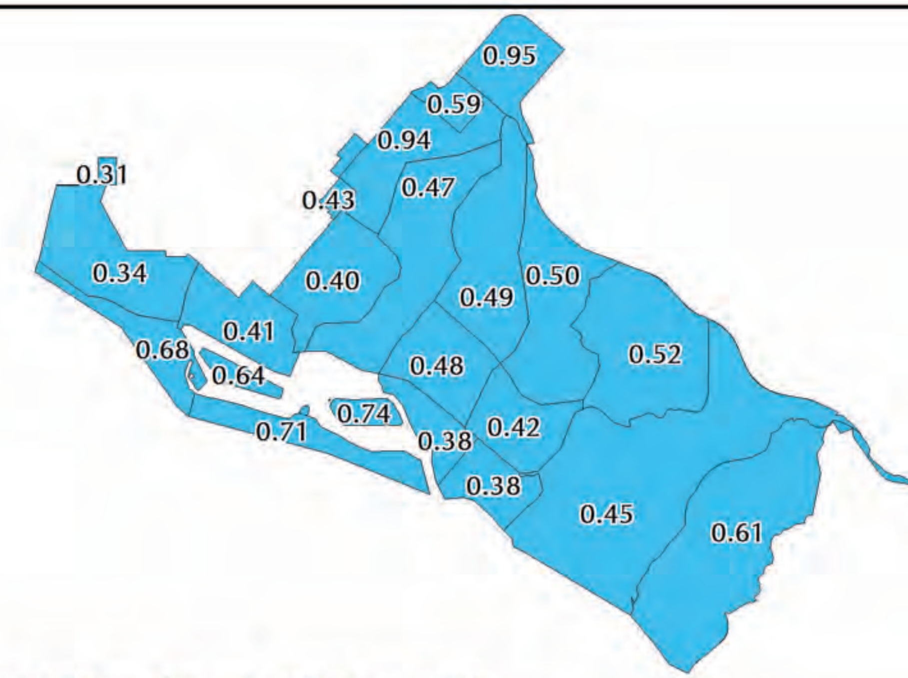
CITY OF NEWPORT BEACH CALIFORNIA

Project Number: 3311
Date: 2014

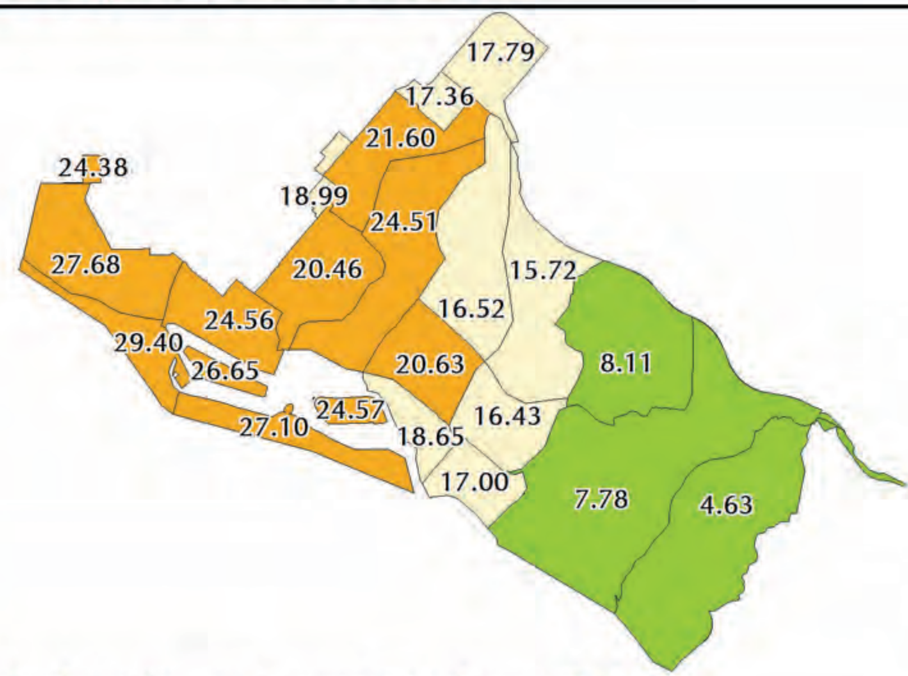
Plate H-4



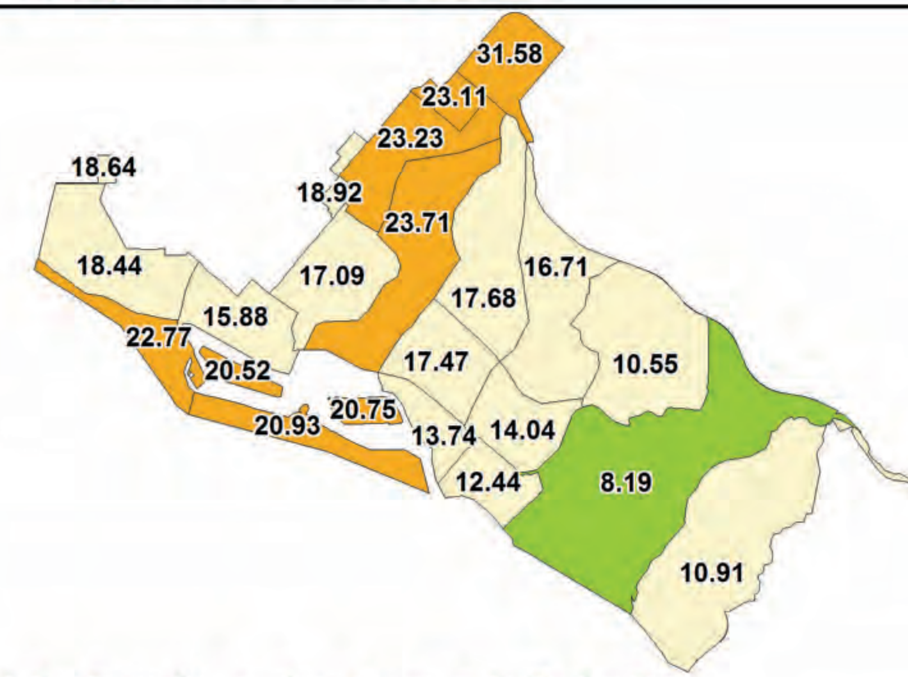
Magnitude 7.8 Earthquake on San Andreas Fault



Magnitude 6.8 Earthquake on Whittier Fault



Magnitude 6.8 Earthquake on Newport-Inglewood Fault



Magnitude 7.1 Earthquake on San Joaquin Hills Fault

EXPLANATION

Sources: Federal Emergency Management Agency, HAZUS-MH, 2000

Building Losses (as a Percentage of Total Dollar Exposure) by Census Tract
(labels show percentage of building losses estimated for each census tract)

- less than 1%
- 1-9.99%
- 10-19.99%
- 20-39.99%
- 40-59.99%
- 60% and greater

Earth Consultants International

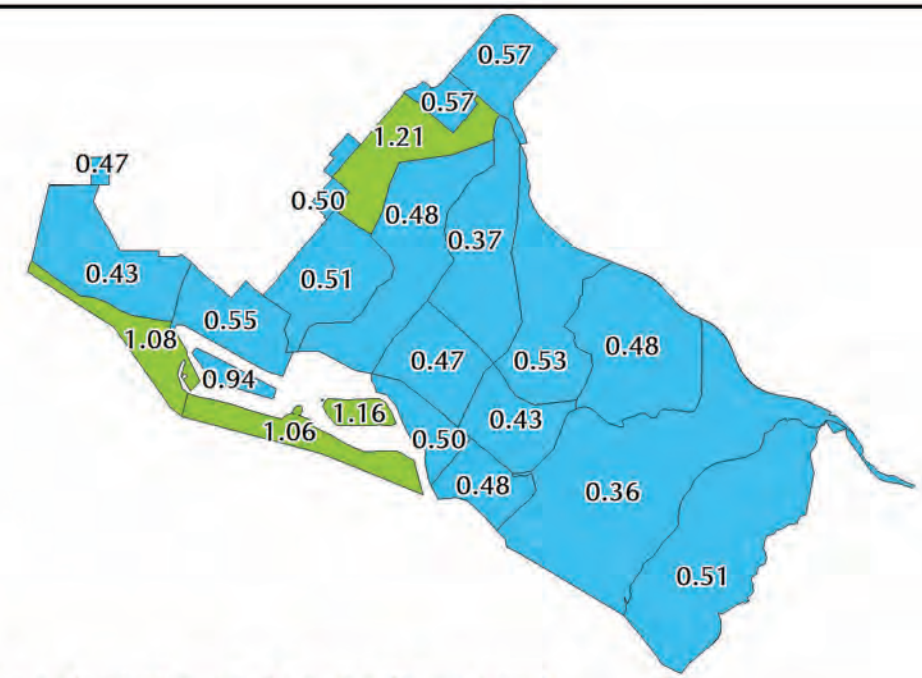
Project Number: 3311
Date: 2014

Residential Building Losses as a Percentage of Total Dollars Exposure

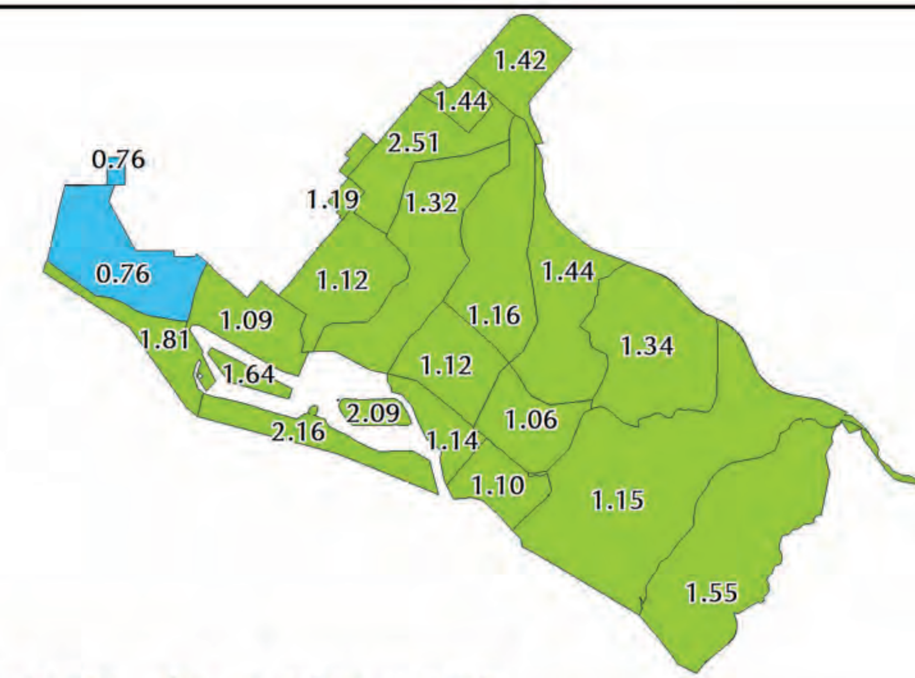
(Based on Four Earthquake Scenarios)

Newport Beach, California

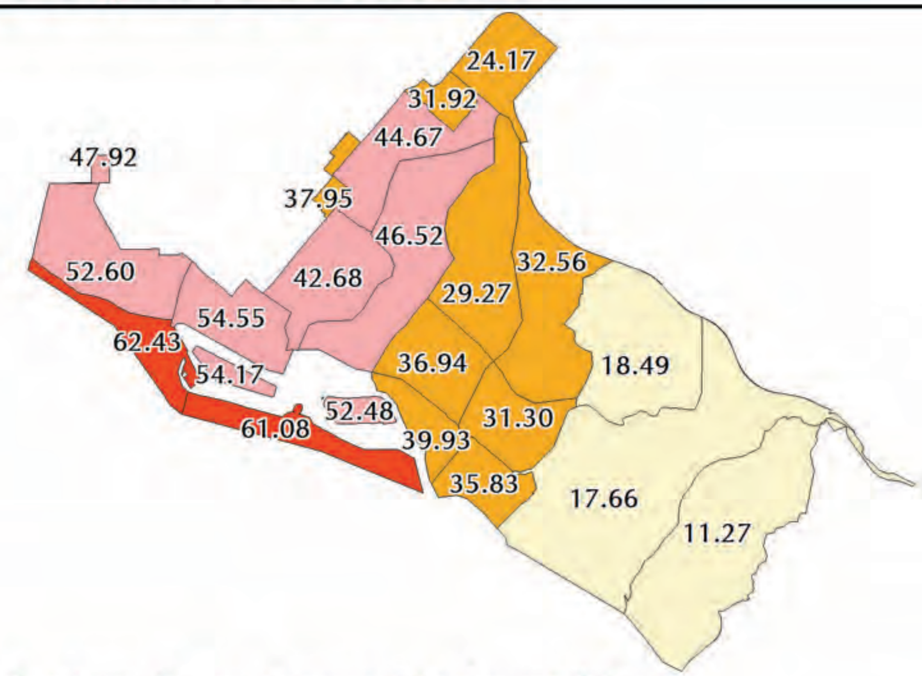
Plate H-5



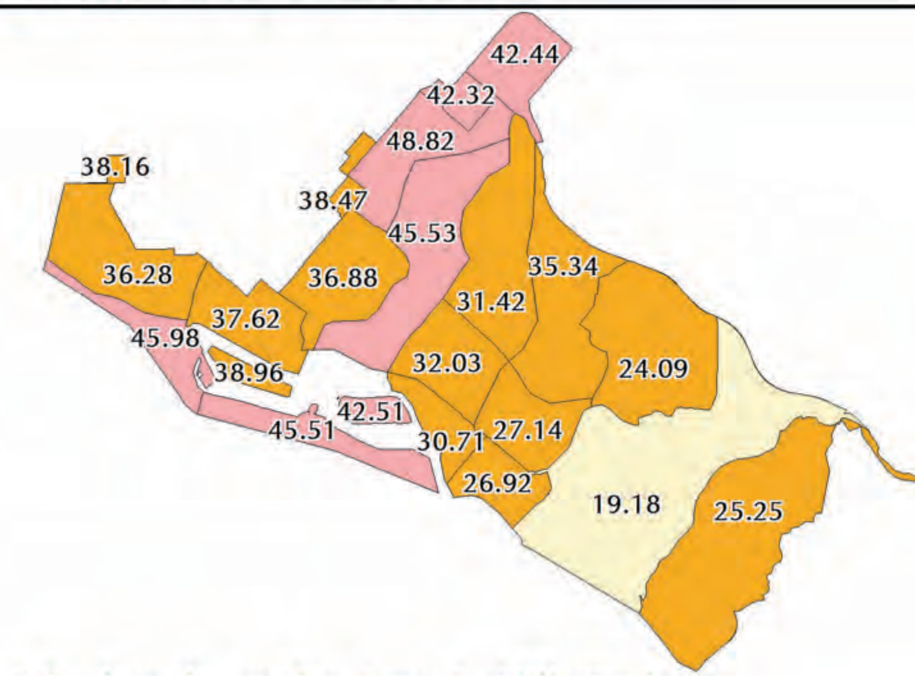
Magnitude 7.8 Earthquake on San Andreas Fault



Magnitude 6.8 Earthquake on Whittier Fault



Magnitude 6.8 Earthquake on Newport-Inglewood Fault



Magnitude 7.1 Earthquake on San Joaquin Hills Fault

EXPLANATION

Building Losses (as a Percentage of Total Dollar Exposure) by Census Tract
(labels show percentage of building losses estimated for each census tract)

- less than 1%
- 1-9.99%
- 10-19.99%
- 20-39.99%
- 40-59.99%
- 60% and greater

Sources: Federal Emergency Management Agency, HAZUS-MH, 2000

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Project Number: 3311
Date: 2014

Commercial Building Losses as a Percentage of Total Dollar Exposure

(Based on Four Earthquake Scenarios)

Newport Beach, California

Plate H-6

NOTES:

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Geomorphic Map

Newport Beach, California

EXPLANATION

0 50 100 200 300 400

Elevation (m)

Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER

Source: US Geological Suvery 10 m Digital Elevation Model

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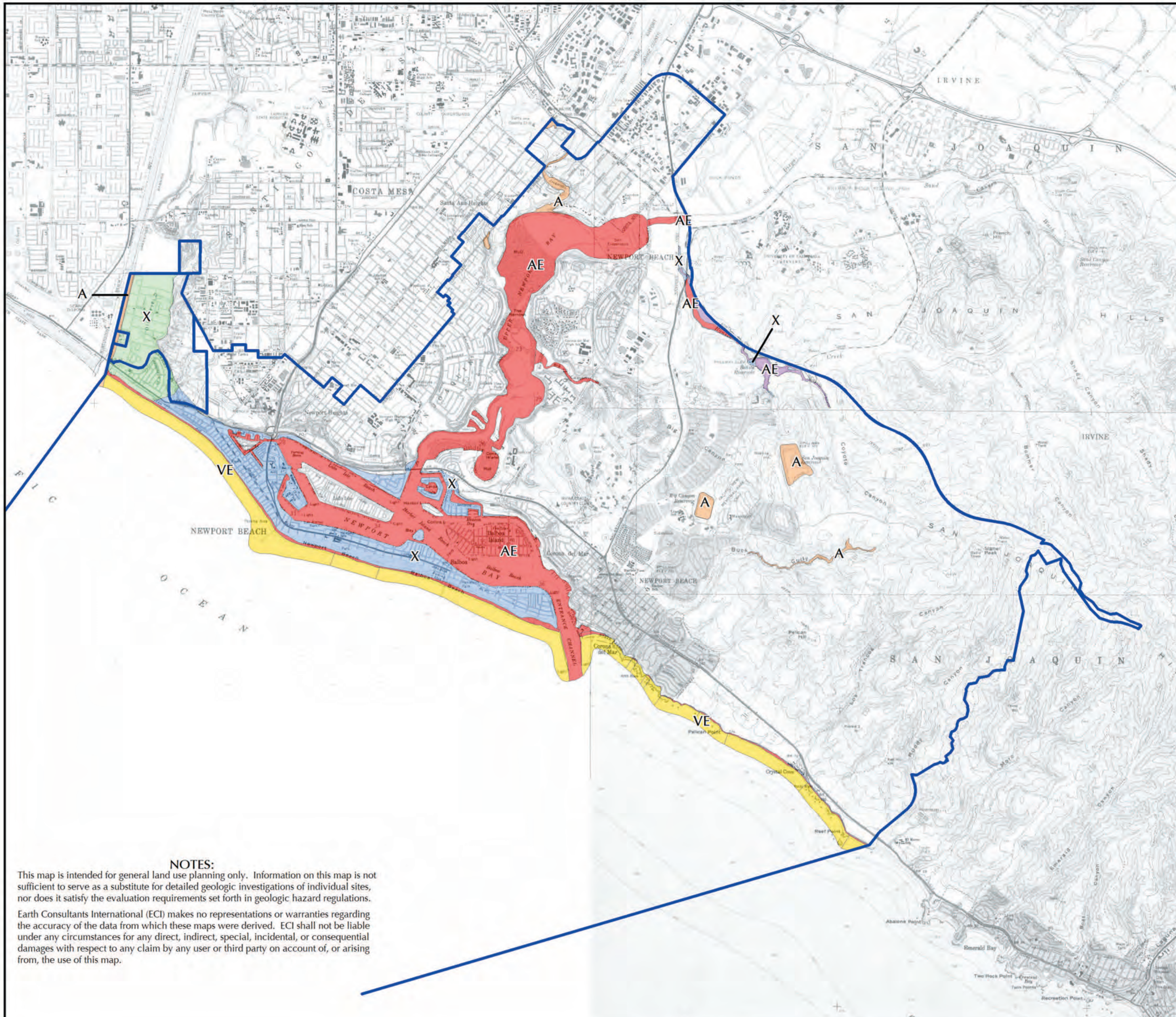
Project Number: 3311
Date: 2014

CITY OF NEWPORT BEACH CALIFORNIA

Plate H-7

FEMA Flood Zones Map
Newport Beach, California



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EXPLANATION

FEMA Flood Insurance Rate Zones

High Risk Areas (Special Flood Hazard Areas)

- A — Zone that corresponds to the 100-year flood areas, as determined by approximate methods. Because detailed hydraulic analyses were not performed, no base flood elevations or depths have been determined. Mandatory flood insurance is required.
- AE — Zone that corresponds to the 100-year flood areas, as determined by detailed hydraulic analyses. In most cases, base flood elevations are shown at selected intervals.* Mandatory flood insurance is required.
- AE — Floodway zone*. Watercourse channel that generally must be kept free of encroachment. Development is subject to special regulations.
- VE — Coastal flood zone with velocity hazard (wave action), base flood determined.

Moderate and Low Risk Areas

- X — Zone that corresponds to areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood. No base flood elevations or depths are shown. Flood insurance is available but not required.
- X — Zone that corresponds to areas protected from the 100-year flood by levees. Flood insurance is available but not required.
- X — Zone that corresponds to areas outside of the 500-year flood. Flood insurance is available but not required.
- Newport Beach City Boundary

* See FEMA Flood Insurance Rate Maps and FEMA FLood Insurance Study for Orange County for Base Flood Elevations.

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: Federal Emergency Management Agency, 2009, Digital Flood Insurance Rate Map Database, Orange County, California, USA

Pannels: 06059C0264J, 06059C0267J, 06059C0269J, 06059C0286J, 06059C0288J, 06059C0289J, 06059C0377J, 06059C0381J, 06059C0382J, 06059C0384J, 06059C0401J, 06059C0402J, 06059C0403J, 06059C0404J, 06059C0408J

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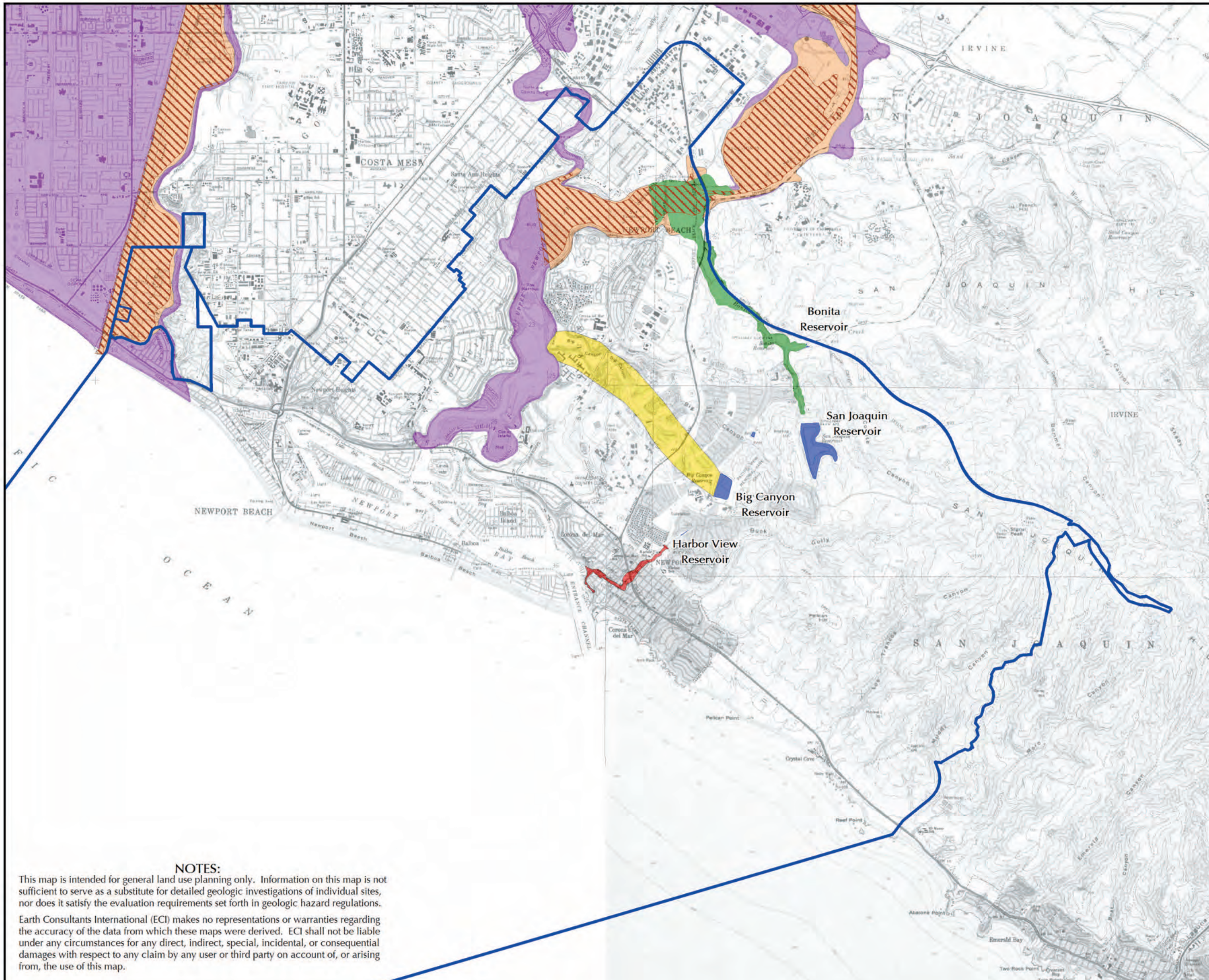
CITY OF NEWPORT BEACH CALIFORNIA

Project Number: 3311
Date: 2014

Plate H-8



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Dam Failure Inundation Map

Newport Beach, California

EXPLANATION

- Harbor View Reservoir Failure Inundation Pathway
- San Joaquin Reservoir Failure Inundation Pathway
- Villa Park Reservoir Failure Inundation Pathway
- Santiago Creek Reservoir Failure Inundation Pathway
- Prado Dam Failure Inundation Pathway
- Big Canyon Reservoir Failure Inundation Pathway
- Reservoir
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER

Source: California Office of Emergency Services

Earth Consultants International

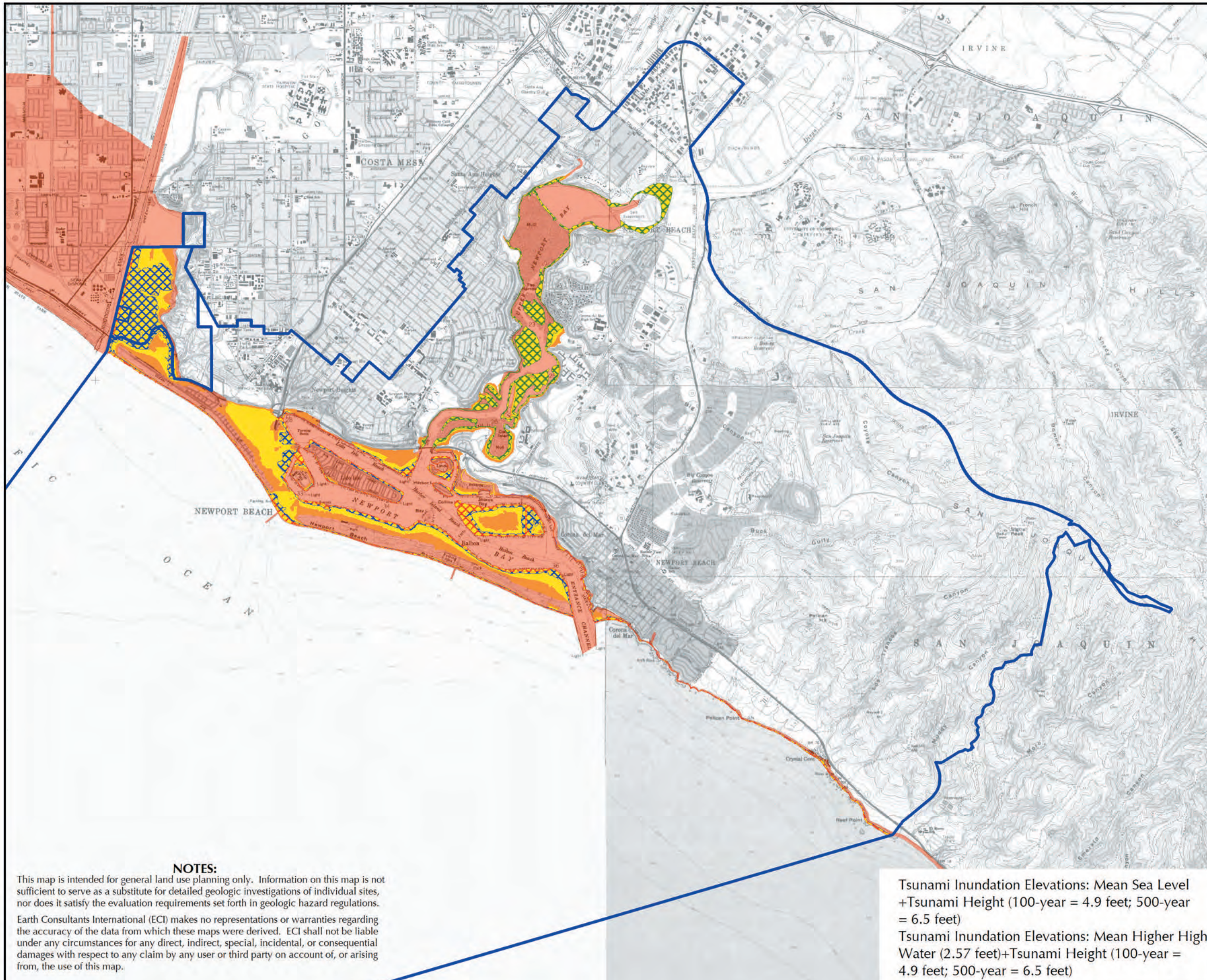
Project Number: 3311
Date: 2014

CITY OF NEWPORT BEACH CALIFORNIA

Plate H-9

Tsunami Inundation at Mean Sea Level and Mean Higher High Water

Newport Beach, California



EXPLANATION

Tsunami Hazard Zones - Mean Sea Level

- 100-year Zone (Inundation Elevation = 4.9 feet)
- 500-year Zone (Inundation Elevation = 6.5 feet)
- Zone of Minimal but Potential Tsunami Inundation

Tsunami Hazard Zones - Mean Higher High Water

- 100-year Zone (Inundation Elevation = 7.47 feet)
- 500-year Zone (Inundation Elevation = 9.07 feet)
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 **Miles**

1 0 1 2 3 **Kilometers**

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: Houston,1980; Legg et al., 2003; Borrero et al., 2004; USGS 10-m Digital Elevation Model

Earth Consultants International

Project Number: 3311
Date: 2014

CITY OF NEWPORT BEACH CALIFORNIA

Plate H-10

Tsunami Inundation Elevations: Mean Sea Level +Tsunami Height (100-year = 4.9 feet; 500-year = 6.5 feet)
Tsunami Inundation Elevations: Mean Higher High Water (2.57 feet)+Tsunami Height (100-year = 4.9 feet; 500-year = 6.5 feet)

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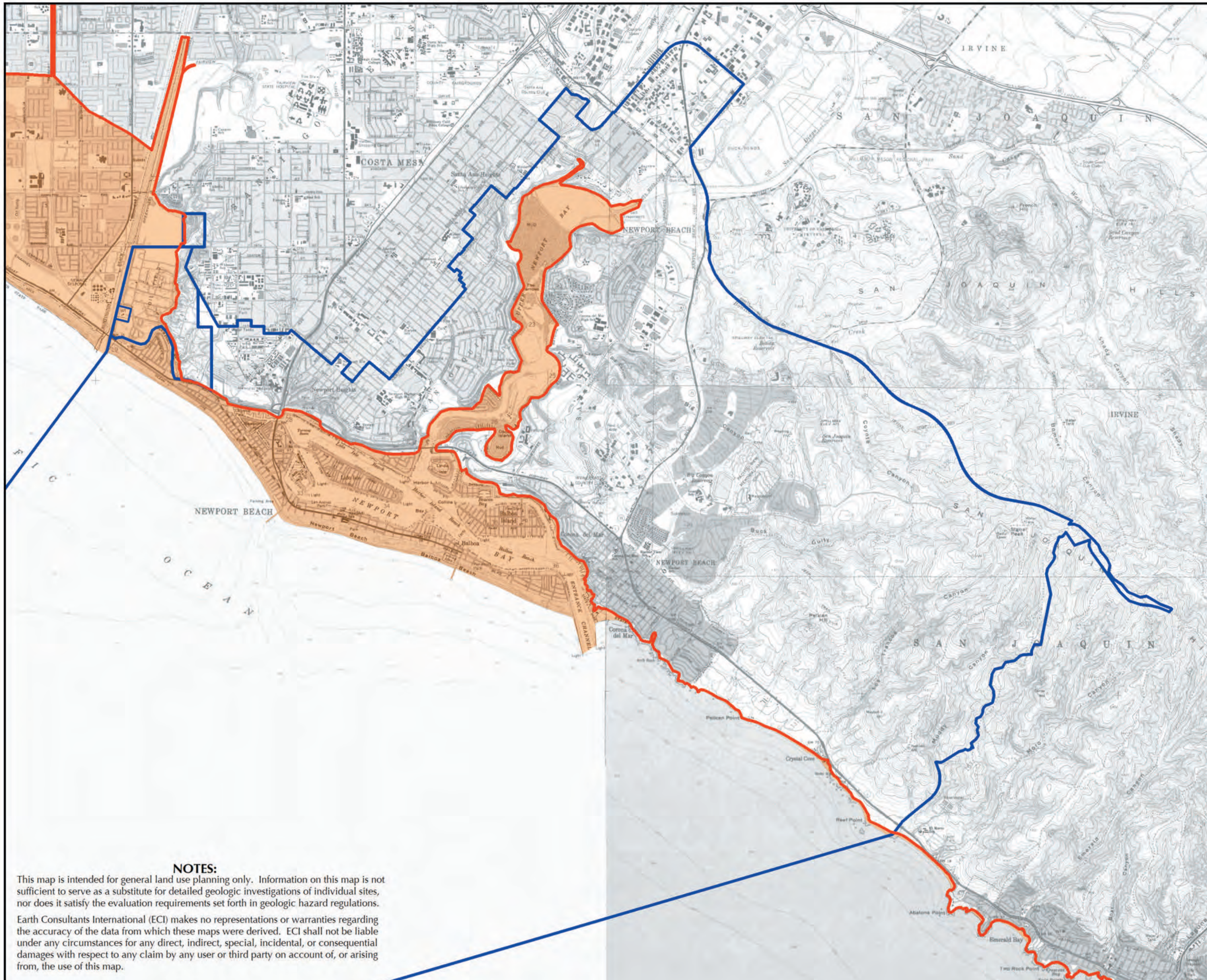

Tsunami Inundation

Newport Beach, California

EXPLANATION

- Tsunami Inundation Line
- Tsunami Inundation Area
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 **Miles**

1 0 1 2 3 **Kilometers**

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Sources: California Emergency Management Agency (2009) with University of Southern California - Tsunami Research Center, California Geological Survey), and National Oceanic and Atmospheric Agency Center for Tsunami Research

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Date: 2014

Plate H-11

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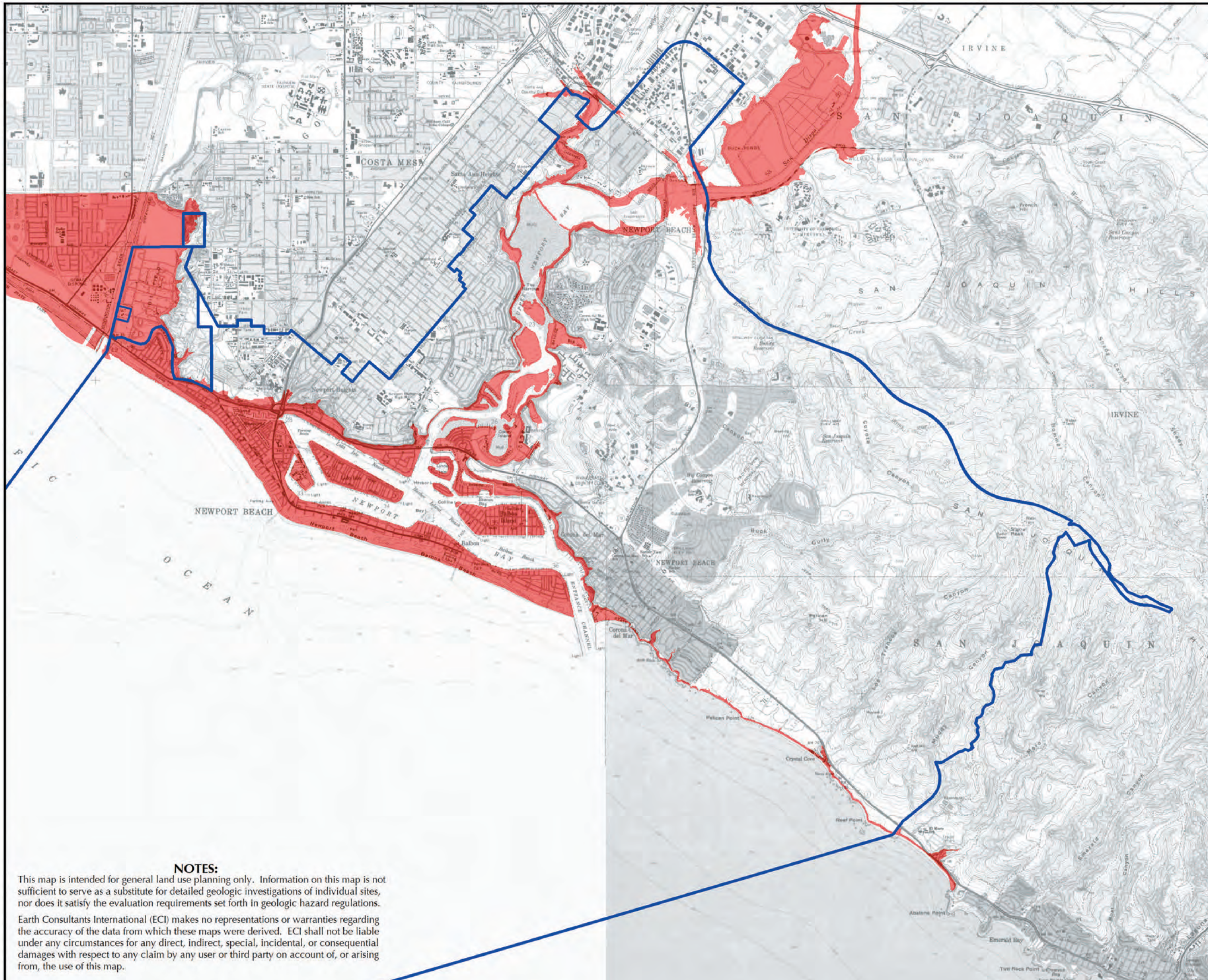
Potential Tsunami Runup Inundation Caused by a Submarine Landslide

Newport Beach, California



EXPLANATION

- Area that would be inundated by a tsunami generated by a submarine landslide offshore of Newport Beach (areas at or lower than 32 foot elevation)
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: City of Newport Beach, 2007 based on unpublished research by J. C. Borrero and others at University of Southern California

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Date: 2014

CITY OF NEWPORT BEACH CALIFORNIA

Plate H-12

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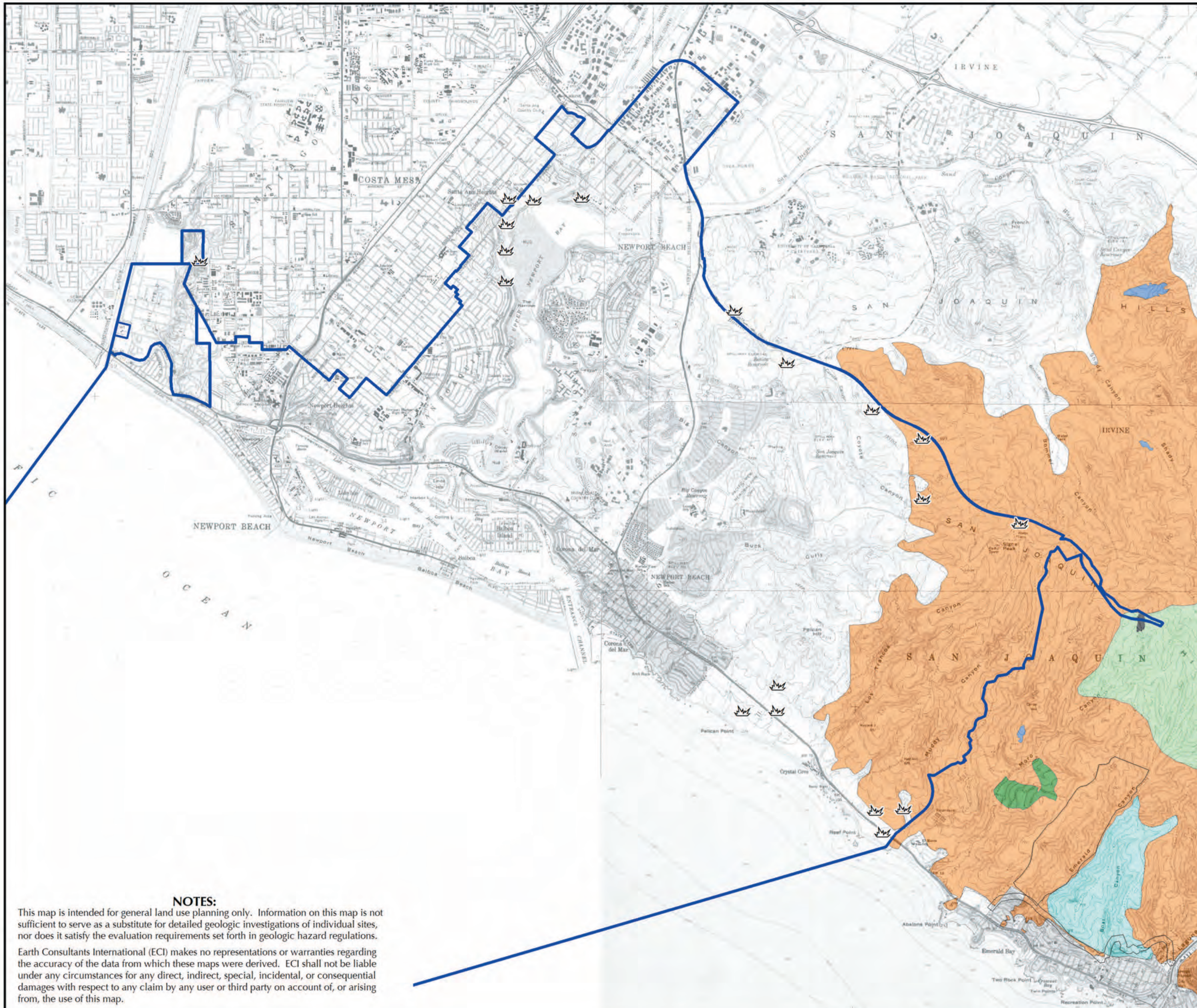
Historical Wildland Fires in Newport Beach, California



EXPLANATION

Fires reported by the OC FIre Authority

- 73 Fire, 8/07/2001
- Laguna Fire, 10/27/1993
- Niger Fire, 09/25/1955
- Other Wildland fires in 1991-2001 reported by Orange Co. Fire Authority

Fires Reported by FRAP

- 1970-1980
- 2000-2005
- 1990-2000
- prescribed burns/ fuel treatments

Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Sources: Orange County Fire Authority, 2001
http://frap.fire.ca.gov/data/frapgisdata-subset.php, 2013

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CITY OF NEWPORT BEACH CALIFORNIA

Project Number: 3311
Date: 2014

Plate H-13

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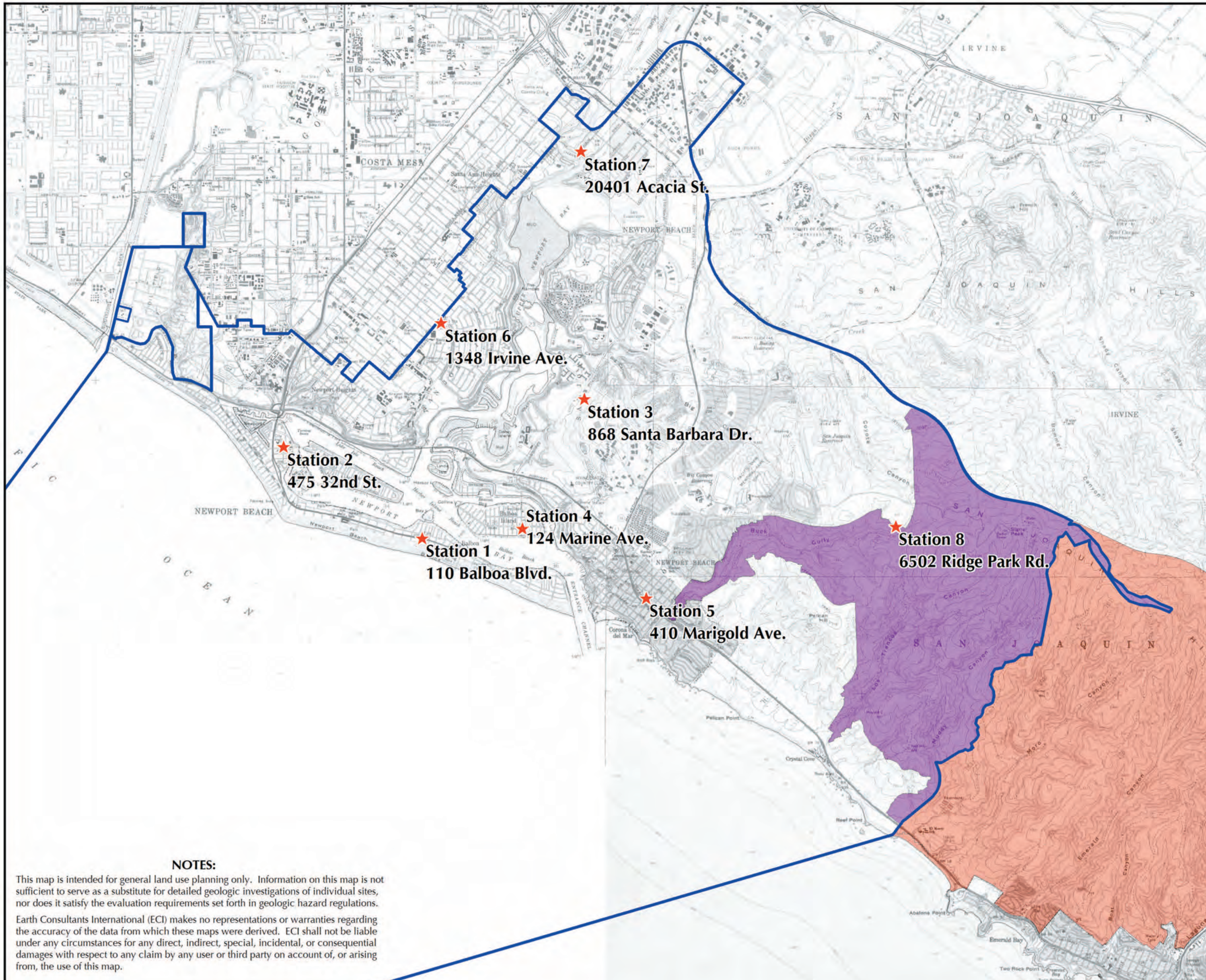

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Wildfire Hazard Map

Newport Beach, California

EXPLANATION

Fire Hazard Severity Zones

Local Responsibility Area

Very High Fire Hazard Severity Zone

State Responsibility Area

Very High Fire Hazard Severity Zone

Fire Station

Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

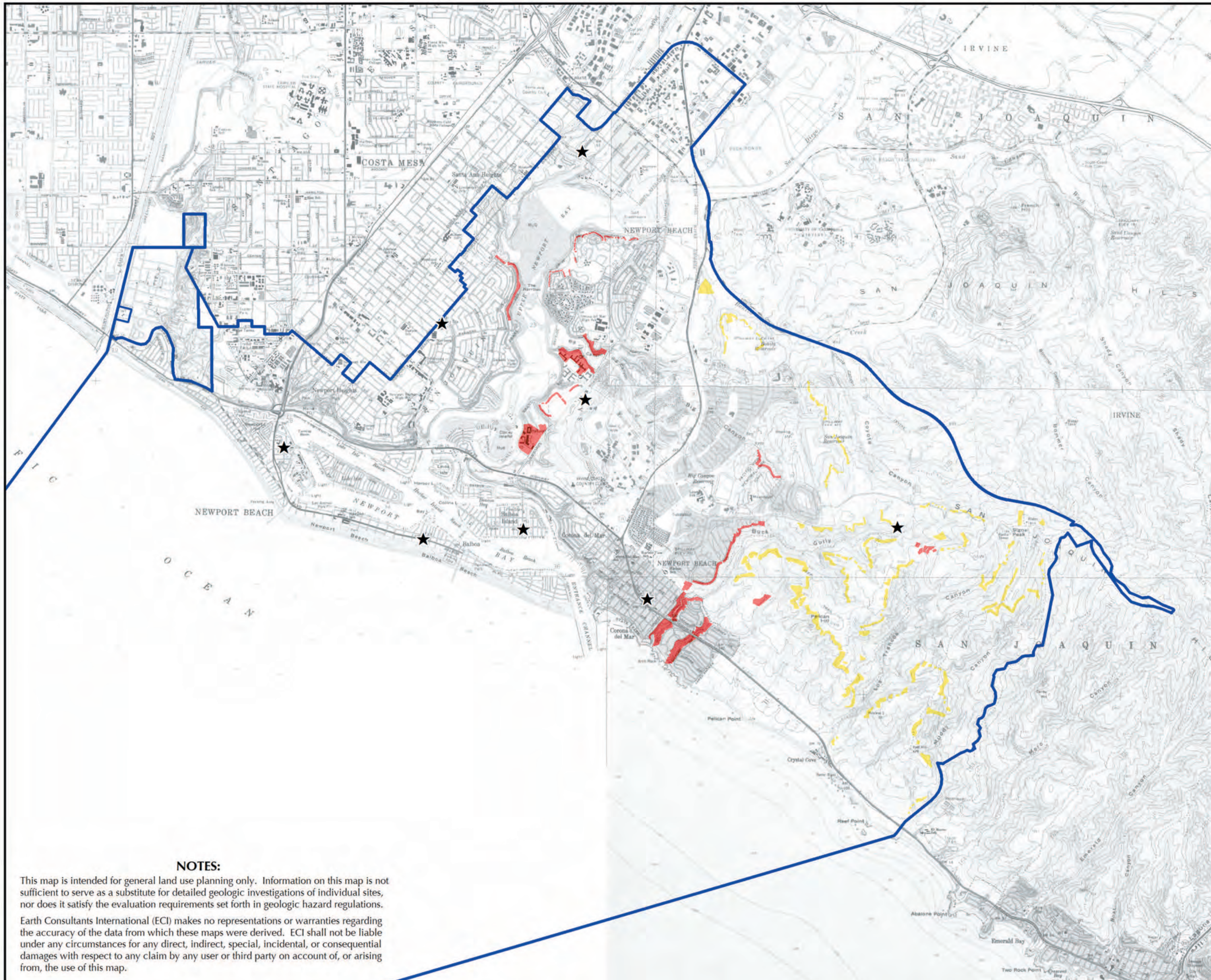
1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Sources: City of Newport Beach Fire Department

Earth Consultants International

Project Number: 3311
Date: 2014

Plate H-14



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Areas with Vegetation Management Requirements

Newport Beach, California

EXPLANATION

Fire Hazard Areas

- Hazard Reduction Zone
- Fuel Modification Zone

★ Fire Station

Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

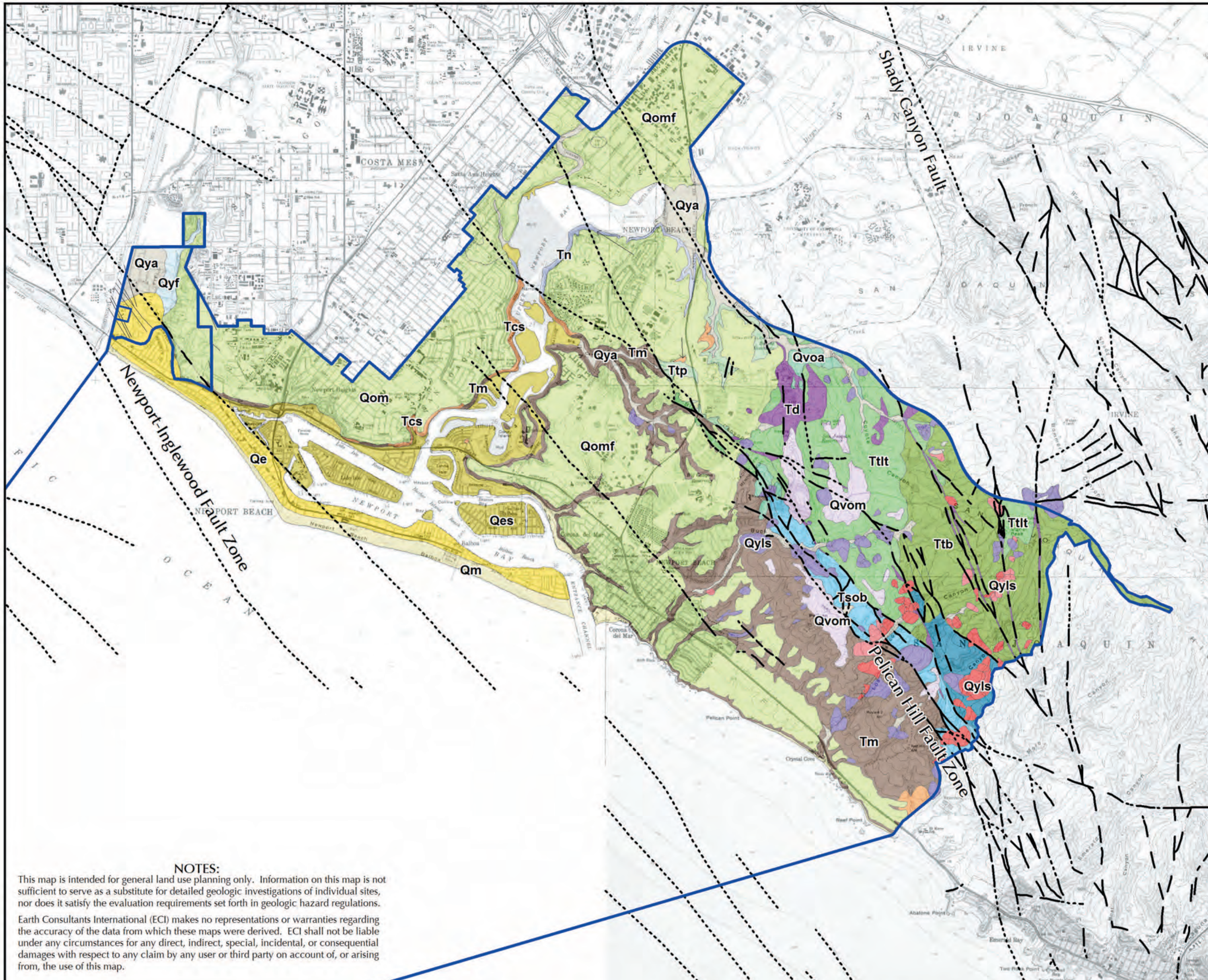
Base Map: USGS Topographic Map from Sure!MAPS RASTER
Sources: Orange County Fire Authority, 2003; City of Newport Beach, 2002

Earth Consultants International

CITY OF NEWPORT BEACH CALIFORNIA

Project Number: 3311
Date: 2014

Plate H-15



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Geologic Map

Newport Beach, California

EXPLANATION

SYMBOLS

Fault: solid where location known, dashed where approximate, dotted where concealed.

Geologic Contact

Newport Beach City Boundary

for the description of geologic units, refer to Plate H-16a

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: Morton et al., 1976 and Morton, 1999

Earth Consultants International

Project Number: 3311
Date: 2014

CITY OF NEWPORT BEACH CALIFORNIA

Plate H-16

GEOLOGIC UNIT DESCRIPTIONS

Quaternary

Young Surficial Deposits

Unit	Description
Qm	Marine sediments (late Holocene) - Unconsolidated, active or recently active beach sand deposits.
Qe	Eolian sediments (late Holocene) - Unconsolidated, active or recently active sand dune deposits.
Qes	Estuarine sediments (late Holocene) - Unconsolidated, active, or recently active, sandy, silty, and clayey organic-rich intertidal deposits.
Qya	Young fluvial channel sediments (Holocene and latest Pleistocene) - Unconsolidated sand, silt, clay, and gravel in active or recently active stream channels.
Qyf	Young alluvial fan sediments (Holocene and latest Pleistocene) - Unconsolidated sand, silt, and clay.
Qyls	Mapped landslide (Holocene and latest Pleistocene) - Highly fragmented and broken to largely coherent bedrock blocks.
Qyls	Previously mapped landslide just outside a now-graded area (Holocene and latest Pleistocene) - Landslide may have been remediated during grading.
Qyls	Previously mapped landslide in a now-graded area (Holocene and latest Pleistocene) - Landslide was probably remediated during grading.

Older Surficial Deposits

Unit	Description
Qom/Qomf	Old marine sediments (late to middle Pleistocene) - Light gray to brownish gray silty sand and fine-grained sand locally with gravel and shell fragments. East of Newport Bay, covered with veneer of younger alluvial fan sediments (Qomf).
Qvom	Very old marine sediments (middle to early Pleistocene) - Light gray to yellow fine- to medium-grained sand, locally clay-rich and reddish in color; gravelly near the base.
Qvoa	Very old channel sediments (middle to early Pleistocene) - Reddish brown to yellowish brown gravel, sand, silt and clay; typically poorly bedded, locally with cross-bedded lenses of sand and gravel; locally cemented.

Tertiary

Tertiary Sedimentary Rocks

Unit	Description
Tn	Niguel Formation (Pliocene) - Light gray to grayish yellow sandstone interbedded with greenish siltstone and yellowish brown to pale reddish brown conglomerate and breccia.
Tcs	Capistrano Formation Siltstone Facies (late Miocene) - Yellowish to brownish gray concretionary siltstone and mudstone with lenses of whitish gray sandstone; sparse diatomaceous and tuffaceous beds.
Tm	Monterey Formation (middle to late Miocene) - White to yellowish gray siliceous and diatomaceous siltstone, shale, and clayey siltstone with interbedded fine-grained sandstone. Locally contains lenses and thin beds of water-laid tuff.
Tsob	San Onofre Breccia (middle Miocene) - Brown to yellowish brown breccia with interbedded conglomerate, sandstone, siltstone, and mudstone.
Tt	Topanga Formation (middle Miocene) - Marine sandstone, siltstone, and shale.
Ttb	Paularino Member - Pale gray, tuffaceous siltstone and sandstone with interbedded breccia. Contains andesite flows locally sandstones and breccia contain abundant andesite fragments.
Ttp	Los Trancos Member - Pale gray, brownish gray and olive-gray, siltstone and clayey siltstone with interbedded shale and medium- to coarse-grained sandstone.
Ttlt	Bommer Member - Yellowish brown to brownish gray, medium- to coarse-grained sandstone and silty sandstone. Minor siltstone and conglomerate.
Tv	Vaqueros Formation (early Miocene) - Yellowish brown fine-grained sandstone with interbedded siltstone, shale, mudstone, and minor conglomerate.

Intrusive Igneous Rocks

Unit	Description
Ta	Andesitic intrusive rocks (middle Miocene) - Dark gray to olive gray intrusive rock primarily of andesitic composition.
Td	Diabase intrusive rocks (middle Miocene) - Diabasic textured shallow intrusive rocks.

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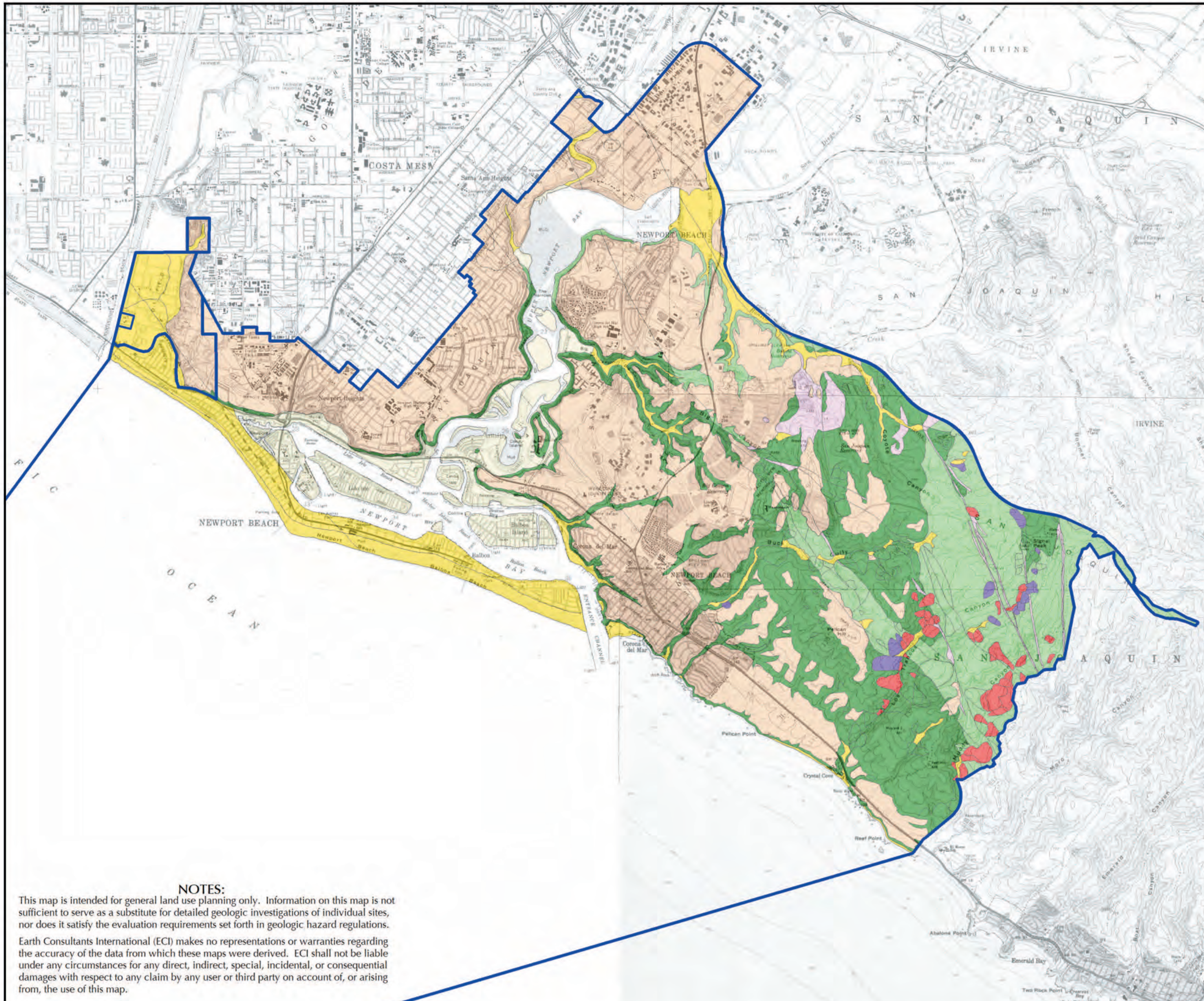
Explanation for Geologic Map

Plate H-16a



NOTES:

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Engineering Materials Map

Newport Beach, California

EXPLANATION

UNIT DESCRIPTIONS

Surficial Materials

- Unconsolidated, friable, fine- to coarse-grained sand of low density; locally contains variable amounts of silt, gravel, and cobbles; saturated in the tidal zone and locally in canyon bottoms.
- Unconsolidated, clay, silt, and friable sand of low density and high organic content; typically saturated.
- Sand and silty sand with minor gravel and cobbles; moderate to high density; massive to cross-bedded; friable below the soil zone; within the San Joaquin Hills, locally cemented and jointed.
- Mapped Landslide materials of variable density. Fractured to broken bedrock, locally mixed with soils; typically contain water perched above the rupture zone.
- Previously mapped Landslide just outside now-graded area. Landslide may have been remediated during grading.

Bedrock

- Chiefly fine-grained sedimentary rocks of moderate to high density; bedding ranges from massive to laminated; commonly to intensely fractured, sheared, and folded; contain weak, plastic, clay beds; locally cemented and hard.
- Chiefly coarse-grained sedimentary rocks of high density; bedding massive to crudely developed; fractured and sheared near faults; commonly very hard and cemented.
- Igneous rocks of high density; massive; commonly fractured and jointed; locally highly altered and decomposed; hard and very resistant where un-weathered.
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER

Source: Based on data from Morton et al., 1976 and Morton, 1999

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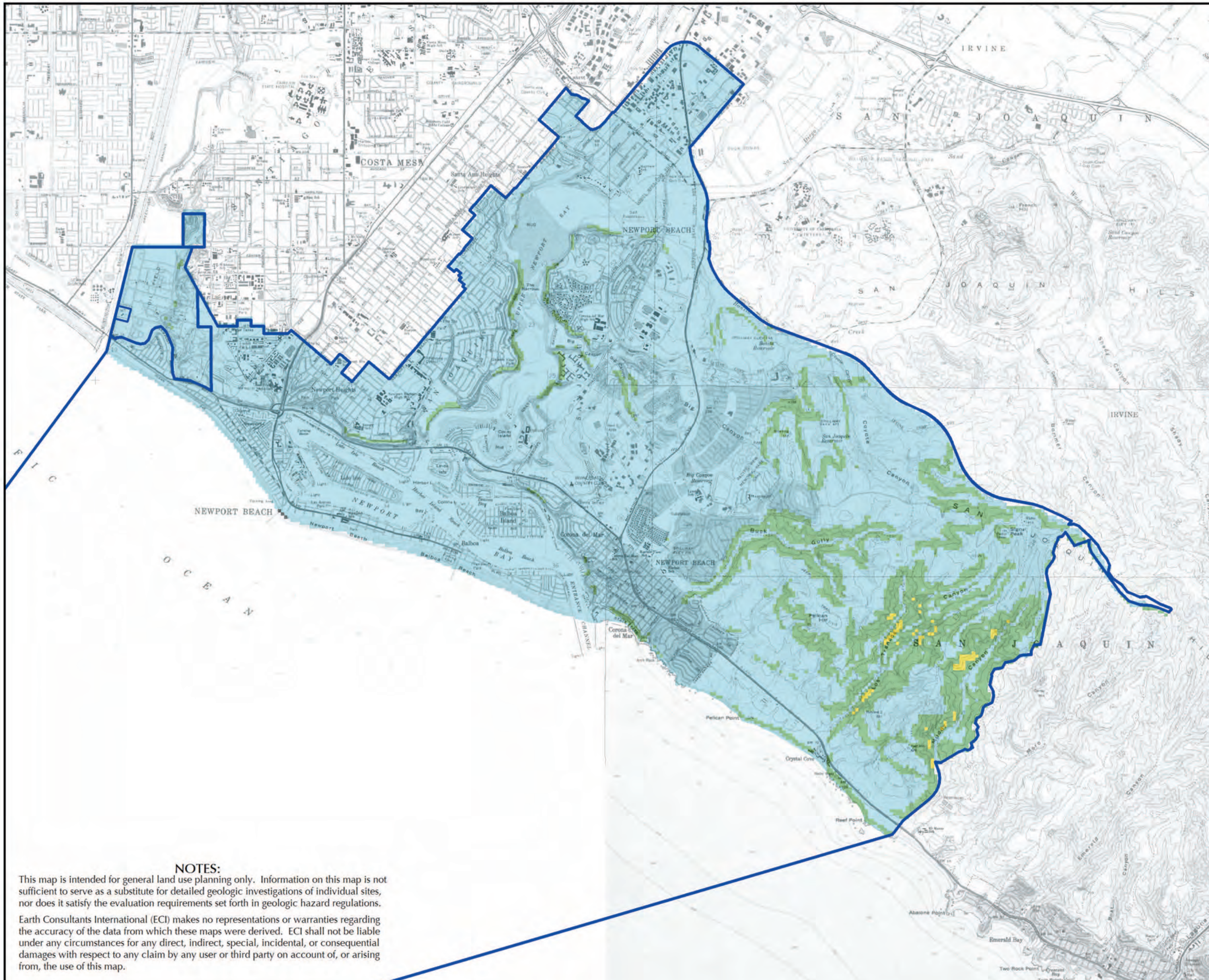
Plate H-17

Slope Distribution Map

Newport Beach, California



EXPLANATION

Slope (in degrees)

- 0 to 10
- 10 to 26
- 26 to 40

Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: Derived from Contour Map provided by City of Newport Beach (2007)

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CITY OF NEWPORT BEACH CALIFORNIA

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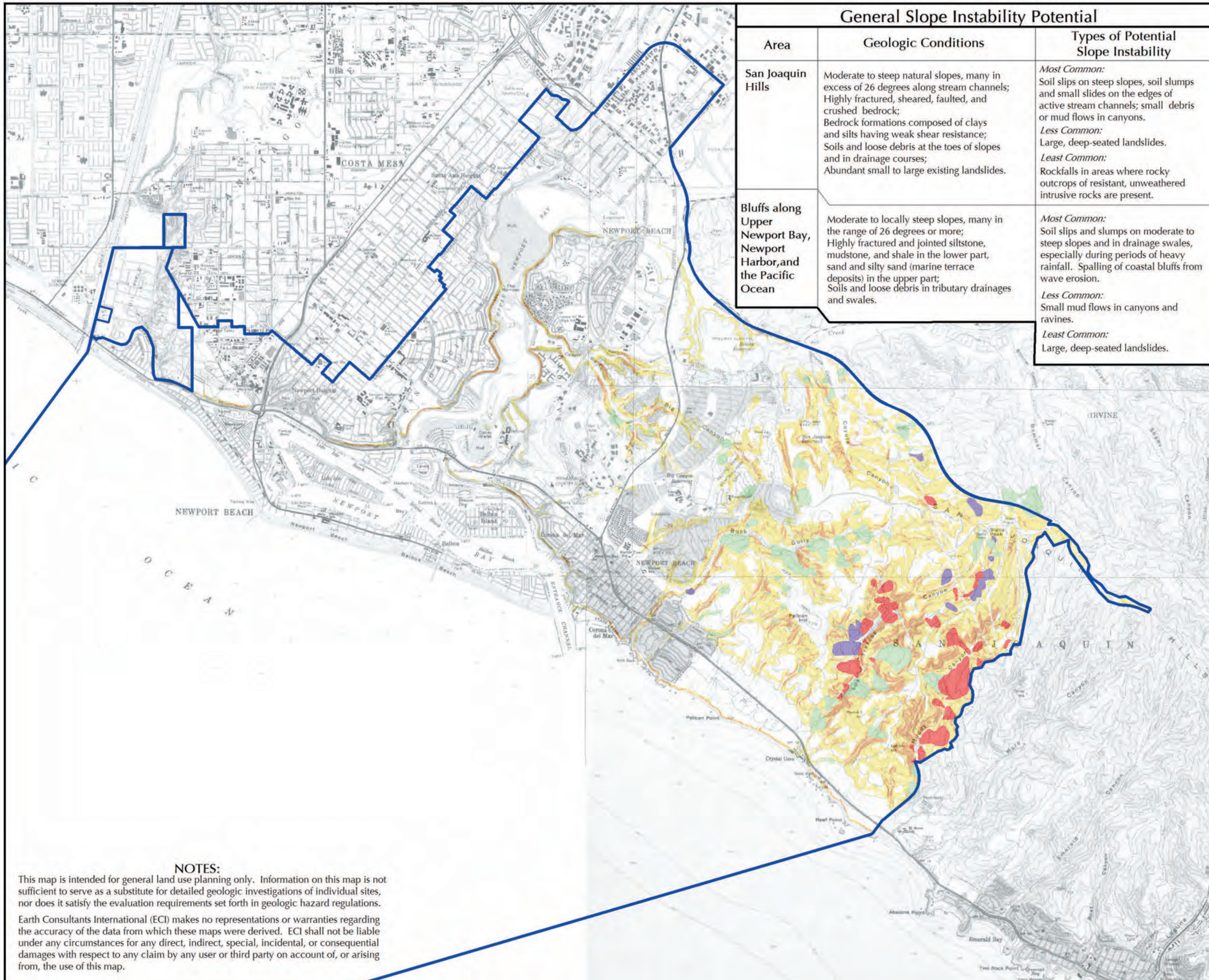
Plate H-18

Slope Instability Map

Newport Beach, California



General Slope Instability Potential

Area	Geologic Conditions	Types of Potential Slope Instability
San Joaquin Hills	Moderate to steep natural slopes, many in excess of 26 degrees along stream channels; Highly fractured, sheared, faulted, and crushed bedrock; Bedrock formations composed of clays and silts having weak shear resistance; Soils and loose debris at the toes of slopes and in drainage courses; Abundant small to large existing landslides.	*Most Common:* Soil slips on steep slopes, soil slumps and small slides on the edges of active stream channels; small debris or mud flows in canyons. *Less Common:* Large, deep-seated landslides. *Least Common:* Rockfalls in areas where rocky outcrops of resistant, unweathered intrusive rocks are present.
Bluffs along Upper Newport Bay, Newport Harbor, and the Pacific Ocean	Moderate to locally steep slopes, many in the range of 26 degrees or more; Highly fractured and jointed siltstone, mudstone, and shale in the lower part, sand and silty sand (marine terrace deposits) in the upper part; Soils and loose debris in tributary drainages and swales.	*Most Common:* Soil slips and slumps on moderate to steep slopes and in drainage swales, especially during periods of heavy rainfall. Spalling of coastal bluffs from wave erosion. *Less Common:* Small mud flows in canyons and ravines. *Least Common:* Large, deep-seated landslides.

EXPLANATION

Slope Instability Rating

- Very High
- High

Mapped Landslides

- Mapped landslide. Highly fragmented and broken to largely coherent bedrock blocks.
- Previously mapped landslide just outside a now-graded area. Landslide may have been remediated during grading.
- Previously mapped landslide in a now-graded area. Landslide was probably remediated during grading.
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: Based on data from Morton et al., 1976 and Morton, 1999. Modified based on Google Earth depictions of developed areas in the San Joaquin Hills.

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City of Newport Beach California

Plate H-19

NOTES:
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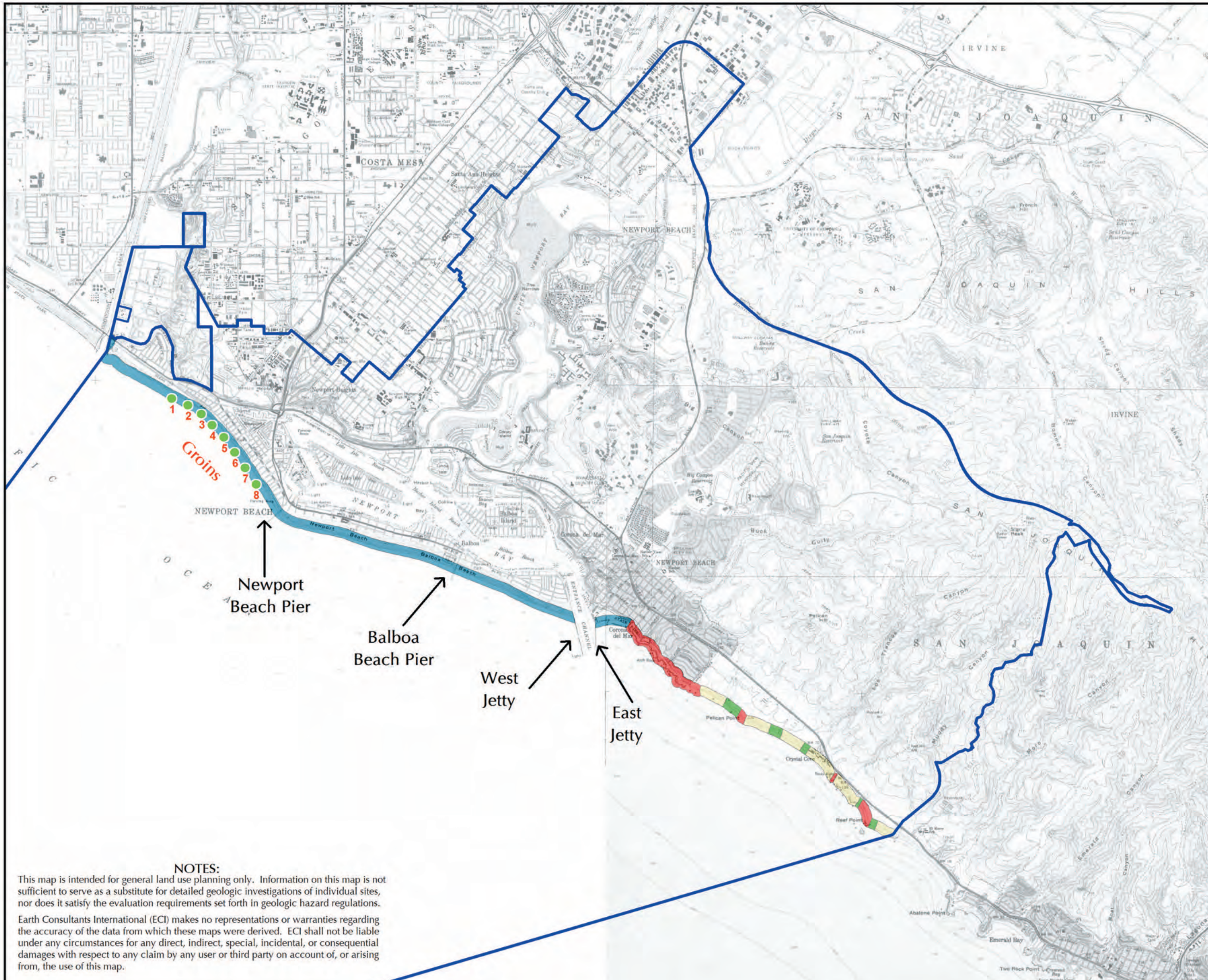

Coastal Erosion Hazard Map

Newport Beach, California

EXPLANATION

- Sandstone member of Monterey Formation; most resistant bluff-forming unit. Prone to landsliding or mass wasting where undercut by wave action, especially at points. Fails as large blocks.
- Siltstone member of Monterey formation; very fissile and fractured; tends to form an apron of talus at the base of slopes.
- Pleistocene marine terrace deposits; prone to landsliding along steep cuts (i.e. Highway 1), and to erosion by rilling and gullying along blufftops.
- Beach and eolian sand covering the gently sloping to level beaches. Continuously reworked by wave and wind action.
- Newport Beach City Boundary

Scale: 1:60,000

0.5 0 0.5 1 1.5 Miles

1 0 1 2 3 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER

Mapping by Earth Consultants International

Earth Consultants International

Project Number: 3311
Date: 2014

CITY OF NEWPORT BEACH CALIFORNIA

Plate H-20

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Helpful Websites:

General

http://www.consrv.ca.gov/cgs/
California Geological Survey

http://www.cpuc.ca.gov
California Public Utilities Commission

http://www.fire.ca.gov
California Department of Forestry & Fire Protection

http://www.oes.ca.gov
California Office of Emergency Services

http://www.fire.ca.gov
California Department of Forestry & Fire Protection

http:// www.bsc.ca.gov
Site of the California Building Standards Commission. Provides information regarding the status of the building codes being considered for future approval in California.

http://www.gps.caltech.edu
California Institute of Technology, GPS Division

http://www.oes.ca.gov
California Office of Emergency Services

http://www.seismic.ca.gov
California Seismic Safety Commission

http://www.sce.com
Southern California Edison

http://www.data.scec.org
Southern California Earthquake Center

http://www.nifc.gov
National Interagency Fire Center

http://www.census.gov
U.S. Census Bureau

http://www.eqe.com
Risk Management - ABS Consulting

http://www.fema.gov
FEMA

http://www.fema.gov/hazus
FEMA's HAZUS website

http://www.usgs.gov
U.S. Geological Survey

Geologic Hazards in General

http://geohazards.cr.usgs.gov/
USGS Hazard Team website. Hazard information on commonly recognized hazards such as earthquakes, landslides, and volcanoes. Contains maps and slide shows.

http://www.usgs.gov/themes/hazard.html
A webpage by the USGS on hazards such as hurricanes, floods, wildland fire, wildlife disease, coastal storms and tsunamis, and earthquakes. Also has information on their Hazard Reduction Program.

http://vulcan.wr.usgs.gov/Glossary/Sediment/framework.html
A webpage by the USGS on sedimentation and transport processes, with examples from the Mount St. Helens explosion.

http://www.consrv.ca.gov/cgs/index.htm
Homepage for the California Geologic Survey (formerly the Division of Mines and Geology). Information on their publications (geologic reports and maps), programs (seismic hazard mapping, Alquist-Priolo Earthquake Fault Study Zone maps); and other

brochures (asbestos, natural hazard disclosure). For California Geological Survey Notes – informational brochures covering a variety of subjects refer to http://www.consrv.ca.gov/cgs/information/publications/cgs_notes/index.htm

www.oes.ca.gov/
California Governor's Office of Emergency Services website. Contains information on response plans regarding natural disasters (earthquakes), terrorist attacks, and electrical outages, and information on past emergencies.

Geologic Maps

http://wrgis.wr.usgs.gov/wgmt/scamp/scamp.html
Homepage for the Southern California Aerial Mapping Project (SCAMP), which is the USGS' program to update geologic maps of Southern California at a 1:100,000 scale and release these in a digital GIS format.

Seismic Hazards, Faults, and Earthquakes

http://gmw.consrv.ca.gov/shmp/
Shows the current list of seismic hazard maps available from the California Geologic Survey. These can be downloaded in Adobe Acrobat (pdf) format.

www.scecdc.scec.org.
Southern California Earthquake data center (hosted by SCEC, USGS, and Caltech. Shows maps and data for recent earthquakes in Southern California and worldwide. Catalogs of historic earthquakes.

http://www.consrv.ca.gov/cgs/rghm/quakes/index.htm
List of California earthquakes (date, magnitude, latitude longitude, description of damage).

http://geohazards.cr.usgs.gov/eq/html/canvmap.html
Website at the USGS Earthquake Hazard's Program that lists seismic acceleration maps available for downloading.

www.seismic.ca.gov/
Homepage of the California Seismic Safety Commission. Contains information on California earthquake legislation, safety plans, and programs designed to reduce the hazards from earthquakes. Includes several publications of interest, including "The Homeowner's Guide to Earthquake Safety." Also contains a catalog of recent California earthquakes.

http://neic.usgs.gov/
Homepage of the National Earthquake Information Center. Maintains an extensive global seismic database on earthquake parameters. Its mission is to rapidly determine the location and size of all destructive earthquakes worldwide, and disseminate that information as quickly as possible to concerned national and international agencies, scientists, and the public in general.

http://www.scsn.org/
Site where Shakemaps for actual and scenario earthquakes can be obtained.

Flooding, Dam Inundation, and Erosion (Note: the information on some of these websites has been removed due to safety concerns; but may be posted again in the future in limited form).

http://www.usace.army.mil/public.html#Regulatory
US Army Corps of Engineers website regarding waterway regulations.

http://www.fema.gov/fima/
FEMA website about the National Flood Insurance Program.

http://www.worldclimate.com/
Precipitation rates at different rain stations in the world measured over time.

http://waterdata.usgs.gov
Stream gage measurements for rivers throughout the US.

http://www.usatoday.com/weather/whhcalif.htm
Article on historical storms that have impacted the southern California area

http://ceres.ca.gov/planning/nhd/dam_inundation.html

Coastal Flooding

http://www.prh.noaa.gov/pr/ptwc/bulletins.htm
Pacific Tsunami Warning Center National Weather Service

http://www.usc.edu/dept/tsunamis/
USC Tsunami Research Group

http://www.pmel.noaa.gov/tsunami-hazard/
The National Tsunami Hazard Mitigation Program

http://hurricanes.noaa.gov
The National Oceanic and Atmospheric Administration web page on hurricanes and other coastal processes.

Fire Hazards, Wildfires and Related Topics

http://www.ocfa.org/
Orange County Fire Authority's website.

http://osfm.fire.ca.gov/FFLaws.html
Site that pertains to California laws about fires and firefighters.

http://www.fire.ca.gov/
California Department of Forestry and Fire Protection's website.

http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp
California Fire Plan

http://www.fireplan.gov
National Fire Plan

http://nfpa.org/
National Fire Protection Association website

http://firewise.org/
Site dedicated to providing information to homeowners about becoming firewise in the urban/wildland interface.

http://www.fema.gov/
Federal Emergency Management Agency website; includes general information on how to prepare for wildfire season, current fire events, etc.

http://www.usfa.fema.gov/
U.S. Fire Administration Website.

http://www.iso.com
Insurance Services Office Website.

Landslides and Debris Flows

http://landslides.usgs.gov/index.html
USGS Landslide webpage. Links to their publications, recent landslide events, and bibliographic databases.

http://gmw.consrv.ca.gov/shmp/
California Geologic Survey website on Seismic Hazard maps.

http://vulcan.wr.usgs.gov/Glossary/Lahars/framework.html
USGS Volcanic Observatory webpage, with links regarding mudflows, debris flows and lahars.

http://www.fema.gov/hazards/landslides/landslif.shtm
Federal Emergency Management Agency (FEMA) fact sheet webpage about landslides and mudflows.

Others

http://www.oes.ca.gov/
California Office of Emergency Services

http://www.noaa.gov/
National Oceanic and Atmospheric Administration website. Provides information on weather updates, hurricanes, tornadoes, and severe weather events, drought, etc.

http://www.tornadoproject.com
The Tornado Project website. List of tornadoes spawned by hurricanes and tropical storms. Last updated in 2000, but provides a good list of historical events.

http://www.cpuc.ca.gov/puc/
California Public Utilities Commission website. State entity that regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation.

RESOLUTION NO. 2016-59

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF NEWPORT BEACH, CALIFORNIA, APPROVING THE UPDATED CITY OF NEWPORT BEACH'S LOCAL HAZARDS MITIGATION PLAN (LHMP)

WHEREAS, the City of Newport Beach is subject to various natural hazards such as earthquakes, wildfires, tsunamis, floods, strong winds, and landslides; and

WHEREAS, the City of Newport Beach seeks to maintain and enhance the City by reducing the potential loss of life, property damage, and environmental impacts from natural disasters, while accelerating economic recovery from those disasters; and

WHEREAS, the Federal Disaster Mitigation Act of 2000 requires all cities, counties, and special districts to update a Local Hazards Mitigation Plan every five years in order to be eligible for and to receive disaster mitigation funding from the Federal Emergency Management Agency (FEMA); and

WHEREAS, the City of Newport Beach has updated the Local Hazards Mitigation Plan in order to promote sound public policy designed to protect citizens, critical infrastructure, private property, and the environment from natural hazards. The Local Hazards Mitigation Plan has been updated to meet current federal law requirements, and to serve as a reference document and basis for hazard mitigation projects and grant applications for citywide hazard mitigation programs.

NOW, THEREFORE, BE IT RESOLVED that the City Council of the City of Newport Beach adopts the updated Local Hazards Mitigation Plan which has been approved by the Federal Emergency Management Agency (FEMA).

ADOPTED this 10th day of May, 2016.

Diane B. Dixon
Mayor

ATTEST:

Leilani I. Brown
City Clerk

CITY OF NEWPORT BEACH
CALIFORNIA

STATE OF CALIFORNIA }
COUNTY OF ORANGE } ss.
CITY OF NEWPORT BEACH }

I, Leilani I. Brown, City Clerk of the City of Newport Beach, California, do hereby certify that the whole number of members of the City Council is seven; that the foregoing resolution, being Resolution No. 2016-59 was duly and regularly introduced before and adopted by the City Council of said City at a regular meeting of said Council, duly and regularly held on the 10th day of May, 2016, and that the same was so passed and adopted by the following vote, to wit:

AYES: Council Member Peotter, Council Member Duffield, Council Member Selich, Council Member Curry, Council Member Petros, Mayor Pro Tem Muldoon, Mayor Dixon
NAYS: None

IN WITNESS WHEREOF, I have hereunto subscribed my name and affixed the official seal of said City this 11th day of May, 2016.

Leilani I. Brown, MMC
City Clerk
Newport Beach, California

(Seal)

CITY OF NEWPORT BEACH CALIFORNIA