City of Los Angeles

2017 Local Hazard Mitigation Plan

Eric Garcetti, *Mayor*

Aram Sahakian, *General Manager*
Emergency Management Department

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TETRA TECH

City of Los Angeles 2017 Local Hazard Mitigation Plan

August 2017

PREPARED FOR

City of Los Angeles Emergency Management Department
200 N. Spring Street
Room 1533
Los Angeles, California 90012

PREPARED BY

Tetra Tech
1999 Harrison Street
Suite 500
Oakland, CA 94612
Phone: 510.302.6300
Fax: 510.433.0830
tetratech.com

Tetra Tech Project # 103S4869

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ACKNOWLEDGMENTS

City of Los Angeles

- Carol Parks, Special Projects Officer, Emergency Management Department
- Faye Cousin, Emergency Management Coordinator I/Special Projects
- Amrita Spencer, Administrative Intern I.
- Erricka Peden, Secretary

Consultants

- Rob Flaner, CFM, Tetra Tech, Inc., Project Manager
- Denise Davis, Tetra Tech, Inc., Planner
- Jessica Cerutti, CFM, Tetra Tech, Inc., Project Planner
- Carol Bauman, GISP, Tetra Tech, Inc., Risk Assessment Lead
- Stephen Veith, MUP, Tetra Tech, Inc., GIS/Hazus Analyst
- Kari Valentine, CFM, Tetra Tech, Inc., Planner
- Dan Portman, Tetra Tech, Inc., Technical Editor

Stakeholders

- Hassan Baroon, Geosciences and Environment, California State University, Los Angeles
- Eric Boldt, National Oceanic and Atmospheric Administration National Weather Service
- Roy Forbes, Neighborhood Council District 4
- Ken Hudnut, United States Geological Survey
- Steve LaDochy, Geosciences and Environment, California State University, Los Angeles
- Alyssa Newton-Mann, USC Sea Grant
- Nick Sadrpour, USC Sea Grant
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- Dr. Lin Wu, Department of Geography and Anthropology, California State Polytechnic University, Pomona

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EXECUTIVE SUMMARY

HAZARD MITIGATION OVERVIEW

Hazard mitigation is the use of long-term and short-term policies, programs, projects, and other activities to alleviate the death, injury, and property damage that can result from a disaster. The City of Los Angeles has developed a hazard mitigation plan to reduce risks from disasters to the people, property, economy and environment within the city. The plan complies with federal and state hazard mitigation planning requirements to establish eligibility for funding under Federal Emergency Management Agency (FEMA) grant programs.

UPDATING THE CITY OF LOS ANGELES PLAN

The *City of Los Angeles 2017 Local Hazard Mitigation Plan* is the second comprehensive update to the City's hazard mitigation plan, meeting federal requirements for regular review and update of hazard mitigation plans. The City of Los Angeles prepared its initial local hazard mitigation plan in 2004, and FEMA approved that plan in 2005. A revision was developed in 2010 and approved in July 2011. The 2017 update includes a number of significant changes and enhancements:

- A reorganization and repackaging of the plan to be more user-friendly and conducive to updates
- An enhanced risk assessment
- A new risk ranking methodology
- Updated mission, goals and objectives
- Updated and enhanced public outreach
- A revised mitigation action plan prioritization protocol
- An enhanced definition of critical facilities and infrastructure.

This planning effort was supplemented by a FEMA Hazard Mitigation Assistance grant that covered 75 percent of the cost for development of this plan, with the balance achieved through in-kind contributions. The City of Los Angeles Emergency Management Department managed the project.

PLAN DEVELOPMENT APPROACH

A core planning team was assembled to facilitate the update of this plan, consisting of City of Los Angeles Emergency Management Department staff and a contract consultant. A 27-member steering committee was assembled to oversee the plan update, consisting of both governmental and non-governmental stakeholders within the planning area, which was defined as the incorporated area of the City of Los Angeles. Coordination with other local, state, and federal agencies involved in hazard mitigation occurred throughout the plan update process. The planning team and Steering Committee reviewed the existing hazard mitigation plan, the California statewide hazard mitigation plan, and existing programs that may support hazard mitigation actions.

The planning team implemented a multi-media public involvement strategy that was approved by the Steering Committee. The strategy included participation at popular community events to make the public aware of the

hazard mitigation plan update. Public outreach efforts included a hazard mitigation survey, a project website, the use of social media (Facebook, Twitter and Nextdoor) and multiple press releases.

Based on the review of existing plans and programs, the input received through the public involvement strategy, the direction of the Steering Committee, and the findings of a new, detailed risk assessment performed for this update, the planning team assembled a document that meets federal hazard mitigation planning requirements. Once pre-adoption approval of the document has been granted by the California Office of Emergency Services and FEMA Region IX, the final adoption phase will begin. The City of Los Angeles City Council will adopt the updated plan.

RISK ASSESSMENT

Risk assessment is the process of measuring the potential loss of life resulting from hazards, as well as personal injury, economic injury and property damage, in order to determine the vulnerability of people, buildings, and infrastructure to hazard events. For this update, risk assessment models for natural hazards were enhanced with new data and technologies that have become available since 2010. The Steering Committee used the risk assessment to rank risk from natural hazards and to gauge the potential impacts of each natural hazard of concern in the planning area. Human-caused hazards were also included in the risk assessment; however, risk was not ranked for these hazards. Each hazard of concern assessed includes discussion of the following:

- Hazard identification and profile
- Assessment of the impact of hazards on physical, social, and economic assets
- Identification of particular areas of vulnerability
- Estimates of the cost of potential damage, where applicable.

Based on the risk assessment, natural hazards were ranked for the risk they pose to the overall planning area, as shown in Table ES-1.

Table ES-1. Natural Hazard Risk Ranking

Hazard Ranking	Hazard Event	Category
1	Earthquake	High
2	Adverse Weather	High
3	Landslide/Debris Flow	High
4	Wildland/Urban Interface Fire	High
5	Drought	Medium
6	Flood	Medium
7	Dam Failure	Medium
8	Sea Level Rise	Low
9	Tsunami	Low

MISSION STATEMENT, GOALS, AND OBJECTIVES

The Steering Committee collaborated to revise the 2011 mission statement, goals, and objectives for this update. The committee developed new goals and objectives in which the objectives stand alone rather than being subsets of the goals. The Steering Committee added a purpose to the mission statement from the previous plan, resulting in the following new mission statement for this update:

> "To reduce risk and increase resilience, the mission of the City of Los Angeles Local Hazard Mitigation Plan is to establish and promote a comprehensive mitigation policy and program to protect City residents, their property, public facilities, infrastructure and the environment from natural and manmade hazards."

Of five goals in the 2011 hazard mitigation plan, two were unchanged for this update and three were modified; one new goal was added, resulting in the following set of goals:

1. Protect life, property, and cultural resources.
2. Increase public awareness.
3. Coordinate with other programs that can support or enhance hazard mitigation.
4. Increase emergency services effectiveness.
5. Pursue cost-effective and environmentally sound mitigation measures.
6. Strive to increase adaptive capacity to reduce risk from hazard impacts based on future conditions.

Individual Steering Committee members identified 50 plan objectives, of which the following 16 were selected by 50 percent or more of the participants:

1. Reduce repetitive property losses due to flood, fire and earthquake by updating land use, design, and construction policies.
2. Identify natural and manmade hazards that threaten life and property in the City.
3. Use hazard data while reviewing proposed development opportunities.
4. Encourage the incorporation of mitigation measures into repairs, major alterations, new development, and redevelopment practices, especially in areas subject to substantial hazard risk.
5. Encourage and support leadership within the private sector, non-profit agencies and community-based organizations to promote and implement local hazard mitigation activities.
6. Incorporate risk reduction considerations in new and updated infrastructure and development plans to reduce the impacts of hazards.
7. Continue providing City emergency services with training and equipment to address all identified hazards.
8. Develop and provide updated information about threats, hazards, vulnerabilities, and mitigation strategies to state, regional, and local agencies, as well as private sector groups.
9. Establish and maintain partnerships among all levels of government, private sector, community groups, and institutions of higher learning that improve and implement methods to protect life and property.
10. Create financial and regulatory incentives to motivate stakeholders such as homeowners, private sector businesses, and nonprofit community organizations to mitigate hazards and risk.
11. Continue developing and strengthening inter-jurisdictional coordination and cooperation in the area of emergency services.
12. Support the protection of vital records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery.
13. Coordinate state and local efforts to reduce greenhouse gas emissions and implement climate adaptation strategies through hazard mitigation plans and actions.
14. Implement mitigation programs and projects that protect not only life and property, but the environment as well.
15. Promote and implement hazard mitigation plans and projects that are consistent with state, regional and local climate action and adaptation goals, policies, and programs.
16. Advance community resilience through preparation, adoption, and implementation of state, regional and local multi-hazard mitigation plans and projects.

MITIGATION ACTION PLAN

Mitigation actions presented in this update are designed to reduce or eliminate losses resulting from hazard events. The update process resulted in the identification of 113 mitigation actions to be led by 16 departments. The majority of these actions are within the current capabilities of the City of Los Angeles, resulting in high implementation priority over the next five years.

IMPLEMENTATION AND MAINTENANCE

Plan implementation will occur over the next five years as City departments begin to implement the actions identified in this plan. Full implementation of the recommendations of this plan will require time and resources. The measure of the plan's success will be its ability to adapt to changing conditions. The City of Los Angeles assumes responsibility for adopting the recommendations of this plan and committing resources toward implementation. The framework established by this plan prioritizes actions whose benefits exceed their cost. The planning team and Steering Committee developed this plan with extensive public input, and public support of the actions identified in this plan will help ensure the plan's success.

The Steering Committee developed a plan maintenance strategy that includes annual progress reporting, a strategy for continued public involvement, a commitment to plan integration with other relevant plans and programs, and continued oversight from a plan maintenance steering committee.

PART 1—PLANNING PROCESS AND COMMUNITY PROFILE

1. INTRODUCTION TO HAZARD MITIGATION PLANNING

1.1 WHY PREPARE THIS PLAN?

1.1.1 The Big Picture

Hazard mitigation is defined as any action taken to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster. It involves long- and short-term actions implemented before, during and after disasters. Hazard mitigation activities include planning efforts, policy changes, programs, studies, improvement projects, and other steps to reduce the impacts of hazards.

For many years, federal disaster funding focused on relief and recovery after disasters occurred, with limited funding for hazard mitigation planning in advance. The Disaster Mitigation Act (DMA; Public Law 106-390), passed in 2000, shifted the federal emphasis toward planning for disasters before they occur. The DMA requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. Regulations developed to fulfill the DMA's requirements are included in Title 44 of the Code of Federal Regulations (44 CFR).

The responsibility for hazard mitigation lies with many, including private property owners, commercial interests, and local, state and federal governments. The DMA encourages cooperation among state and local authorities in pre-disaster planning. The enhanced planning network called for by the DMA helps local government articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk-reduction projects.

The DMA also promotes sustainability in hazard mitigation. To be sustainable, hazard mitigation needs to incorporate sound management of natural resources and address hazards and mitigation in the largest possible social and economic context.

1.1.2 Purposes for Planning

The City of Los Angeles prepared a hazard mitigation plan in compliance with the DMA that was adopted and approved in July 2011 (City of Los Angeles, 2011). This update to the 2011 plan fulfills a DMA requirement that hazard mitigation plans be regularly updated. It identifies resources, information, and strategies for reducing risk from natural hazards. Elements and strategies in the plan were selected because they meet a program requirement and because they best meet the needs of the City of Los Angeles and its residents. The plan will help guide and coordinate mitigation activities throughout the planning area. It was developed to meet the following objectives:

- Meet or exceed program requirements specified under the DMA.
- Enable the City of Los Angeles to continue using federal grant funding to reduce hazard risk through mitigation.
- Meet the needs of the City of Los Angeles as well as state and federal requirements.
- Create a risk assessment that focuses on City of Los Angeles hazards of concern.
- Meet the planning requirements of the Federal Emergency Management Agency's (FEMA's) Community Rating System (CRS), allowing the City of Los Angeles to maintain or enhance its CRS classification.

- Coordinate existing plans and programs so that high-priority projects to mitigate possible disaster impacts are funded and implemented.

1.2 WHO WILL BENEFIT FROM THIS PLAN?

All residents and businesses of the City of Los Angeles are the ultimate beneficiaries of this hazard mitigation plan. The plan reduces risk for those who live in, work in, and visit the City of Los Angeles. It provides a viable planning framework for all foreseeable natural hazards. Participation in development of the plan by key stakeholders helped ensure that outcomes will be mutually beneficial. The plan's goals and recommendations can lay groundwork for the development and implementation of local mitigation activities and partnerships.

1.3 CONTENTS OF THIS PLAN

This hazard mitigation plan is organized into three primary parts:

- Part 1—Planning Process and Community Profile
- Part 2—Risk Assessment
- Part 3—Mitigation Strategy.

Each part includes elements required under federal guidelines. DMA compliance requirements are cited at the beginning of subsections as appropriate to illustrate compliance.

The following appendices provided at the end of the plan include information or explanations to support the main content of the plan:

- Appendix A—Public outreach information used in preparation of this update
- Appendix B—Descriptions of the sources and methods used to generate hazard maps for this plan
- Appendix C—Review of mitigation actions recommended in the City's previous hazard mitigation plan
- Appendix D— Template for progress reports to be completed as this plan is implemented

2. PLAN UPDATE—WHAT HAS CHANGED

2.1 THE PREVIOUS PLAN

The City of Los Angeles prepared its initial local hazard mitigation plan in compliance with the DMA in 2004, and FEMA approved that plan in 2005. A revision was developed in 2010 and approved in July 2011. The City's defined purpose for the local hazard mitigation plan was to integrate hazard mitigation strategies into the day-to-day activities and programs of the City of Los Angeles. The following goals were established:

- Protect life and property.
- Increase public awareness.
- Strengthen partnerships.
- Increase emergency service effectiveness.
- Ensure environmental and historical preservation.

Review and revision of the hazard mitigation plan included re-prioritizing the risk ratings for hazards in the City of Los Angeles according to new information. Data from annual surveys and recent scientific studies was used to rank each identified hazard in eight categories: magnitude, duration, distribution, area affected, frequency, probability, vulnerability and community profile. The results of this revised rating for the 2011 update are summarized in Table 2-1.

Table 2-1. Risk Ratings for All Hazards and Vulnerabilities

Hazard	Risk Score
High Risk Rating	
Earthquake	22
Terrorism	20
Brush Fire	18
Flood	18
Public Health Issues	18
Hazardous Materials Incident	17
Civil Unrest	16
Transportation	16
Moderate Risk Rating	
Drought	14
Special Events	14
Severe Weather	13
Dam Failure	13
Critical Infrastructure	13
Low Risk Rating	
Tsunami	12
Landslide	11
High-Rise Fire	9
Radiological Incident/Accident	9

The 2011 plan recommended actions for mitigating the risks these hazards present. City departments and agencies were given specific responsibilities for implementing specific mitigation actions, using a mitigation strategy project worksheet created during the 2010 update process.

2.2 WHY UPDATE?

2.2.1 Federal Eligibility

Title 44 of the Code of Federal Regulations (44 CFR) stipulates that hazard mitigation plans must present a schedule for being monitored, evaluated and updated. This provides an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. A jurisdiction covered by a plan that has expired is not able to pursue federal funding for which a current hazard mitigation plan is a prerequisite.

2.2.2 Changes in Development

Hazard mitigation plan updates must reflect development changes in the planning area since approval of the previous plan (44 CFR Section 201.6(d)(3)). The update must describe development changes in hazard-prone areas that increased or decreased vulnerability. If no development changes impacted the jurisdiction's overall vulnerability, plan updates may validate the information in the previously approved plan. This requirement ensures that the mitigation strategy continues to address the risk and vulnerability of existing and potential development and takes into consideration possible future conditions that could impact vulnerability.

The City of Los Angeles planning area experienced a 6.28-percent increase in population between 2010 and 2016, an average annual growth rate of 0.90 percent per year. The City has adopted a general plan that governs land-use decisions and policy-making, as well as a building code and specialty ordinances based on state and federal mandates. This hazard mitigation plan update assumes that some new development triggered by the increase in population occurred in hazard areas. All such new development would have been regulated pursuant to local programs and codes. Therefore, it is assumed that hazard vulnerability did not measurably increase even if exposure did. Any new development would have accounted for potential hazard impacts under codes and standards such as the International Building Code and flood damage prevention requirements of the National Flood Insurance Program (NFIP).

2.3 THE UPDATED PLAN—WHAT IS DIFFERENT?

The updated 2017 plan differs from the initial plan in a variety of ways:

- It is reorganized into three parts:
  - Planning process and community profile
  - Risk assessment
  - Hazard mitigation strategy.
- The risk assessment has been enhanced.
- The following new hazards were added to the risk assessment:
  - Critical infrastructure
  - High-rise/high-occupancy building fire
  - Special events
  - Cyber-attack
  - Space weather

- Hazardous material, transportation and radiological incidents
- Public health hazards
- Terrorism and weapons of mass destruction
- Civil unrest.

- The impacts of climate change on the natural hazards of concern were profiled
- A new risk ranking methodology was used.
- The plan mission statement, goals and objectives were refined.
- An enhanced public outreach effort was conducted.
- A revised mitigation action plan prioritization protocol was used.
- The definition of critical facilities and infrastructure was enhanced.

Table 2-2 indicates the major changes between the two plans as they relate to 44 CFR planning requirements.

Table 2-2. Plan Changes Crosswalk

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(b): In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: (1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval; (2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and (3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.	The 2011 plan update was facilitated through a Local Hazard Mitigation Plan advisory task force made up of representatives from City departments, outside government agencies, special districts within the City limits, educational institutions, private and non-profit business organizations, and community-based organizations. Seventeen neighboring jurisdictions, educational institutions, government agencies, social service and business groups were invited to participate in the initial planning process. All but three invited organizations played active roles in the plan development. Involvement included: • Membership on and participation in Task Force meetings • Provision of technical information • Expert advice and consultation • Assistance in outreach activities • Review of plan components during development. The 2011 plan includes no reference to a formal public engagement strategy for public access to the plan update process.	The plan development process for this update followed the Community Rating System (CRS) 10-step planning process, which features the facilitation of a planning process through an organized steering committee. The process included a robust commitment to public engagement through all phases using multiple media. Chapter 3 of this plan describes the planning process.
§201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	The 2011 plan includes a risk assessment of 17 natural and non-natural hazards of concern. These are primarily qualitative risk assessments, except for quantitative modeling for the earthquake hazard using Hazus.	Significant enhancements were made to the risk assessment for the 2017 update. Over 20 hazards of concern were grouped into 14 categories covering both that natural and non-natural hazard spectrum. The risk assessment includes multiple-scenario modeling for dam failure, earthquake, flood and sea-level rise. Hazard profiles are standardized for each hazard of concern, so that there is uniformity in the discussion of each hazard and the information provided can support ranking of risk for each jurisdiction.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(2)(i): [The risk assessment shall include a] description of the ... location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	The 2011 plan includes qualitative discussion of each hazard of concern that meets the requirement as specified.	A robust profile was created for each hazard profiled that addresses the potential impacts of climate change on the natural hazards of concern. Profiles in each hazard category include information on past events, location, frequency, severity, warning time, secondary impacts, exposure, vulnerability, future trends, scenarios and issues.
§201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community	Using existing studies and documents, the 2011 plan discussed vulnerability with an emphasis on exposure and land use. There was extensive discussion of vulnerability to the earthquake hazard. The risk assessment used Hazus for the earthquake hazard only.	Vulnerability was assessed for all hazards of concern. The Hazus computer model was used for the dam failure, earthquake, flood and tsunami hazards. These were Level 2 (user defined) analyses using city and county data. Site-specific data on City-identified critical facilities were entered into the Hazus model. Hazus outputs were generated for other hazards by applying an estimated damage function to an asset inventory extracted from Hazus.
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods	The flood risk assessment section of the plan refers to the City's "Repetitive Loss Plan" that was created in 1994 as part of the City's CRS application. The plan includes no information on the number or types of repetitive losses or the causes of repetitive flooding.	The plan includes a comprehensive analysis of repetitive loss areas that includes an inventory of the number and types of structures in the repetitive loss area. Repetitive loss areas are delineated, causes of repetitive flooding are cited, and these areas are reflected on maps.
§201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area.	The 2011 plan includes facility counts for identified critical facilities and infrastructure that intersect the hazards of concern, but includes no discussion of the general building stock exposure to those hazards.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern—both general building stock and critical facilities and infrastructure. Critical facilities were defined for the planning area and were inventoried by exposure. Each hazard chapter provides a discussion of future development trends.
§201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) and a description of the methodology used to prepare the estimate.	Replacement costs were estimated for identified critical facilities and infrastructure within the hazard areas assessed. No losses were estimated for general building stock.	Loss estimates in dollars were generated for all hazards of concern. These estimates were generated by Hazus for the dam failure, earthquake, flood, and tsunami hazards as well as sea level rise. For the other hazards, loss potential was defined by a range of percentages of replacement cost for the exposed inventory. The asset inventory was generated in Hazus and was the same for all hazards.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	The 2011 plan includes no discussion of existing land use in the identified hazards areas. Additionally, the plan includes no consistent discussion of the future development trends in identified hazards areas.	There is a discussion of future development trends as they pertain to each hazard of concern. This discussion looks predominantly at the existing land use and the current regulatory environment that dictates this land use.
§201.6(c)(3): The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.	The 2011 plan identified a mission, five overarching goals, and over 400 actions that strive to meet those goals.	The 2017 update contains a mission statement, goals, objectives, and actions. The actions are city department specific and strive to meet multiple objectives. The objectives are broad, similar to the strategies identified in the 2011 plan. All objectives meet multiple goals and stand alone as components of the plan. A core capability assessment by the City looks at its regulatory, technical, financial, public outreach, National Flood Insurance Program (NFIP) program and adaptive capacity capabilities.
§201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	The 2011 plan included a mission statement and five goals, with objectives identified to meet each goal	A mission, six goals, and 16 objectives are described in Chapter 21. All are new for this update. Goals and objectives stand on their own merit. Each was selected based on its ability to support a higher level component. Each component was identified based on core capabilities of the City.
§201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	Section V of the 2011 plan identifies a prioritization methodology and hundreds of actions to be implemented by the City.	Chapter 22 includes a catalog of mitigation best management practices that was developed through a facilitated process that identified the strengths, weaknesses, obstacles and opportunities of the City for each identified hazard of concern. This catalog identifies actions that manipulate the hazard, reduce exposure to the hazard, reduce vulnerability, and increase mitigation capability. The catalog further segregates actions by scale of implementation. A table in the action plan analyzes each action by mitigation type to illustrate the range of actions selected.
§201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the National Flood Insurance Program, and continued compliance with the program's requirements, as appropriate.	Mitigation actions were identified in the 2011 plan that can be associated with the maintenance of full compliance and good standing under the NFIP.	The City of Los Angeles participates in the NFIP and has identified actions stating its commitment to maintain compliance and good standing under the program. The City reviewed its current NFIP programmatic capabilities and included the results in Chapter 4.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(3)(iii): [The mitigation strategy shall describe] how the actions identified in Section ©(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	The 2011 plan identified a prioritization strategy for the hundreds of mitigation actions identified in the plan. The strategy is identified in Section V, Part A. Each implementing agency prioritized proposed new projects based on factors including: the five goals in support of the plan's mission; the availability of funding; the relative cost-effectiveness of the project compared to alternatives; the extent to which the proposed project complements existing programs; the extent to which the project addresses risks assessed in Section IV; and the potential of economic and social damage.	A new prioritization scheme was applied for this plan update. Each recommended initiative is prioritized using a qualitative methodology that looked at the objectives the project will meet, the timeline for completion, how the project will be funded, the impact of the project, the benefits of the project and the costs of the project. This prioritization scheme is detailed in Chapter 23.
§201.6(c)(4)(i): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	Section II of the 2011 plan includes a maintenance strategy that included a schedule for annual review and update.	Chapter 23 of this plan update includes a detailed plan maintenance strategy centered on an annual progress report via an automated platform that will be maintained by the City over the 5-year performance period of the plan. This is an entirely new strategy from the 2011 plan.
§201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	Section II of the 2011 plans includes a plan maintenance strategy. This strategy did not identify a clear action for plan incorporation.	Chapter 23 details recommendations for incorporating the plan into other planning mechanisms, such as: • General plan • Emergency response plan • Capital improvement programs • Municipal code • The City's resilience plan Specific current and future plan and program integration activities are detailed in the capability assessment in Chapter 4.
§201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.	Section II of the 2011 plans includes a plan maintenance strategy. This strategy did not identify a clear action for continued public involvement.	Chapter 23 details a comprehensive strategy for continuing public involvement.
§201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commission, Tribal Council).	The 2011 plan was adopted by the Los Angeles City Council in July 2011.	Chapter 23 will include all formal adoption and FEMA plan approval documentation once adopted by the City.

3. PLAN UPDATE APPROACH

The process followed to develop the City of Los Angeles 2017 Local Hazard Mitigation Plan had the following primary objectives:

- Secure grant funding
- Form a planning team
- Define the planning area
- Establish a steering committee
- Coordinate with other agencies
- Review existing programs
- Engage the public.

These objectives are discussed in the following sections.

3.1 GRANT FUNDING

This planning effort was supplemented by a FEMA Hazard Mitigation Assistance grant in fiscal year 2014. The City of Los Angeles Emergency Management Department was designated to manage the project. It covered 75 percent of the cost for development of this plan, with the balance achieved through in-kind contributions.

3.2 FORMATION OF THE PLANNING TEAM

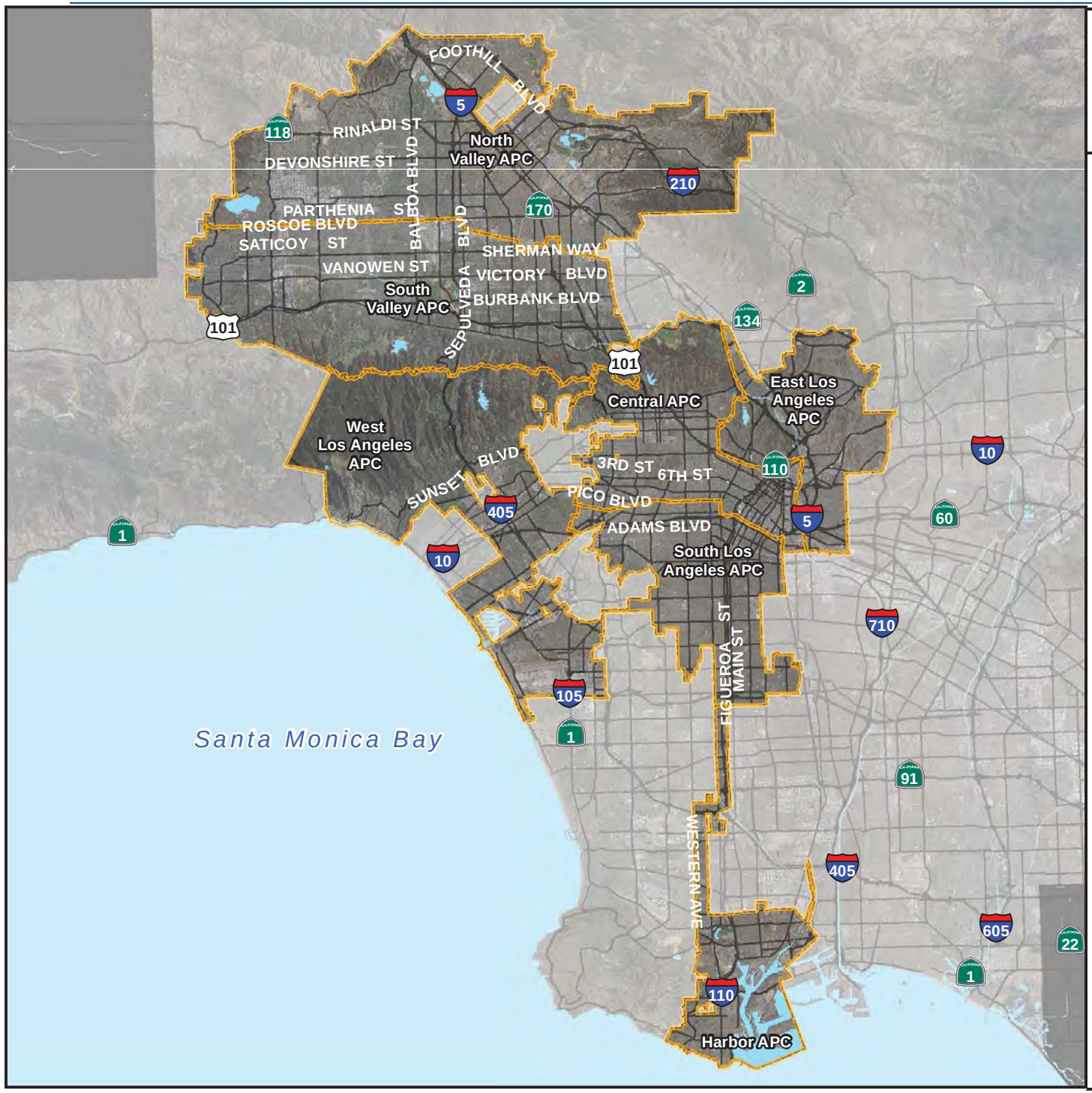
The City of Los Angeles hired Tetra Tech, Inc. to assist with development and implementation of the plan. The Tetra Tech project manager assumed the role of the lead planner, reporting directly to the City of Los Angeles project manager. A planning team was formed to lead the planning effort, made up of the following members:

- Carol Parks, City of Los Angeles Emergency Management Department
- Faye Cousin, City of Los Angeles Emergency Management Department
- Amrita Spencer, City of Los Angeles Emergency Management Department
- Rob Flaner, Tetra Tech (project manager)
- Jessica Cerutti, Tetra Tech (lead project planner)
- Denise Davis, Tetra Tech (planner/public outreach discipline lead)
- Carol Baumann, Tetra Tech (risk assessment discipline lead)

This planning team coordinated regularly during the course of this project to track plan development milestones and to identify meeting content for a working group established to help with development of the update.

3.3 DEFINING THE PLANNING AREA

The planning area consists of the incorporated limits for City of Los Angeles. Relevant planning area characteristics are described in Chapter 4. The defined planning area is shown in Figure 3-1.



City of Los Angeles

Figure 3-1

Planning Area

Area Planning Commission (APC) Boundary

Water Bodies & Channels

Major Highways & Transportation Corridors

0 3 6 12

Miles

N
W E
S

Map Data Sources: City of Los Angeles, Caltrans, USDA

3.4 THE STEERING COMMITTEE

Hazard mitigation planning enhances collaboration and support among diverse parties whose interests can be affected by hazard losses. A steering committee was formed to oversee all phases of the plan. The members of this committee included key City of Los Angeles staff, residents, and other stakeholders from within the planning area. The planning team assembled a list of candidates representing interests within the planning area that could have recommendations for the plan or be impacted by its recommendations. The team confirmed a committee of 27 members at the kickoff meeting. Seven alternate members were also named. Table 3-1 lists the Steering Committee members.

Leadership roles and ground rules were established during the Steering Committee's initial meeting on January 11, 2017. The Steering Committee agreed to meet twice in the first month of the planning process, and monthly afterward throughout the course of the plan's development. The planning team facilitated each Steering Committee meeting, which addressed a set of objectives based on the work plan established for the planning process. The Steering Committee met seven times from January through July. Meeting agendas, meeting summaries and sign-in sheets are available for review upon request. All Steering Committee meetings were open to the public, and agendas and meeting summaries were posted to the hazard mitigation plan website.

3.5 COORDINATION WITH OTHER AGENCIES

Opportunities for involvement in the planning process must be provided to neighboring communities, local and regional agencies involved in hazard mitigation, agencies with authority to regulate development, businesses, academia, and other private and nonprofit interests (44 CFR, Section 201.6(b)(2)). This task was accomplished by the planning team as follows:

- **Steering Committee Involvement**—Agency representatives were invited to join the Steering Committee.
- **Agency Notification**—The following agencies were invited to participate in the plan development process from the beginning and were kept apprised of plan development milestones:

  - California Office of Emergency Services (Cal OES)
  - California Department of Water Resources (DWR)
  - FEMA Region IX
  - National Oceanic and Atmospheric Administration (NOAA)
  - United States Geological Survey (USGS)
  - University of Southern California, Sea Grant
  - California State University, Pomona
  - California State University, Los Angeles
  - Los Angeles County Office of Emergency Management
  - Residents within Council Districts
  - Community Emergency Response Team (CERT)
  - Neighborhood Council Coalition

  These agencies received meeting announcements, meeting agendas, and meeting minutes by e-mail throughout the plan development process. Some of these agencies supported the effort by attending meetings or providing feedback on issues.

- **Pre-Adoption Review**—All the agencies listed above were provided an opportunity to review and comment on this plan during the public comment period, primarily through the hazard mitigation plan website. Each agency was sent an e-mail message informing them that draft portions of the plan were available for review. In addition, the complete draft plan was sent to Cal OES and FEMA for a pre-adoption review to ensure program compliance.

Table 3-1. Steering Committee Members

Name	Title	Department or Agency
Faye Cousin (Chair)	Emergency Management Coordinator I, Special Projects	Los Angeles Emergency Management Department
Carol Parks (Vice-Chair)	Special Projects Officer	Los Angeles Emergency Management Department
Ahee Han	Policy Director	City of Los Angeles Mayor's Office of Public Safety
Eric Boldt	Warning Coordination Meteorologist	National Oceanic and Atmospheric Administration National Weather Service
Roy Forbes	Resident	Neighborhood Council District 4
Michael Hammett	Officer in Charge of Emergency Preparedness Unit	Los Angeles Police Department
Lisa Hayes	Emergency Preparedness Coordinator	Los Angeles Department of Water and Power
Emily Helder	Public Health Emergency Planner	Los Angeles Emergency Management Department, Public Health
Ken Hudnut	Science Advisor for Risk Reduction, Natural Hazards Mission Area	United States Geological Survey
John Ignatczyk	Captain, Disaster Preparedness Officer	Los Angeles Fire Department
Chris Ipsen	Public Information Officer	City of Los Angeles
Diana Kitching	City Planner	Los Angeles Department of City Planning
Steve LaDochy	Professor, Geography & Urban Analysis	Geosciences and Environment, California State University, Los Angeles
Tim Lee	Chief Information Security Officer	Information Technology
Jonathon Lozon	Police Officer II, Emergency Preparedness Unit	Los Angeles Police Department
Leslie Luke	Deputy Director	Los Angeles County Office of Emergency Management
David Malin	Emergency Management Coordinator II	Los Angeles Harbor Department
EJ Martinez	Emergency Management Coordinator	Los Angeles, Housing and Community Investment
Jeff Napier	Chief Inspector	Los Angeles Department of Building Services
Alyssa Newton-Mann	Regional Planning and Policy Specialist	USC Sea Grant
Richard Pope	ADA Coordinator	Los Angeles Department on Disability
Nick Sadrpour	Science, Research and Policy Specialist	USC Sea Grant
Paul Shively	Valley Bureau CERT Coordinator	Community Emergency Response Team
Susan Shu	Senior Civil Engineer	Bureau of Engineering, Department of Public Works, City of Los Angeles
Clint Simmons	Resident	West Adams Neighborhood Council
Brandy Welch	Emergency Management Coordinator	Los Angeles World Airports
Lin Wu	Professor	Department of Geography, California State University, Pomona - Polytechnic
ALTERNATES		
Connie Sanchez	For Lisa Hayes	Los Angeles Department of Water and Power
Christopher Winn	For John Ignatczyk	Los Angeles Fire Department
Marissa Aho	For Ahee Han	City of Los Angeles Mayor's Office
Brandon Dean	For Emily Helder	Los Angeles Emergency Management Department, Public Health
Michelle Levy	For Diana Kitching	Los Angeles Department of City Planning
Sally Richman	For EJ Martinez	Los Angeles, Housing and Community Investment

3.6 REVIEW OF EXISTING PROGRAMS

Hazard mitigation planning must include review and incorporation, if appropriate, of existing plans, studies, reports and technical information (44 CFR, Section 201.6(b)(3)). Chapter 4 of this plan provides a review of laws and ordinances in effect within the planning area that can affect hazard mitigation actions. In addition, the following programs can affect mitigation within the planning area:

- City of Los Angeles Resilience Plan
- Regional Adapt LA: Coastal Impacts Planning for the Los Angeles Region
- Sustainable City Plan
- Resilience by Design
- California Fire Code
- 2016 California Building Code
- California State Hazard Mitigation Forum
- City Capital Improvement Programs
- City Emergency Operations Plan
- City General Plan
- The Framework Element
- Housing Element
- Safety Element
- City Zoning Ordinances
- City Coastal Program Policies.

An assessment of all City of Los Angeles regulatory, technical and financial capabilities to implement hazard mitigation actions is presented in Chapter 4.

3.7 PUBLIC INVOLVEMENT

Broad public participation in the planning process helps ensure that diverse points of view about the planning area's needs are considered and addressed. The public must have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (44 CFR, Section 201.6(b)(1)).

3.7.1 Strategy

The strategy for involving the public in this plan emphasized the following elements:

- Include members of the public on the Steering Committee (two residents served on Steering Committee throughout the planning process).
- Use a survey to determine if the public's perception of risk and support of hazard mitigation has changed since the initial planning process.
- Attempt to reach as many planning area residents as possible through the following activities:
  - Development of a public outreach plan, approved by the Steering Committee
  - Attendance at advertised public outreach events and meetings with live interaction
  - Development of a hazard mitigation plan webpage on the City Emergency Management Department website and additional City department websites
  - Use of social media, such as Nextdoor, Instagram, Facebook and Twitter
  - Development and advertisement of a public survey posted on Survey Monkey to collect pertinent information from residents and the business community.

Stakeholders and the Steering Committee

Stakeholders are the individuals, departments, agencies and jurisdictions that have a vested interest in the recommendations of the hazard mitigation plan. The effort to include stakeholders in this process included stakeholder participation on the Steering Committee. The following federal, state, regional, and local stakeholders also played a role in the planning process:

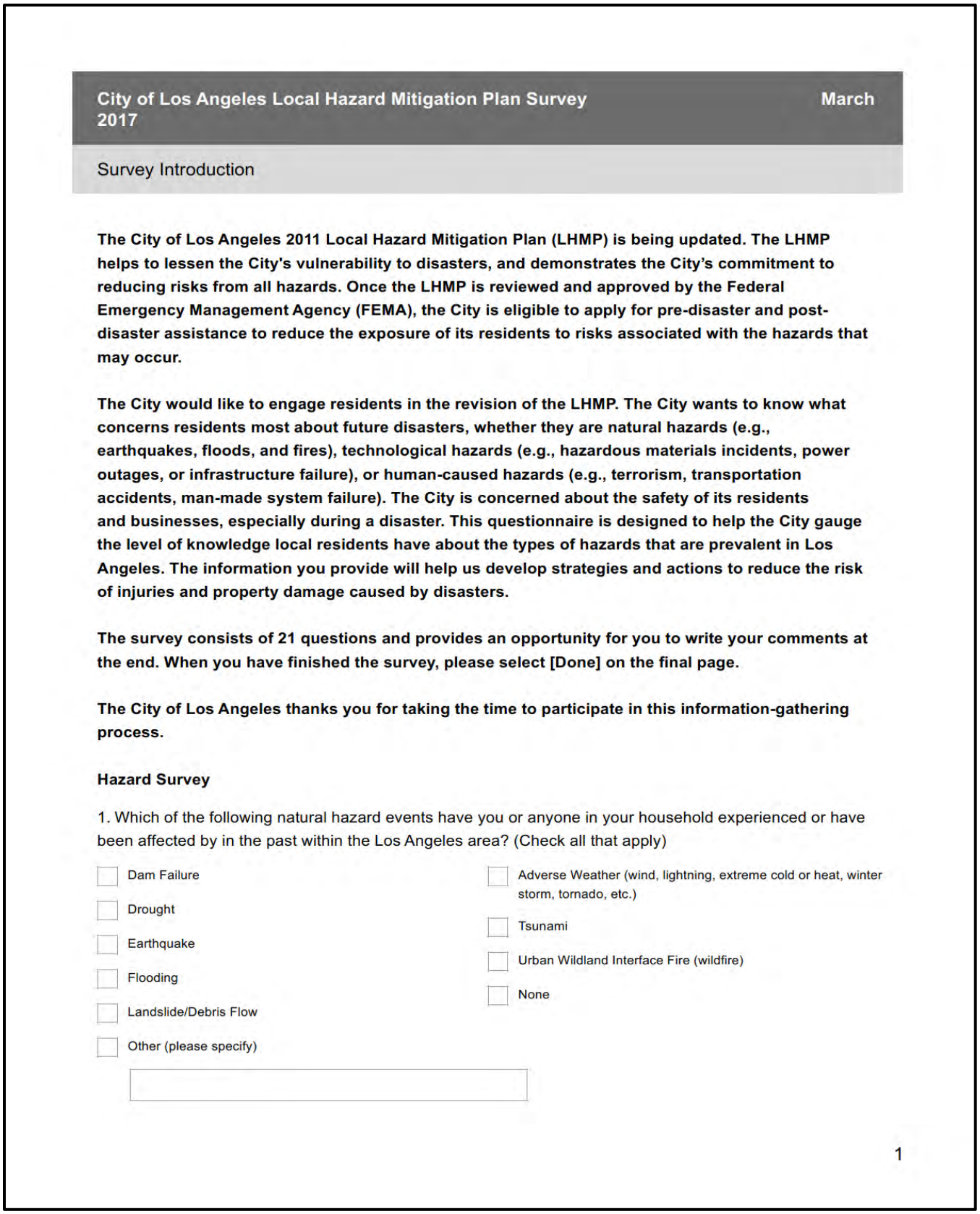
- **Federal Agencies**—FEMA Region IX provided updated planning guidance, provided summary and detailed data for the City from the National Flood Insurance Program (including repetitive loss information), and conducted a plan review. Representatives from NOAA and the USGS served as subject matter experts and advisors on the Steering Committee.
- **State Agencies**—Cal OES provided updated planning guidance and reviewed the draft and final versions of the plan update as part of their state hazard mitigation planning process required by the DMA.
- **Academia**—Representatives from the University of Southern California, California State University, Pomona, and California State University, Los Angeles provided subject matter expertise and data on sea level rise, climate change, earthquake faults and probability. They also served in advisory positions on the Steering Committee.
- **Local Stakeholders**—Jurisdictions within Los Angeles County were given the opportunity to review the draft version of the plan update and remain informed about the planning process. The following organizations received information about the planning process and invitations to provide input:
  - Los Angeles County
  - Alliance of River Communities
  - City of Los Angeles Neighborhood Councils
  - Los Angeles Fire Department Community Emergency Response Teams (CERT)
  - California Coastal Commission
  - Friends of the Los Angeles River
  - Los Angeles Area Chamber of Commerce
  - Water Committee, Sierra Club Angeles Chapter

Survey

A hazard mitigation plan survey (see Figure 3-2) was developed by the planning team with guidance from the Steering Committee. The survey was used to gauge preparedness for all hazards and the level of knowledge of tools and techniques that assist in reducing risk and loss from natural hazards. This survey was designed to help identify areas vulnerable to one or more hazards. The answers to its 21 questions helped guide the Steering Committee in determining planning goals, objectives and mitigation strategies. Surveys were distributed at public-outreach events, and a web-based version of the survey was made available on the hazard mitigation plan website. The complete survey and an analysis of its findings can be found in Appendix A.

Public Events

The planning team attended public events selected by the Steering Committee to make the public aware of the update to the hazard mitigation plan, and invite residents, business owners, and employees to take the online public survey (see Figure 3-3 through Figure 3-6). Residents who attended the events were asked to complete a survey, and each was given an opportunity to provide comments for the Steering Committee. Local media outlets were informed of the events by City press releases.



City of Los Angeles Local Hazard Mitigation Plan Survey March 2017

Survey Introduction

The City of Los Angeles 2011 Local Hazard Mitigation Plan (LHMP) is being updated. The LHMP helps to lessen the City's vulnerability to disasters, and demonstrates the City's commitment to reducing risks from all hazards. Once the LHMP is reviewed and approved by the Federal Emergency Management Agency (FEMA), the City is eligible to apply for pre-disaster and post-disaster assistance to reduce the exposure of its residents to risks associated with the hazards that may occur.

The City would like to engage residents in the revision of the LHMP. The City wants to know what concerns residents most about future disasters, whether they are natural hazards (e.g., earthquakes, floods, and fires), technological hazards (e.g., hazardous materials incidents, power outages, or infrastructure failure), or human-caused hazards (e.g., terrorism, transportation accidents, man-made system failure). The City is concerned about the safety of its residents and businesses, especially during a disaster. This questionnaire is designed to help the City gauge the level of knowledge local residents have about the types of hazards that are prevalent in Los Angeles. The information you provide will help us develop strategies and actions to reduce the risk of injuries and property damage caused by disasters.

The survey consists of 21 questions and provides an opportunity for you to write your comments at the end. When you have finished the survey, please select [Done] on the final page.

The City of Los Angeles thanks you for taking the time to participate in this information-gathering process.

Hazard Survey

1. Which of the following natural hazard events have you or anyone in your household experienced or have been affected by in the past within the Los Angeles area? (Check all that apply)

- ☐ Dam Failure
- ☐ Drought
- ☐ Earthquake
- ☐ Flooding
- ☐ Landslide/Debris Flow
- ☐ Other (please specify)
- ☐ Adverse Weather (wind, lightning, extreme cold or heat, winter storm, tornado, etc.)
- ☐ Tsunami
- ☐ Urban Wildland Interface Fire (wildfire)
- ☐ None

1

Figure 3-2. Sample Page from Survey Distributed to the Public

Figure 3-3. Abilities Expo Event

Figure 3-4. Seismic Retrofit Resource Fair

Figure 3-5. QuakeSmart Preparedness Workshop for Businesses and Organizations

Figure 3-6. QuakeSmart Preparedness Workshop for Businesses and Organizations

The first event was the Abilities Expo, held at the Los Angeles Convention Center on March 25, 2017. The Abilities Expo was a convention of exhibitors for the community of people with disabilities, their families, seniors, veterans and healthcare professionals. The planning team provided emergency and disaster information and spoke with attendees about the plan update process and the public survey.

The Seismic Retrofit Resource Fair was the second event the planning team attended. This event provided resources, information, and materials for owners of soft-story and concrete non-ductile buildings who must comply with a recent mandatory retrofit ordinance for these types of buildings. This event took place at the Los Angeles Convention Center on April 17, 2017. Approximately 10,000 residents were notified of the event via letter from the City of Los Angeles. The planning team provided information to attendees about the public survey and the plan update process. A Hazus work station was present so that property owners could view and receive information about hazards for their specific property address.

The QuakeSmart Preparedness Workshop for Businesses and Organizations was the third live event the planning team attended. This event was a conference for business owners to identify preparedness and mitigation actions needed for business continuity, disaster response, and the cost benefit of preparing for earthquakes and other business interruptions. This event took place on May 18, 2017 at the Cathedral of Our Lady of the Angels. The planning team provided information to attendees about hazards for their specific business address, and spoke with them about the public survey and plan update process. The Hazus work station allowed residents to see information on their property, including exposure and damage estimates for earthquake and flood hazard events. Participating property and business owners were provided printouts of this information for their properties. This tool was effective in illustrating risk to the public. Planning team members were present to answer questions.

On June 17, 2017 the planning team gave a presentation to the Neighborhood Council Coalition - Sierra Club Angeles Chapter at the City of Los Angeles' Emergency Operations Center. The meeting allowed attendees to examine maps and handouts and have direct conversations with project staff. Reasons for planning and information generated for the risk assessment were shared with attendees. This meeting was conducted during the advertised public comment period and was an opportunity to provide comment in person on the proposed draft plan.

Hazard Mitigation Plan Website

During the planning process, a webpage was created on the City of Los Angeles Emergency Management Department website to introduce the hazard mitigation plan update and keep the public apprised of upcoming outreach events, meeting dates and times, public survey, and plan update process (see Figure 3-7). The website address is: http://emergency.lacity.org/hazard-mitigation-plan.

Figure 3-7. Hazard Mitigation Plan Webpage on the Emergency Management Department Website

The site's address was publicized at all public meetings and in all social media releases. Information on the plan development process, the Steering Committee, the survey and drafts of the plan were made available to the public on the website throughout the process. The City of Los Angeles intends to keep a website active after the plan's completion to keep the public informed about successful mitigation projects and future plan updates.

3.7.2 Public Involvement Results

The public involvement strategy used for the plan update introduced the concept of mitigation to the public and provided the Steering Committee with feedback to use in developing the plan. All residents of the planning area had opportunities to provide comment during all phases of the plan update process. Attendance and survey distribution at the public meetings are summarized in Table 3-2.

Table 3-2. Summary of Public Meetings

Date	Location	Number of Public Contacts	Number of Survey Flyers Distributed
March 25, 2017	Abilities Expo, 1201 S Figueroa St, Los Angeles	60	40
April 17, 2017	Seismic Retrofit Fair, 1201 S Figueroa St, Los Angeles	50	30
May 18, 2017	QuakeSmart Conference, 555 West Temple, Los Angeles	35	30
June 17, 2017	Neighborhood Council Coalition, 500 E. Temple Street, Los Angeles	15	15
Total		160	115

Survey Outreach

Completed surveys were received from 2,328 respondents. Of these respondents, over 79 percent have experienced an earthquake, 57 percent have been affected by drought, and another 40 percent have been affected by adverse weather. Regarding non-natural hazards, 57 percent of the respondents have experienced civil unrest and 50 percent have experienced critical infrastructure failure. Survey results were shared with the Steering Committee. Detailed survey results are provided in Appendix A. Key results are summarized as follows:

- Survey respondents ranked earthquake as the hazard of highest concern, followed by critical infrastructure failure, terrorism, and drought.
- The majority of respondents believe that the best method to receive emergency preparedness information is from the internet, followed by social media and TV news.
- Over 60 percent of respondents who indicated that they live near an earthquake fault do not have earthquake insurance.
- Over 70 percent of respondents indicated that the presence of a hazard risk zone was not disclosed to them when they purchased their home.
- Over 75 percent of the respondents indicated that disclosure of this type of information would have influenced their decision to purchase or move into a home.
- Most respondents stated that incentives would entice them to spend money to mitigate their property. The two most popular incentives were property tax incentives and insurance premium discounts.

Survey responses included 533 “write in” comments. All of these comments were reviewed by the planning team, though many were determined not to be relevant to the plan or its content.

Public Comments on the Draft Plan

A formal, 14 day public comment period was initiated on June 15, 2017. During this comment period, the public was asked to review the proposed draft of the hazard mitigation plan and provide comments to the Planning Team by June 29, 2017. The public comment period was advertised on the hazard mitigation plan website as well as a press release to all media outlets and social media blast through outlets used by the City.

An opportunity to provide public comment in person was provided at the Neighborhood Council Coalition meeting on June 17, 2017 at the Los Angeles Emergency Operations Center on East Temple Street. During this outreach event, members of the public received a handout outlining the basic purpose of the plan and containing a link to view the plan. The handout also included a link to a form to provide comments on the draft plan. The

Planning Team received 10 comments during the public comment period. Those that were deemed relevant to the overall plan by the planning team were incorporated into the final submittal draft of the plan. Most of the comments fell outside the scope of this plan update and were noted by the planning team for consideration under other emergency management programs of the City. Copies of the comments were retained by the planning team and are available upon request.

3.8 PLAN DEVELOPMENT CHRONOLOGY/MILESTONES

Table 3-3 summarizes important milestones in the plan update process.

Table 3-3. Plan Development Chronology/Milestones

Date	Event	Description
2016		
4/13	City releases a request for proposals to update its hazard mitigation plan	Secure contractor support to facilitate update of the City's hazard mitigation plan
6/22	City Selects Tetra Tech as its technical support Contractor	Technical support secured
11/15	Planning Team call #1	Planning process
11/29	Planning team call #2	Planning process
11/30	City executes contract with Tetra Tech for technical support of hazard mitigation plan update	Notice to proceed
2017		
1/4	Planning Team call #3	Planning process
1/11	1st Steering Committee Meeting	• Project overview, work plan, timeline, important milestones. • Steering Committee's role, purpose, expectations, organization, and charter. • Discuss plan review, public outreach capabilities • Discuss current mission statement • Discuss current plan goals/objectives
1/23	Planning Team call #4	Planning process
1/26	2nd Steering Committee Meeting	• Confirm Steering Committee charter • Confirm mission statement • Confirm plan goals/objectives • Confirm hazards of concern – 21 identified • Define and confirm critical facilities • Hazard scenarios discussion
3/20	Public Outreach	• Press release announcing the planning process, website and hazard mitigation survey.
2/21	Planning Team call #5	Planning process
2/23	3rd Steering Committee Meeting	USGS presentation on fault systems and earthquake scenarios that may impact the Los Angeles area. • Risk assessment update • Objectives exercise—confirm plan objectives • Review and confirm critical facilities—have to define • Discuss capability assessment • Discuss prior action status • Hazard mitigation website development
3/22	Planning Team call #6	Planning process
3/23	4th Steering Committee Meeting	• Risk assessment lead report • Preliminary EQ results • Prior mitigation plan action status • Plan maintenance strategy • Confirm hazard mitigation public survey • Confirm public outreach plan • Determine public engagement meetings schedule
3/24	Public Outreach	Web-based hazard survey deployed
3/25	Public Outreach at Abilities Expo	The Abilities Expo, held at the Los Angeles Convention Center, was a convention of exhibitors for the community of people with disabilities, their families, seniors, veterans and healthcare professionals. Risk assessment data shared with the public as well as distribution of hazard specific information and public survey flyers.

Date	Event	Description
4/17	Public Outreach at Seismic Retrofit Resource Fair	The Seismic Retrofit Fair, held at the Los Angeles Convention Center, provided resources, information and materials for owners of soft-story and concrete non-ductile buildings who must comply with the recent mandatory retrofit ordinance for these types of buildings. Distribution of hazard specific information, public survey information, and Hazus data was provided.
4/27	5th Steering Committee Meeting	• Risk assessment update • Prior mitigation plan action status • Action planning workshop scheduled • Public survey update • Public outreach update • Strengths, weaknesses, obstacles, opportunities session
5/2	Planning Team call #7	Planning process
5/10	Planning Team call #8	Planning process
5/16	Planning Team call #9	Planning process
5/18	Public Outreach at QuakeSmart Preparedness Workshop for Businesses and Organizations	The Quakesmart workshop was for business owners to identify preparedness and mitigation actions needed for business continuity, disaster response, and the cost benefit of preparing for earthquakes and other business interruptions. Distribution of hazard specific information, public survey information, and Hazus data was provided.
5/24-25	Action Planning Workshops	Action planning workshops were held at the Los Angeles Emergency Operations Center, 500 E. Temple, Los Angeles from 1:00 to 4:00 on May 24, and from 9:00 to 12:00 on May 25.
5/25	6th Steering Committee Meeting	• Report on action planning workshops • Risk assessment completion • Mitigation best management practices • Public survey update • Public outreach event report • Confirm date for plan completion • Confirm date for public comment period
5/30	Planning Team call #10	Planning process
6/6	Planning Team call #11	Planning process
6/14	Public Outreach	Press release announcing the beginning of the final public comment period.
6/15	Public Outreach	Initiate 2 week final public comment period for review of the draft plan
6/17	Public Outreach for Plan Review and Public Comment Period	A presentation of the draft plan was provided at the City of Los Angeles Neighborhood Council Coalition at the Emergency Operations Center. The presentation was on the planning process and draft plan for public review.
6/22	7th Steering Committee Meeting	The 7th and final Steering Committee meeting for the plan update process was dedicated to presenting the final draft of the plan and allowing the Steering Committee to comment on it to the planning team.
6/29	Public Outreach	Closure of 2-week Final Public Comment period
6/30	Plan Review	Plan sent to Cal OES for review and approval pending adoption
TBD	Approval Pending Adoption	Approval pending adoption received from FEMA Region IX
TBD	Plan adopted by the Los Angeles City Council	Plan is finalized with the Council's adoption
TBD	Final Approval	FEMA granted final approval of the adopted plan.

4. CITY OF LOS ANGELES PROFILE

4.1 GEOGRAPHIC OVERVIEW

The City of Los Angeles, on the southwest coast of California, is the most populous city in the state, with a 2016 estimated population of 4,030,904 (10 percent of the total population of California). As of the 2010 U.S. Census, the City had an average population density of 8,092 people per square mile. It is the county seat of Los Angeles County. Los Angeles is an irregularly shaped city encompassing over 498 square miles of land (214 square miles of which are hills and mountains) and approximately 29 square miles of water (see Figure 3-1), the state's largest city by area.

4.2 HISTORICAL OVERVIEW

Archeological studies have indicated that people have been living in the area that now surrounds Los Angeles since 3000 B.C. By the time of the arrival of the Spanish in the 1700s, an estimated 5,000 native people lived in the Los Angeles area (McCawley, 1996).

The city that is now Los Angeles was founded in September 1781, with the name "El Pueblo de la Reina de Los Angeles" or "The Town of the Queen of the Angels." By 1800, there were 29 buildings in the community. By 1821, when Mexico became independent of Spain, Los Angeles had grown into the largest self-sustaining farming community in the province of Alta California (Layne, 1935). In 1835, the Mexican Congress declared Los Angeles a city and the capital of Alta California. The City came under the control of the United States in 1848 with the ending of the Mexican American War. Los Angeles was incorporated in the U.S. on April 4, 1850.

The City of Los Angeles mostly remained within its original 28-square-mile area until the 1890s. The first large additions were the districts of Highland Park, Garvanza, and South Los Angeles. In 1906, the approval of the Port of Los Angeles and a change in state law allowed the City to annex "the Shoestring," or Harbor Gateway, a narrow strip from Los Angeles to the port. San Pedro and Wilmington were added in 1909 and Hollywood was added in 1910. Also added in 1910 were Colegrove, Cahuenga, and a part of Los Feliz. By referendum, 170 square miles of the San Fernando Valley, along with the Palms district, were added to the City in 1915, almost tripling its area. Additional annexations brought the City's area to 450 square miles by 1932 and to 469 square miles by 2004 (City of Los Angeles, 2015).

The City's economy began steady growth with completion of the Santa Fe railroad line from Chicago to Los Angeles in 1885 and subsequent immigration from the east (Thompson, 1993). A strong economic base was developed early, in farming, oil, tourism and real estate. Hollywood made the City world famous, and World War II brought new industry, especially high-tech aircraft construction. Since the 1960s old industries have declined, including farming, oil and aircraft, but tourism, entertainment and high tech remain strong.

4.3 MAJOR PAST HAZARD EVENTS

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government. A presidential disaster declaration puts federal recovery programs into motion to help disaster victims, businesses and public entities. Some of the programs are matched by state programs. Declarations are made at the county level, and 27 events since 1969 have drawn presidential disaster declarations that applied to Los Angeles County (see Table 4-1). Los Angeles County has also experienced another 26 federal fire management events since 1978. Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale events in the future.

Table 4-1. Presidential Disaster Declarations Applying to Los Angeles County

Type of Event	FEMA Disaster #	Declaration Date
Severe Winter Storms, Flooding, and Mudslides	4305	3/16/2017
Severe Winter Storms, Flooding, and Debris And Mud Flows	1884	3/8/2010
Wildfires	1810	11/18/2008
Wildfires, Flooding, Mud Flows, and Debris Flows	1731	10/24/2007
Severe Freeze	1689	3/13/2007
Severe Storms, Flooding, Landslides, and Mud and Debris Flows	1585	4/14/2005
Severe Storms, Flooding, Debris Flows, and Mudslides	1577	2/4/2005
Wildfires, Flooding, Mud Flow and Debris Flow	1498	10/27/2003
Severe Winter Storms and Flooding	1203	2/9/1998
Severe Winter Storms, Flooding Landslides, Mud Flow	1046	3/12/1995
Severe Winter Storms, Flooding, Landslides, Mud Flows	1044	1/10/1995
Northridge Earthquake	1008	1/17/1994
Fires, Mud/Landslides, Flooding, Soil Erosion	1005	10/28/1993
Severe Winter Storm, Mud and Landslides, and Flooding	979	2/3/1993
Fire During A Period Of Civil Unrest	942	5/2/1992
Rain/Snow/Wind Storms, Flooding, Mudslides	935	2/25/1992
Severe Freeze	894	2/11/1991
Fires	872	6/30/1990
Severe Storms, High Tides and Flooding	812	2/5/1988
Earthquake and Aftershocks	799	10/7/1987
Coastal Storms, Floods, Slides and Tornadoes	677	2/9/1983
Brush and Timber Fires	635	11/27/1980
Severe Storms, Mudslides and Flooding	615	2/21/1980
Coastal Storms, Mudslides and Flooding	547	2/15/1978
San Fernando Earthquake	299	2/9/1971
Forest and Brush Fires	295	9/29/1970
Severe Storms and Flooding	253	1/26/1969

Many natural hazard events do not trigger federal disaster declarations but have significant impacts on their communities. These events are also important to consider in establishing recurrence intervals for hazards of concern.

4.4 PHYSICAL SETTING

Much of the City of Los Angeles is built within old floodplains and mountains or adjacent to the Pacific Ocean. The population is concentrated in urban centers, which are interspersed by low-density residential neighborhoods. Most of the flat lands of the City have been developed. The remaining open space tends to be concentrated in floodplains or along steep hillside and drainage water courses, which typically have been designated as public park land, recreational, flood control or low intensity uses, consistent with state law. Vulnerability to fires and flooding has increased as development has encroached into the remaining open space areas. Concentrated development and infrastructure have increased the vulnerability of greater numbers of people, businesses and facilities to seismic, fire and flood events, while at the same time providing greater resources for responding to such events.

4.4.1 Topography

The Los Angeles area consists of flat basins defined by the San Gabriel, Santa Susana and Santa Monica Mountains, three major rivers, and the Pacific Ocean (City of Los Angeles Department of City Planning, 2013). The terrain is about 75 percent alluvial plain and 25 percent rugged canyons and hills. Elevations range from 5,074 feet at Sister Elsie Peak in the San Gabriel Mountains to nearly mean sea level in the southwestern part of the City. The San Gabriel and Santa Susana Mountains bound the City on the north and the Santa Monica Mountains extend across the middle of the City. The Palos Verdes Hills and Pacific Ocean bound the City on the south and west (City of Los Angeles, 2010).

4.4.2 Soils and Geology

The 1903 soil survey of Los Angeles (Mesmer, 1903) identifies 17 soil types in the area, as summarized in Table 4-2.

Table 4-2. Identified Soil Types in the Los Angeles Area

Soil	% of Total Survey Area	Soil	% of Total Survey Area	Soil	% of Total Survey Area
Placentia sandy loam	18.1	Oxnard loam	5.4	Maricopa gravelly loam	1.6
Fresno sand	15.9	Fresno fine sand	4.4	Galveston clay	1.3
Santiago silt loam	10.8	Maricopa sandy loam	3.8	Dune sand	0.9
Fresno fine sandy loam	10.6	Los Angeles sandy loam	2.5	River wash	0.5
San Joaquin black adobe	10.3	Fullerton sandy adobe	1.9	Peat	0.3
Oxnard sand	9.8	Sierra adobe	1.9		

Source: Mesmer, 1903

California is divided into several large “geomorphic provinces” defined by similar topography and geologic structure. The northern portion of the City of Los Angeles is in the Transverse Ranges geomorphic province and the southern portion is in the Peninsular Ranges geomorphic province (California Geological Survey, 2002). The boundary between the two provinces is generally the Santa Monica-Hollywood-Raymond fault system along the south edge of the Santa Monica Mountains (Bilodeau, et al., 2007).

The Transverse Ranges geomorphic province is characterized by east-west trending mountains, valleys, and faults that extend eastward from the Channel Islands to the eastern end of the San Bernardino Mountains. Most active faults in the Transverse Ranges are east-west trending faults. Rock types in this province near the City include gneiss, granitic rocks, and sedimentary rocks (Bilodeau et al., 2007). Volcanic rocks are found in the Santa

Monica Mountains. Alluvial sediments are typically in canyon bottoms and valleys, with broad alluvial fans at the mouths of steep canyons.

The Peninsular Ranges geomorphic province extends southward from the south edge of the Transverse Ranges geomorphic province to the tip of Baja California in Mexico (Norris and Webb, 1990). The Peninsular Ranges are characterized by northwest-southeast trending hills and valleys separated by similarly trending faults. Most active faults in the Peninsular Ranges province are northwest trending. Rock types in this province in the Los Angeles region generally include schist and sedimentary rocks. Surface materials in canyon bottoms and basins generally consist of alluvium.

The City of Los Angeles is within a seismically active region that is well known for its many active faults. Due to the area's historical seismicity, it is reasonable to expect future seismic shaking along local or regional faults. The San Andreas Fault is a major tectonic boundary about 34 miles northeast of downtown Los Angeles, outside the city limits. Significant faults within the City include the Newport-Inglewood, Santa Monica, Hollywood, Puente Hills Blind Thrust, Palos Verdes Hills, Verdugo, San Fernando, Northridge, and Santa Susana faults.

Subsurface geology of the area is generally shown in Figure 4-1, which illustrates mapped rock types and seismic faults and folds. The City of Los Angeles is delineated by the blue line in the figure.

4.4.3 Climate

In the basins and valleys along the California coast, climate is subject to wide variations within short distances as a result of the influence of topography on the circulation of marine air. In general, the Los Angeles area has a mild climate characterized by warm, dry summers and cool, wet winters. Temperature and precipitation vary considerably with elevation, topography, and distance from the Pacific Ocean. A storm producing moderate rainfall on the coast (1 inch during a 24-hour period) may produce very heavy rainfall in the mountains (10 to 20 inches during the same 24-hour period). Table 4-3 summarizes key climate data at Los Angeles International Airport on the coast and in downtown Los Angeles.

Table 4-3. Average Los Angeles Climate Data

	L.A. International Airport	Downtown Los Angeles
Period of record	1944 – 2012	1906 – 2012
Average Annual Minimum Temperature	55.3ºF	55.8ºF
Average Annual Maximum Temperature	70.1ºF	74.0ºF
Average Annual Mean Temperature	62.7ºF	64.9ºF
Maximum Temperature	110ºF, September 26, 1963	113ºF, September 27, 2010
Minimum Temperature	27ºF, January 4, 1949	25ºF, February 19, 1911
Average Annual Precipitation	12.02 inches	14.77 inches
One Date Maximum Precipitation	5.60 inches, November 21, 1967	5.88 inches, March 2, 1938

Source: Western Regional Climate Center, 2017

Most precipitation occurs from December through March. Precipitation during the summer is infrequent, and rainless periods of several months are common. Precipitation usually occurs as localized cloudbursts, mostly in the mountains and deserts after summer, and light to moderate rains in winter. Six to eight heavy rain events each year result in most of the total precipitation. In general, the quantity of precipitation increases with elevation.

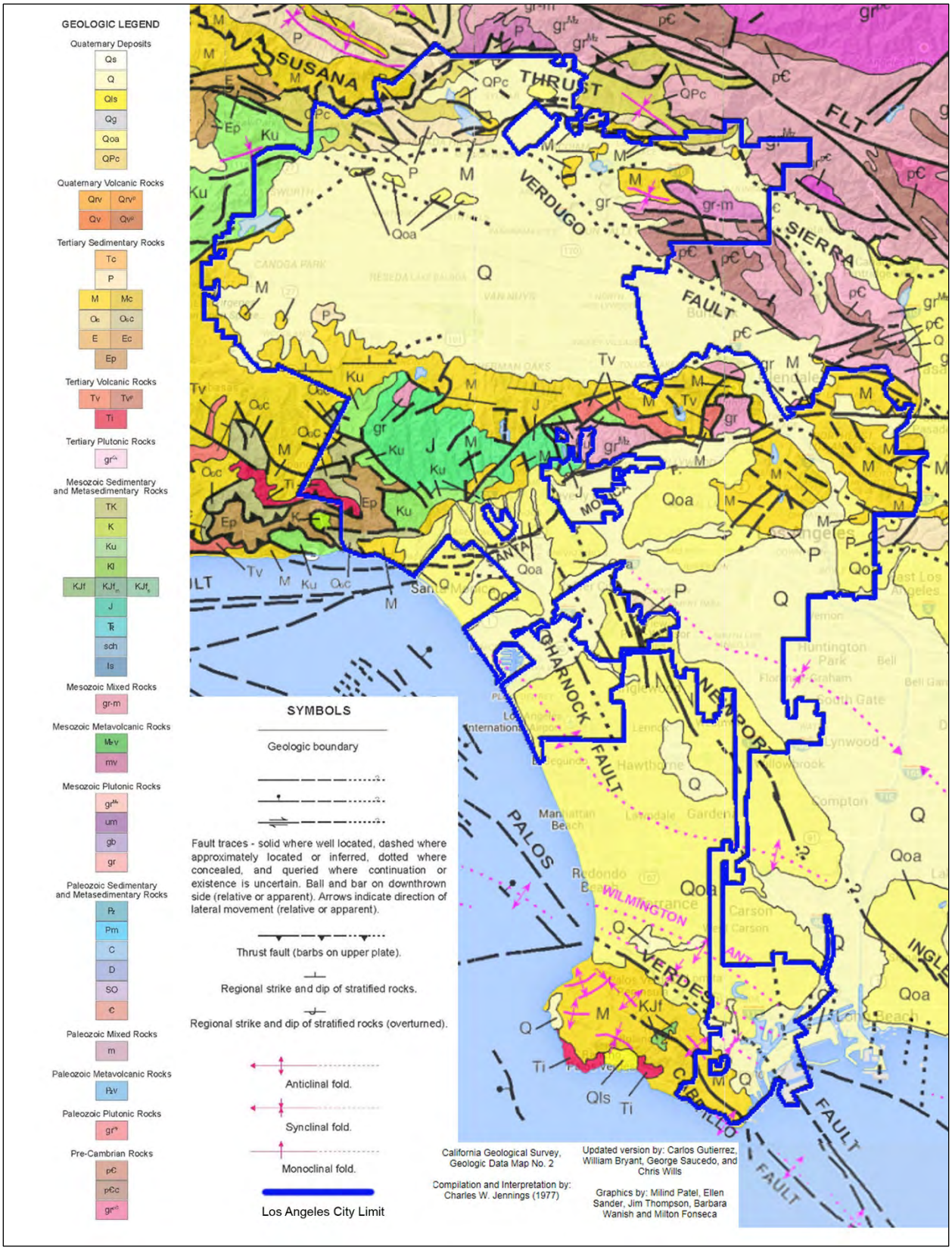


Figure 4-1. Los Angeles Geologic Features

Although the basic air flow above the area is from the west or northwest during most of the year, mountain chains deflect these winds so that, except for the immediate coast, wind direction is more a product of local terrain than of the prevailing circulation. Strong and sometimes damaging winds from the east or northeast occur when there is a strong high-pressure area to the east and an intense low-pressure area approaching the coast from the west. In southern California these winds are called "Santa Ana Winds." Their air is typically very dry, and the winds are strong and gusty, sometimes exceeding 100 mph, particularly near the mouth of canyons oriented along the direction of airflow. These conditions occasionally lead to serious fire suppression problems and often result in the temporary closing of highways to campers, trucks, and light cars. These land and sea breezes are more pronounced in summer and impact air pollution levels.

The Los Angeles area is almost completely enclosed by mountains on the north and east. In addition, a vertical temperature structure (inversion) in the air along most of coastal California tends to prevent vertical mixing of the air. The geographical configuration and coastal location of the Los Angeles area permit a fairly regular daily reversal of wind direction—offshore at night and onshore during the day (WRCC, 2014).

4.5 DEVELOPMENT PROFILE

4.5.1 Land Use

Development patterns in Los Angeles have evolved in response to factors as diverse as the area's geological features and the arrival of the automobile. Of 465 square miles of land in the City, 78 percent is developed. Residential land use covers 56 percent of the land, commercial development accounts for 8 percent, and industrial development makes up 7 percent. This high percentage of development has resulted in a large percentage of the area being covered by impervious surfaces, which alters natural drainage characteristics. Most of the developed City is on the coastal plain; development in the hills and mountainous areas is challenging due to steep slopes, landslide areas and unpredictable bedrock. Of the area of the City that is currently undeveloped (22 percent of the total), only 5 percent is considered to be subject to future urban development (City of Los Angeles Department of City Planning, 2013). Table 4-4 summarizes the breakdown of current land use in the City.

Table 4-4. General Plan Land Use within the Planning Area

	Planning Area	
Land Use	Area (acres)	% of total
Agriculture	76.5	0.03%
Commercial	19,354.2	7.65%
Government	17,842.1	7.05%
Industrial	20,816.2	8.23%
Multi-Family Residential	33,399.1	13.20%
Open Space	51,027.3	20.17%
Parking	13.1	0.01%
Single Family Residential	110,411.6	43.65%
Total	252,940.1	100.00%

A 2008 study by the U.S. Department of Agriculture estimated that 61 percent of the City's non-mountainous land cover is composed of impervious surfaces, such as paving or development, or water features. The remaining areas are estimated to consist of irrigated grass (12 percent), dry grass or bare soil (6 percent) and tree canopy cover (21 percent) (McPherson et al., 2008).

The City's General Plan and zoning code guide local development. The Land Use Element of the General Plan defines 35 Community Plan areas for guidance of the physical development of the City's neighborhoods. These community plan areas are distributed between seven Area Planning Commissions (APCs):

- Central APC
- East Los Angeles APC
- Harbor APC
- North Valley APC
- South Los Angeles APC
- South Valley APC
- West Los Angeles APC

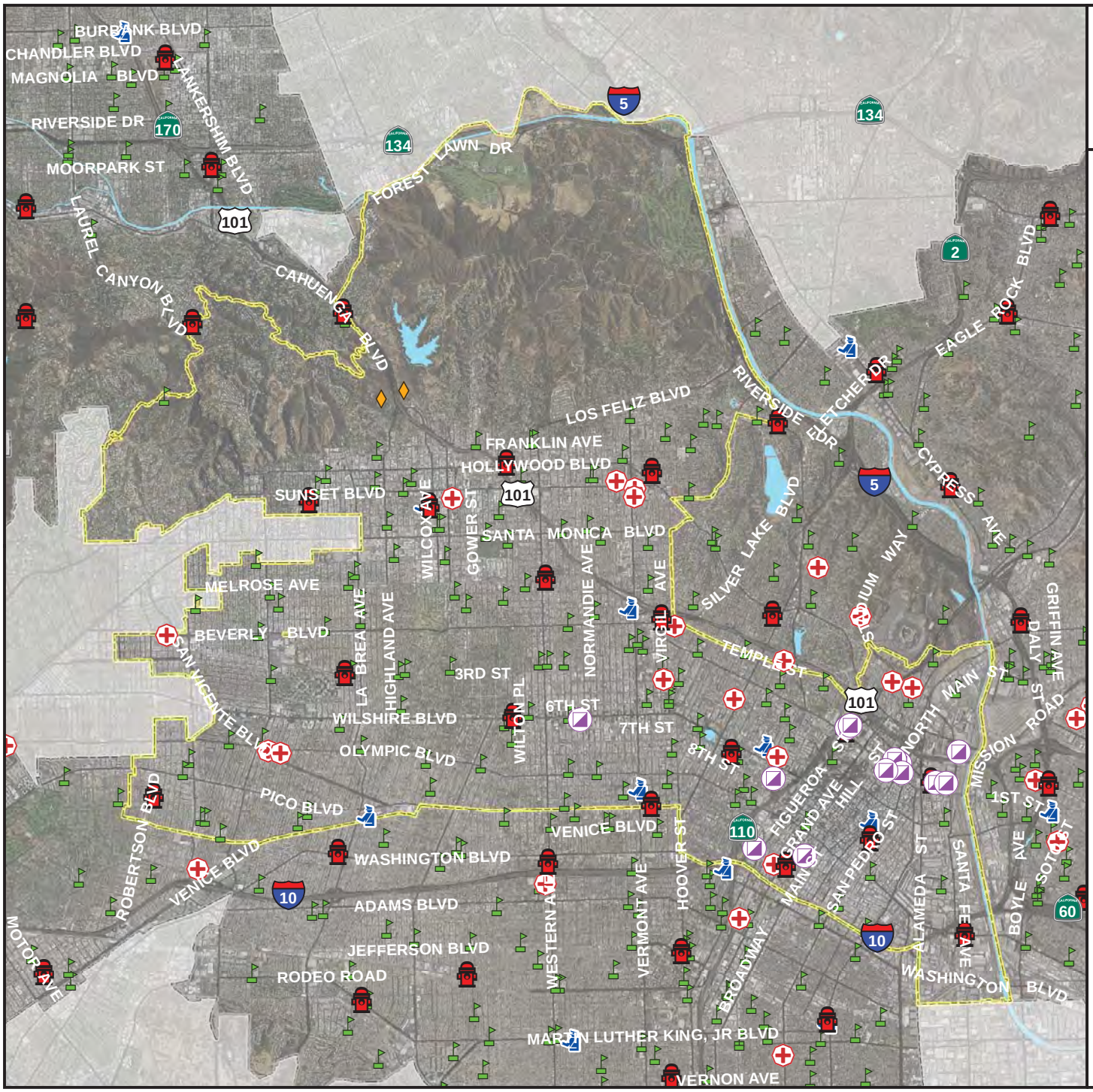
4.5.2 Critical Facilities and Infrastructure

For consistency, the Steering Committee decided to retain the critical facility categories established for the City's previous (2011) hazard mitigation plan:

- **Critical Operating Facilities**—These facilities—referred to as the City's "Big 20" infrastructure buildings—house most City personnel and are required for the day-to-day conduct of City business:
  - City Hall
  - City Hall East
  - City Hall South
  - LAPD Administration Building
  - Personnel Department Building
  - Piper Technical Center
  - San Pedro Municipal Building
  - Braude Building
  - West Los Angeles City Hall
  - Metro Communication/Dispatch
  - Van Nuys City Hall
  - Figueroa Tower#1
  - Figueroa Tower#2
  - Wilshire Towers
  - Garland Building
  - West Los Angeles Inspection Division
  - Convention Center
  - Valley 911 Building
  - Public Works Broadway Building
  - Emergency Operations Center.

- **Critical Response Facilities—**These City facilities are necessary for hazard event response. They include fire stations, police stations, hospitals, and evacuation centers, such as Los Angeles Unified School District schools, and recreation and park facilities.
- **Critical Infrastructure—**Critical public and private infrastructure has two categories:
  - Critical transportation infrastructure includes freeways, streets, bridges, railroads, airports and the harbor.
  - Critical utilities infrastructure includes potable water systems (treatment and reservoirs), wastewater systems (treatment plants, major interceptors and sewer lines), electric power systems (power plants, substations and major transmissions lines), oil refineries, natural gas systems, and communication systems.

Figure 4-2 through Figure 4-15 show the location of critical facilities and infrastructure in the planning area. Due to the sensitivity of this information, a detailed list of facilities is not provided. The list is on file with the City of Los Angeles. Table 4-5 summarizes the general types of critical facilities and infrastructure, respectively. All critical facilities and infrastructure were analyzed in the risk assessment to help rank risk and identify mitigation actions. The risk assessment for each hazard qualitatively discusses critical facilities with regard to that hazard.



Central APC

Figure 4-2.

Critical Operating and Response Facilities

APC Boundary

Los Angeles City Boundary

Critical Operating Facilities

"Big Twenty"

Critical Response Facilities

Fire Stations

Medical Facilities

Police Stations

School & Educational Facilities

Debris Management & Evacuation Areas

0 0.75 1.5 3

Miles

N
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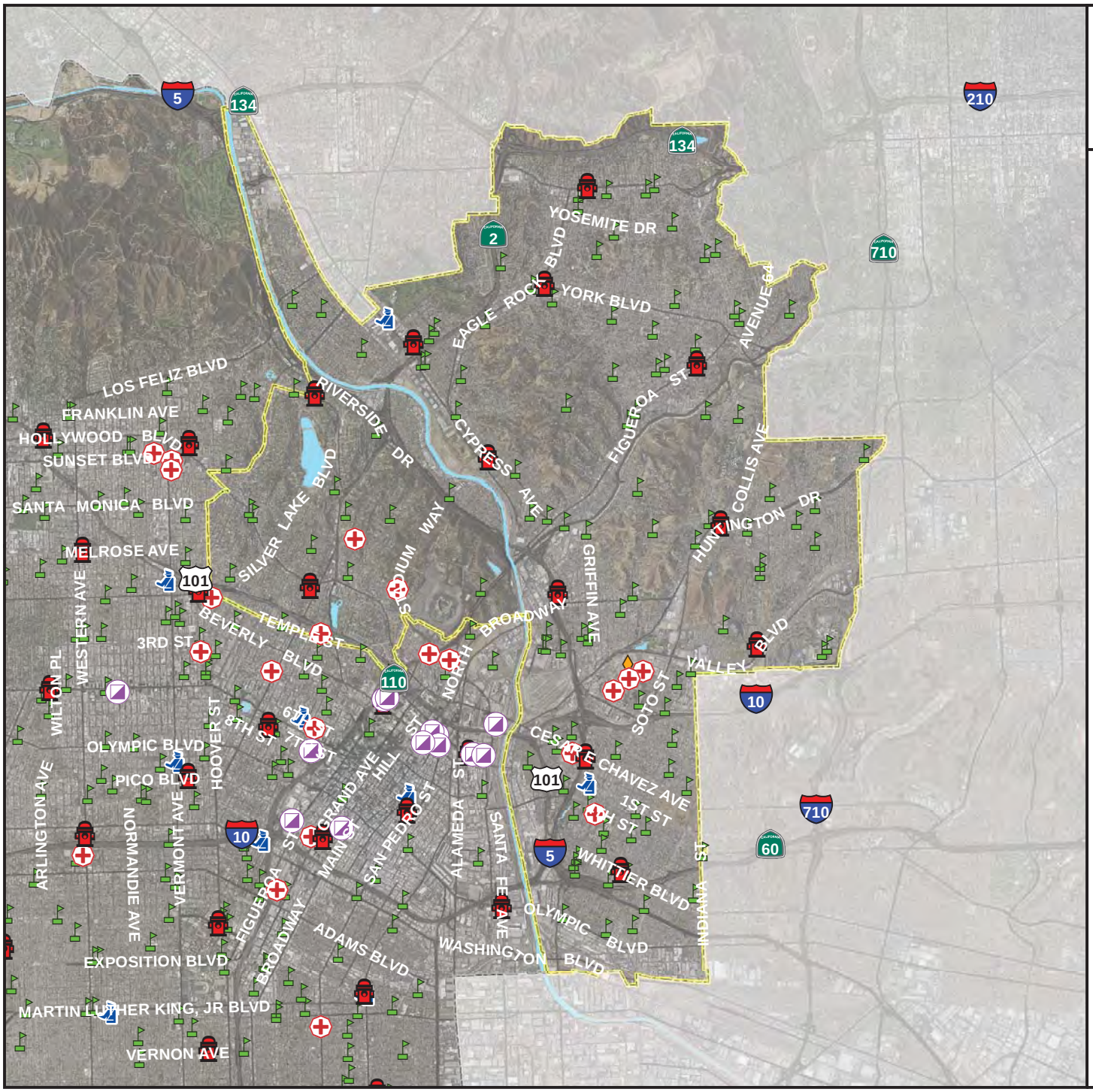
S

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



East Los Angeles APC

Figure 4-3.

Critical Operating and Response Facilities

APC Boundary

Los Angeles City Boundary

Critical Operating Facilities

"Big Twenty"

Critical Response Facilities

Fire Stations

Medical Facilities

Police Stations

School & Educational Facilities

Debris Management & Evacuation Areas

0 0.75 1.5 3

Miles

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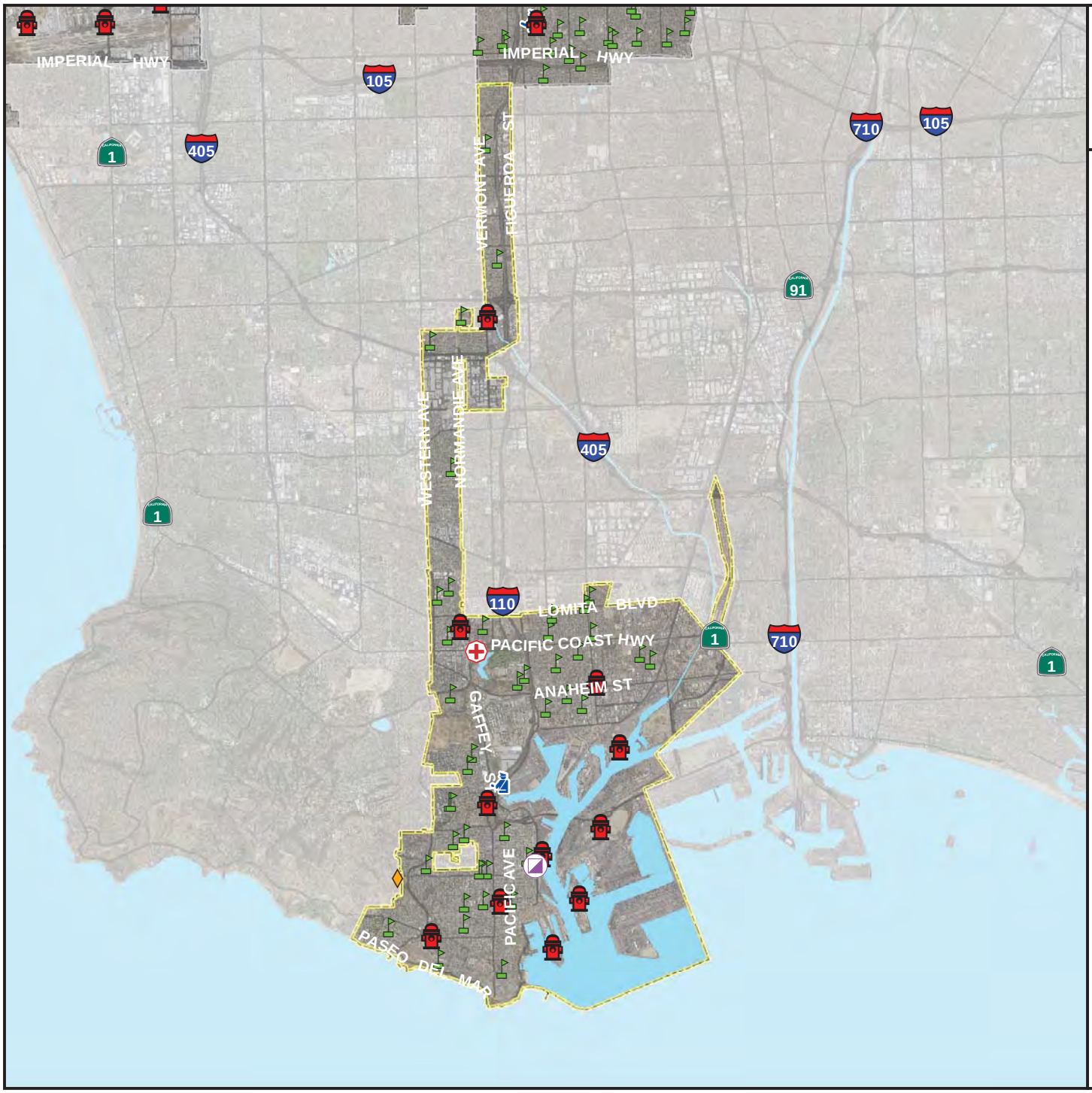
Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



Harbor APC

Figure 4-4.
Critical Operating and Response Facilities

- APC Boundary
- Los Angeles City Boundary

Critical Operating Facilities

- "Big Twenty"

Critical Response Facilities

- Fire Stations
- Medical Facilities
- Police Stations
- School & Educational Facilities
- Debris Management & Evacuation Areas

0 1.25 2.5 5

Miles

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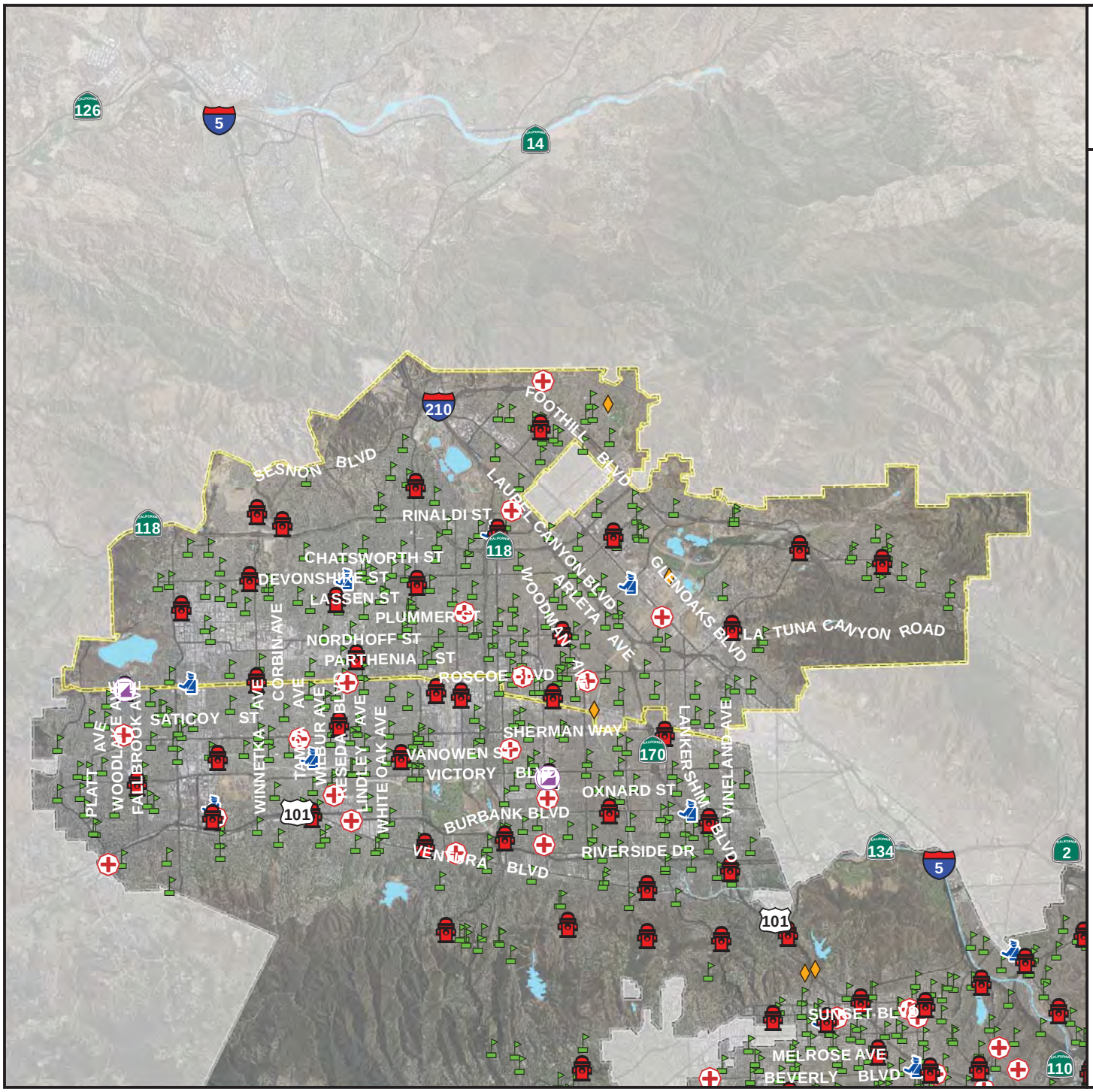
Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



North Valley APC

Figure 4-5.

Critical Operating and Response Facilities

APC Boundary

Los Angeles City Boundary

Critical Operating Facilities

"Big Twenty"

Critical Response Facilities

Fire Stations

Medical Facilities

Police Stations

School & Educational Facilities

Debris Management & Evacuation Areas

0 1.75 3.5 7

Miles

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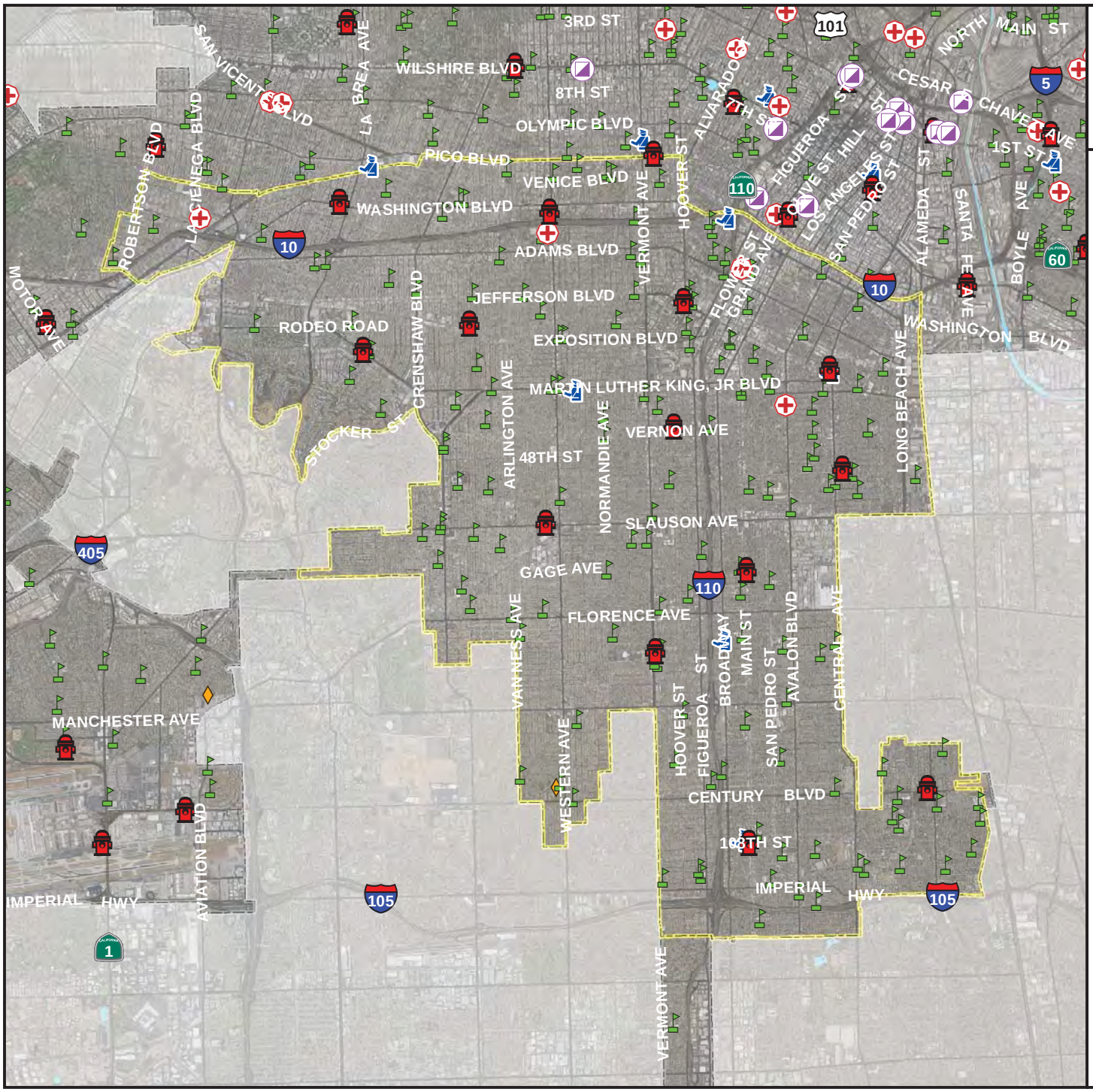
TETRA TECH

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



South Los Angeles APC

Figure 4-6.

Critical Operating and Response Facilities

APC Boundary

Los Angeles City Boundary

Critical Operating Facilities

"Big Twenty"

Critical Response Facilities

Fire Stations

Medical Facilities

Police Stations

School & Educational Facilities

Debris Management & Evacuation Areas

0 0.75 1.5 3

Miles

N
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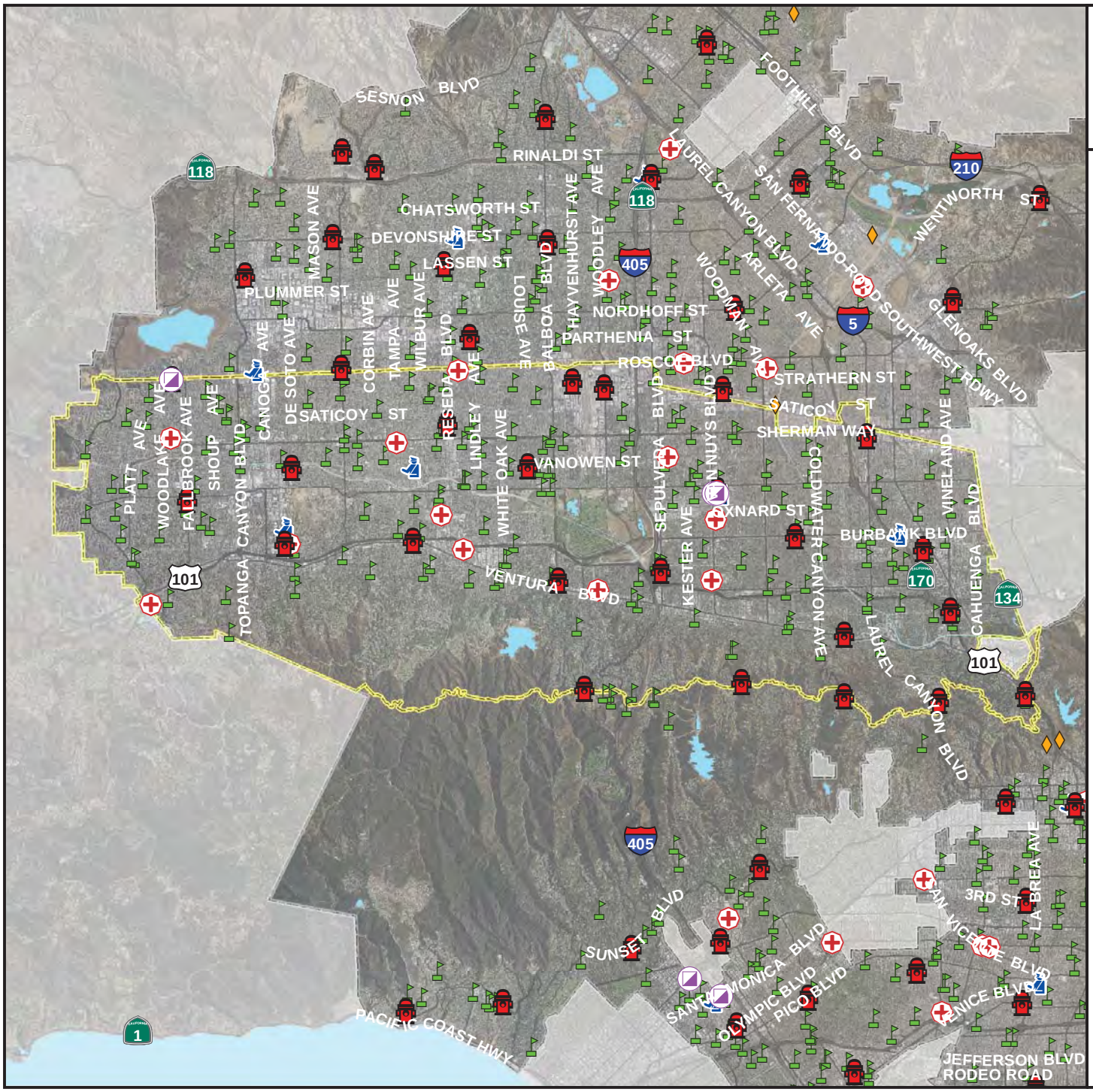
Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



South Valley APC

Figure 4-7.

Critical Operating and Response Facilities

APC Boundary

Los Angeles City Boundary

Critical Operating Facilities

"Big Twenty"

Critical Response Facilities

Fire Stations

Medical Facilities

Police Stations

School & Educational Facilities

Debris Management & Evacuation Areas

0 1.5 3 6

Miles

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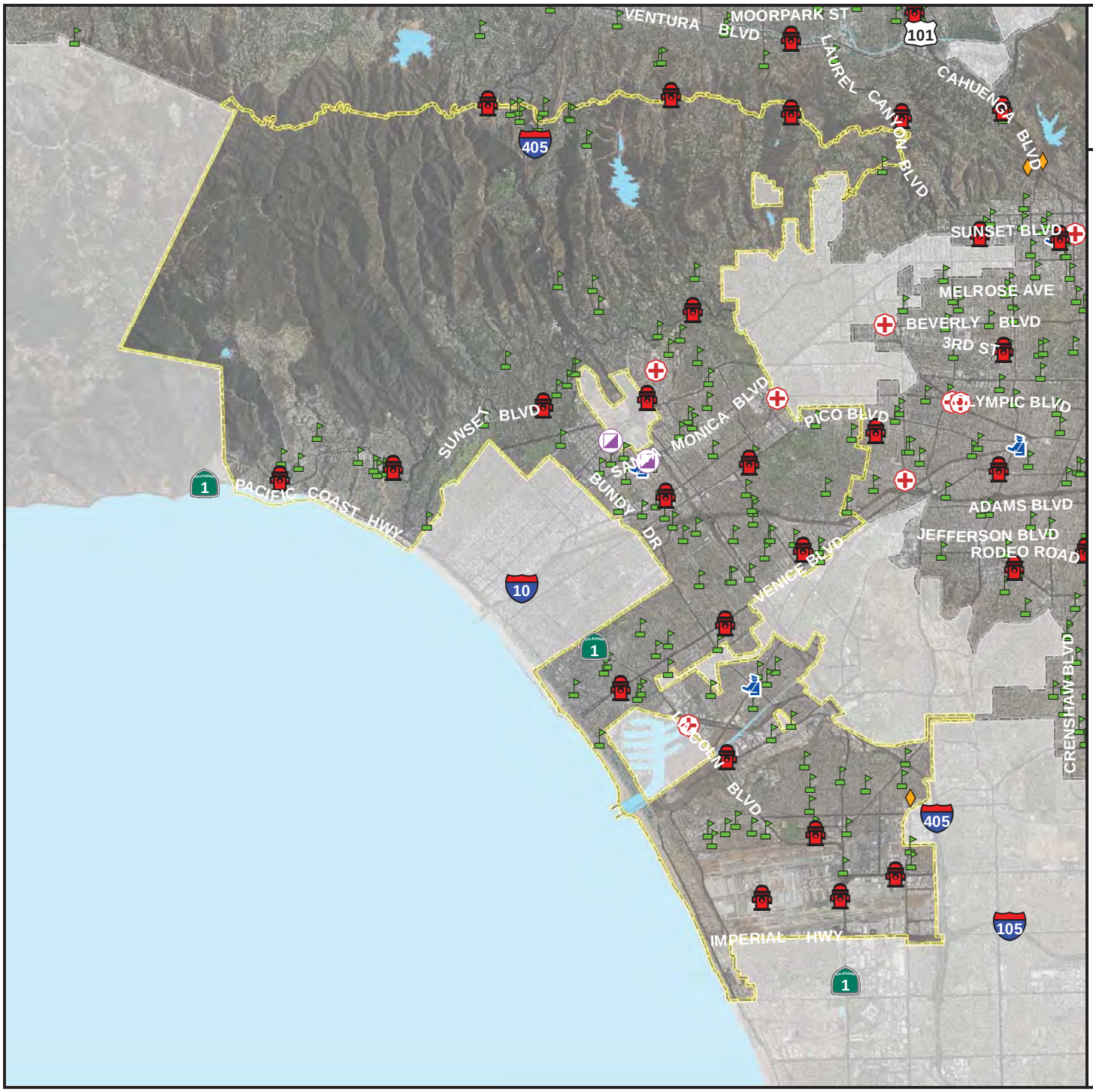
Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



West Los Angeles APC

Figure 4-8.

Critical Operating and Response Facilities

- APC Boundary
- Los Angeles City Boundary

Critical Operating Facilities

- "Big Twenty"

Critical Response Facilities

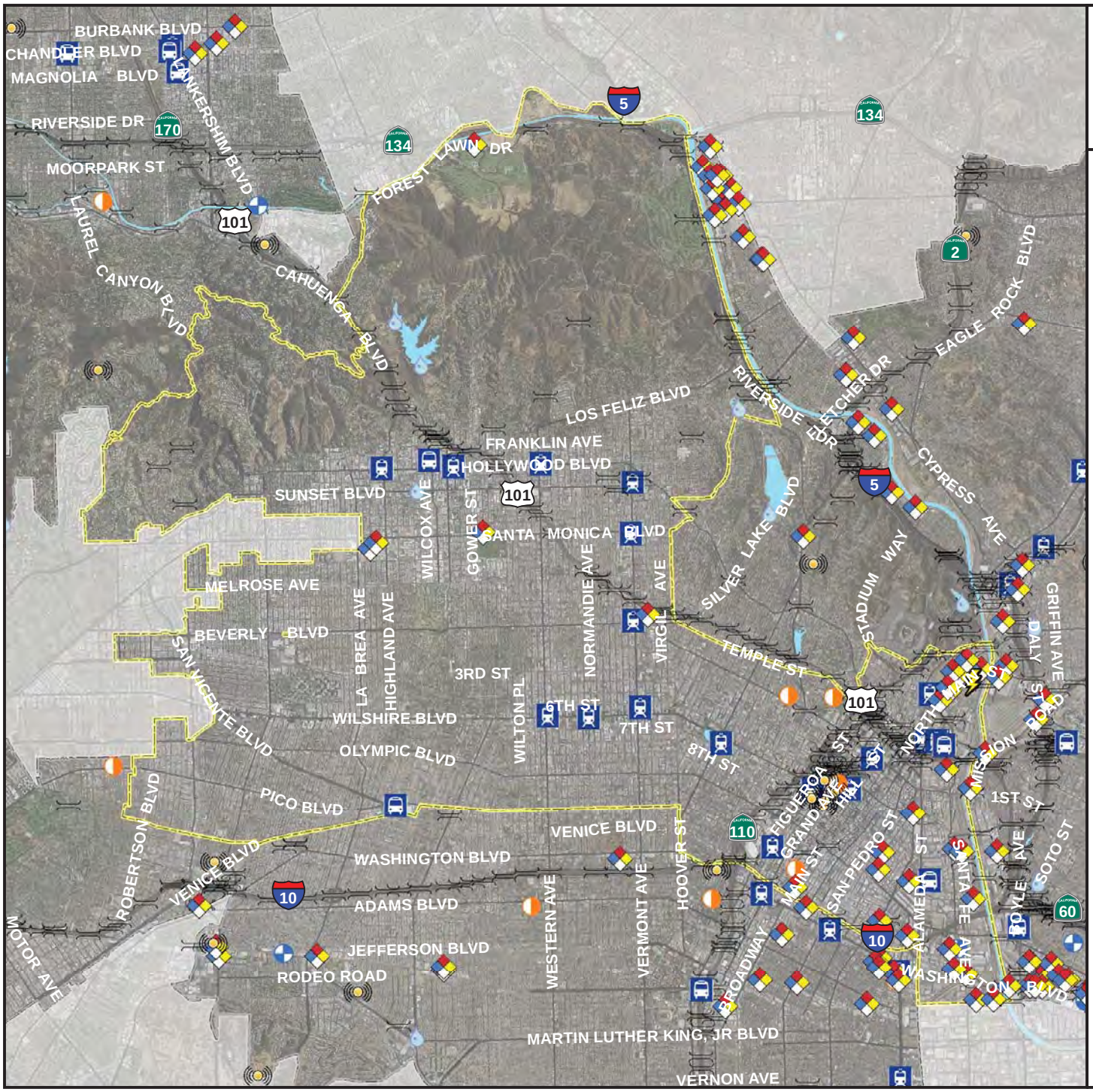
- Fire Stations
- Medical Facilities
- Police Stations
- School & Educational Facilities
- Debris Management & Evacuation Areas

0 1.25 2.5 5

Miles

N
W E
S

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



Central APC

Figure 4-9.
Critical Infrastructure

APC Boundary
Los Angeles City Boundary

Utility Infrastructure

- Communications
- Electric Power
- Hazardous Materials
- Petroleum & Natural Gas
- Potable Water
- Waste Water

Transportation Infrastructure

- Airport Facilities
- Bus Systems
- Bridges
- Light Rail Facilities
- Port / Harbor
- Rail Facilities

0 0.75 1.5 3
Miles

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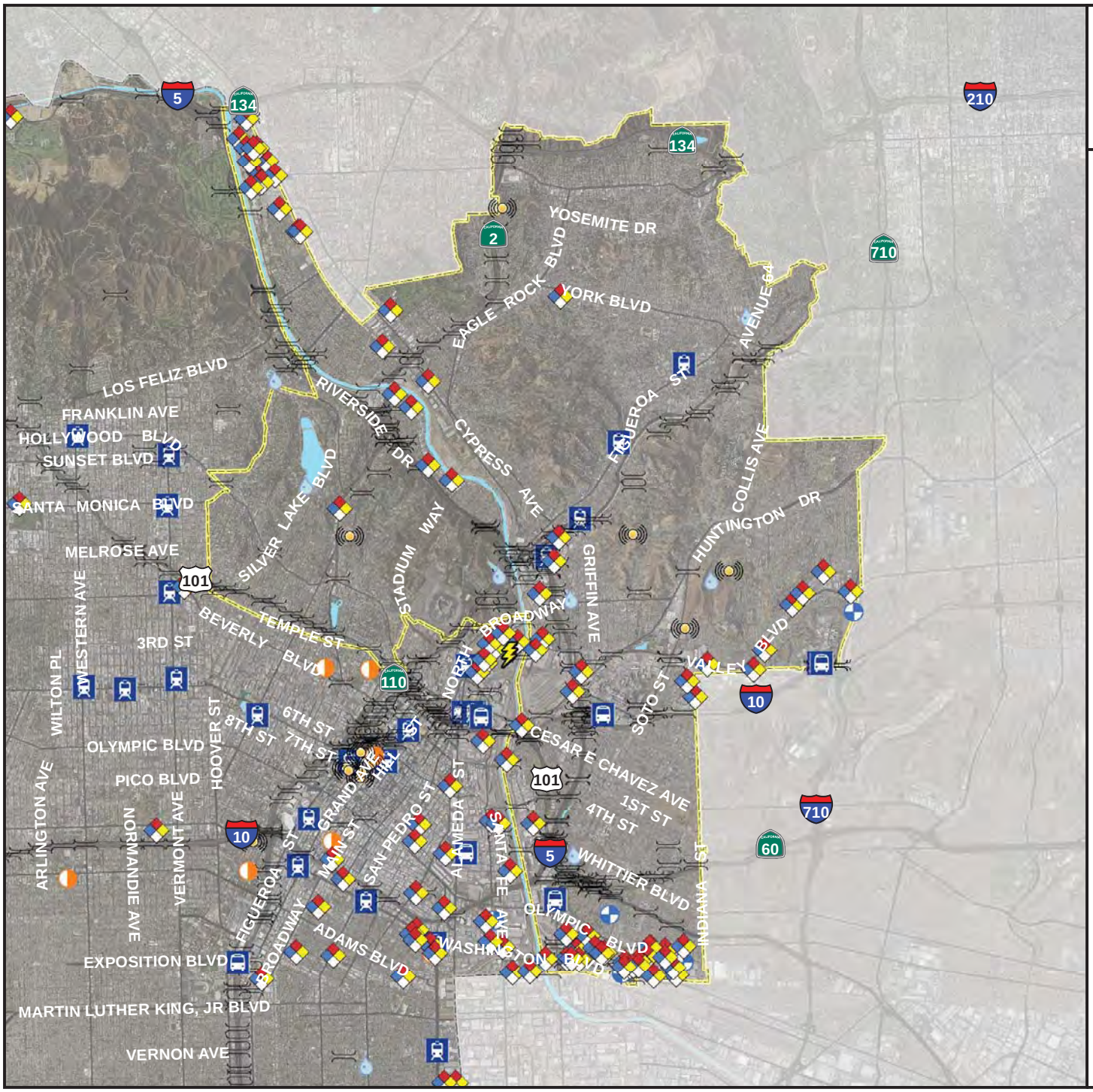
S

TETRA TECH

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



East Los Angeles APC

Figure 4-10.

Critical Infrastructure

APC Boundary

Los Angeles City Boundary

Utility Infrastructure

- Communications
- Electric Power
- Hazardous Materials
- Petroleum & Natural Gas
- Potable Water
- Waste Water

Transportation Infrastructure

- Airport Facilities
- Bus Systems
- Bridges
- Light Rail Facilities
- Port / Harbor
- Rail Facilities

0 0.75 1.5 3

Miles

N
W E
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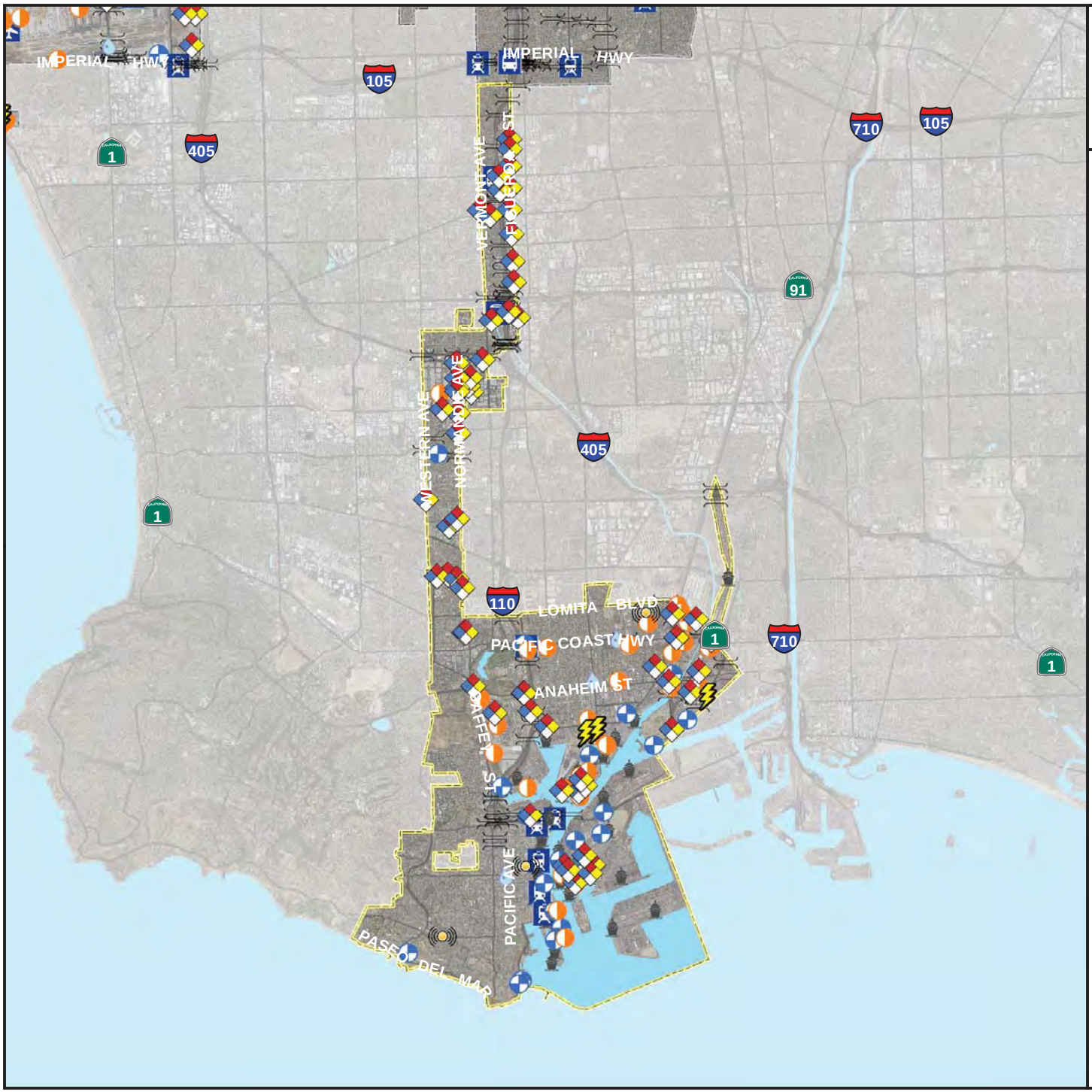
Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



Harbor APC

Figure 4-11.

Critical Infrastructure

APC Boundary

Los Angeles City Boundary

Utility Infrastructure

- Communications
- Electric Power
- Hazardous Materials
- Petroleum & Natural Gas
- Potable Water
- Waste Water

Transportation Infrastructure

- Airport Facilities
- Bus Systems
- Bridges
- Light Rail Facilities
- Port / Harbor
- Rail Facilities

0 1.25 2.5 5

Miles

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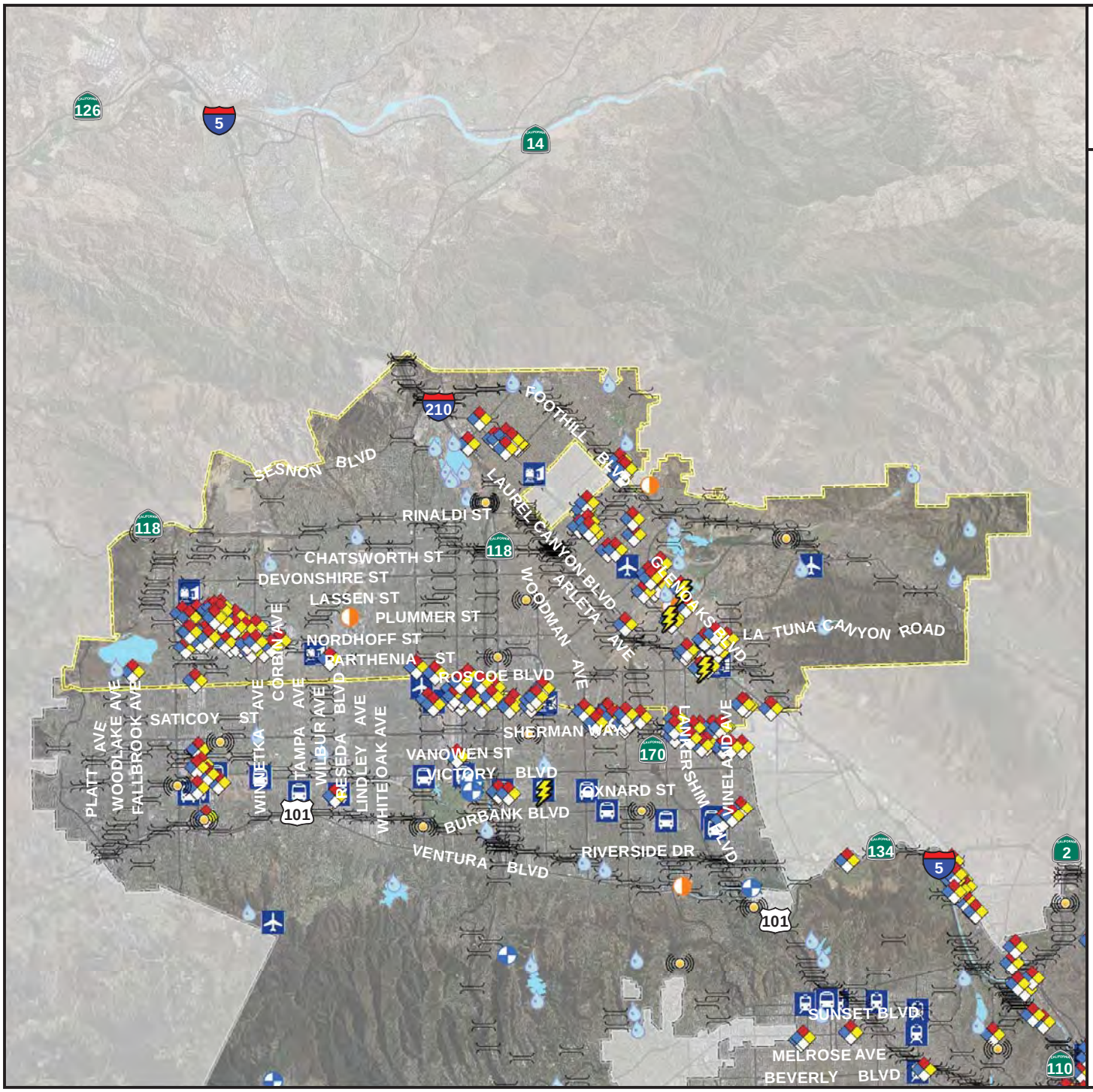
TETRA TECH

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



North Valley APC

Figure 4-12.

Critical Infrastructure

- APC Boundary
- Los Angeles City Boundary

Utility Infrastructure

- Communications
- Electric Power
- Hazardous Materials
- Petroleum & Natural Gas
- Potable Water
- Waste Water

Transportation Infrastructure

- Airport Facilities
- Bus Systems
- Bridges
- Light Rail Facilities
- Port / Harbor
- Rail Facilities

0 1.75 3.5 7

Miles

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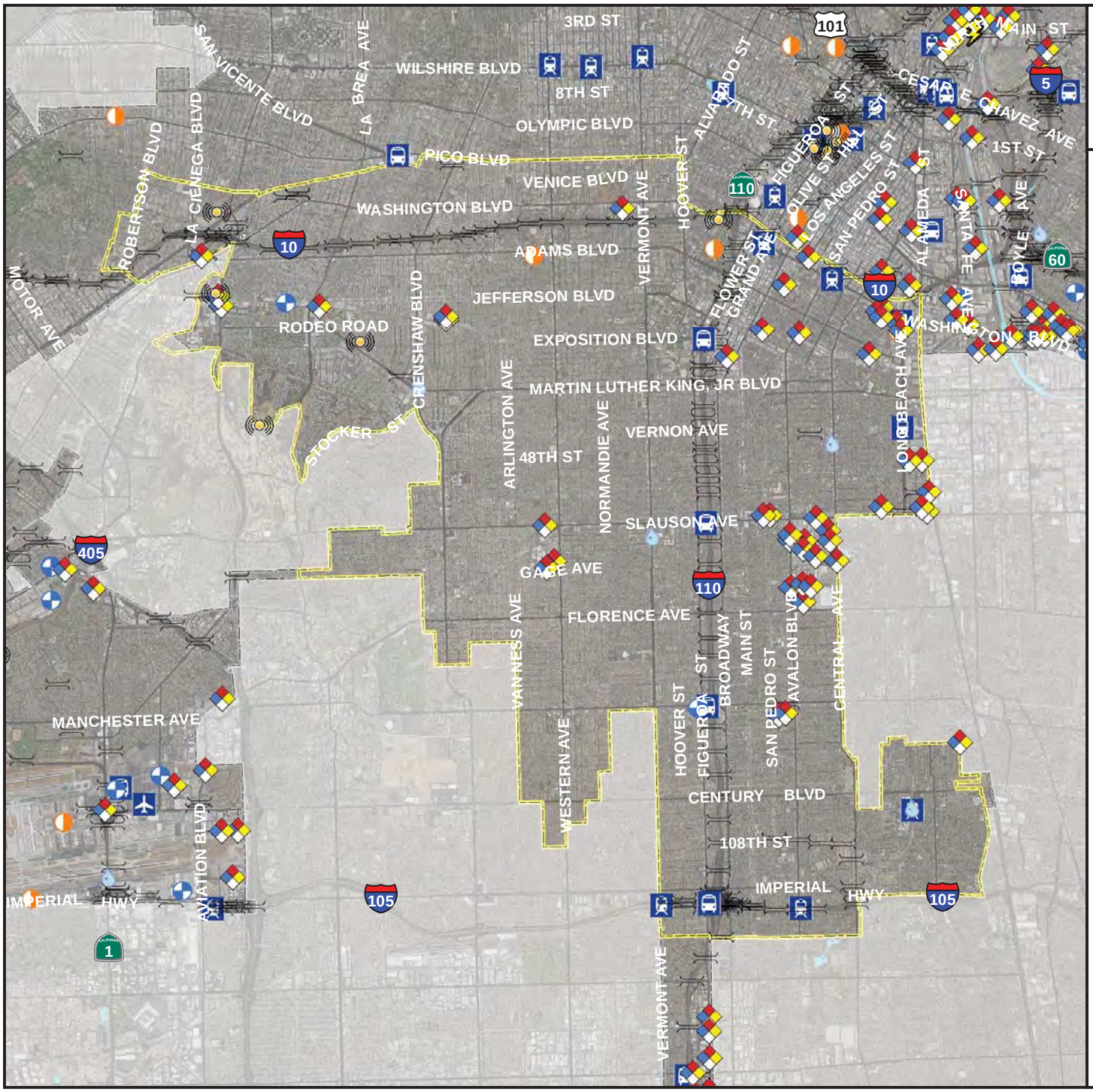
TETRA TECH

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



South Los Angeles APC

Figure 4-13.

Critical Infrastructure

APC Boundary

Los Angeles City Boundary

Utility Infrastructure

- Communications
- Electric Power
- Hazardous Materials
- Petroleum & Natural Gas
- Potable Water
- Waste Water

Transportation Infrastructure

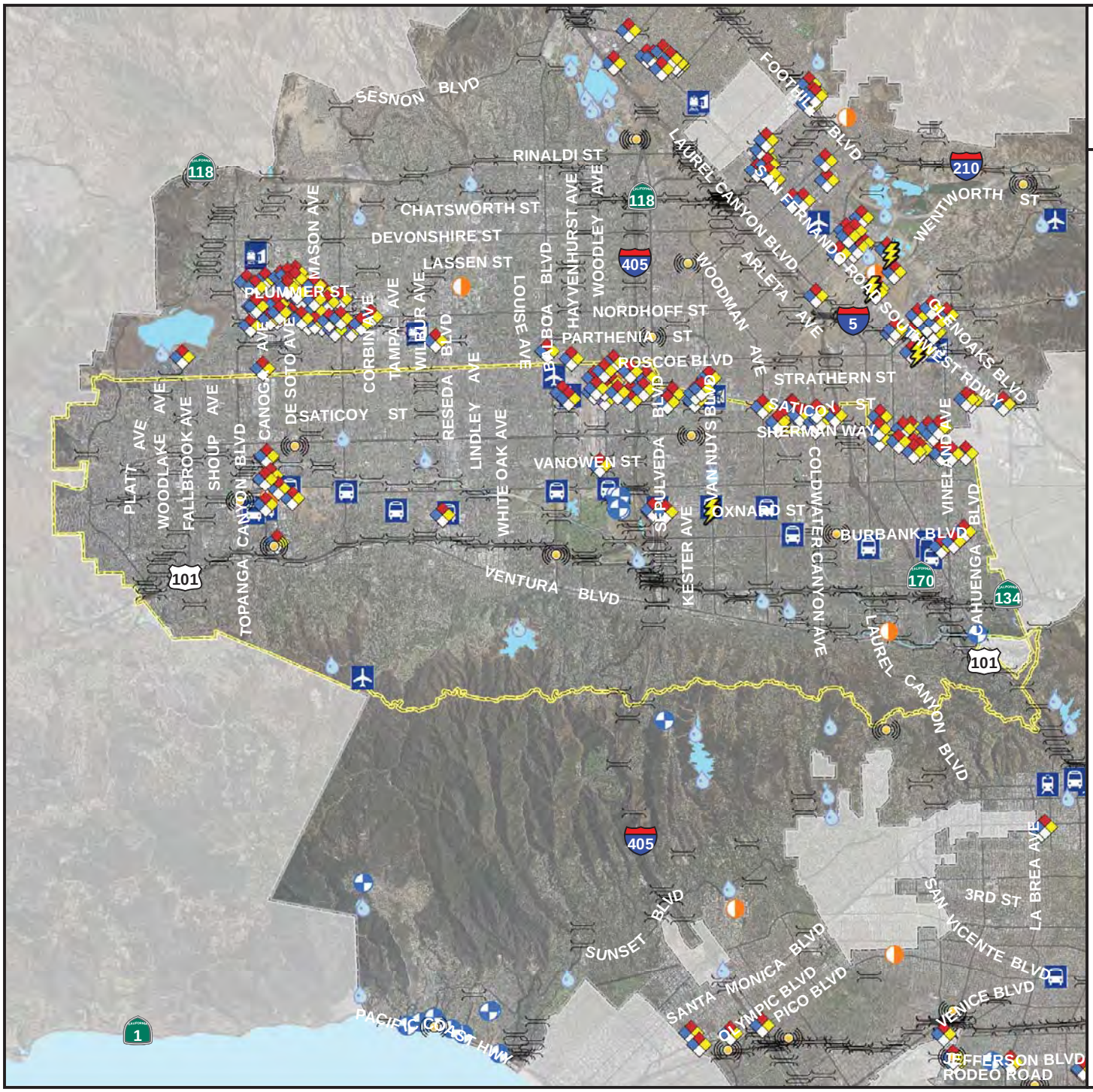
- Airport Facilities
- Bus Systems
- Bridges
- Light Rail Facilities
- Port / Harbor
- Rail Facilities

0 0.75 1.5 3

Miles

N
W E
S

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



South Valley APC

Figure 4-14.
Critical Infrastructure

APC Boundary
Los Angeles City Boundary

Utility Infrastructure

- Communications
- Electric Power
- Hazardous Materials
- Petroleum & Natural Gas
- Potable Water
- Waste Water

Transportation Infrastructure

- Airport Facilities
- Bus Systems
- Bridges
- Light Rail Facilities
- Port / Harbor
- Rail Facilities

0 1.5 3 6

Miles

N
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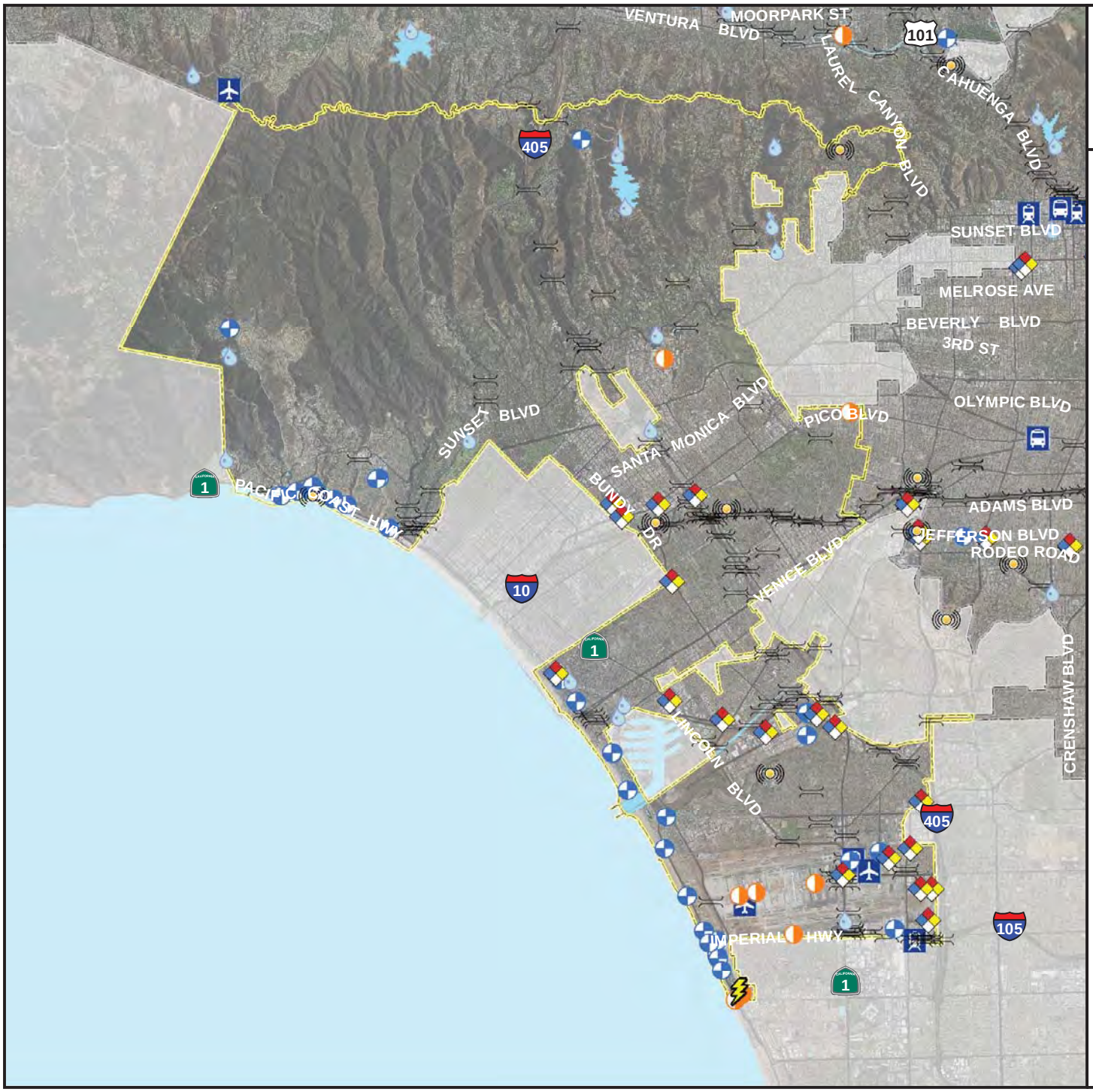
Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA



West Los Angeles APC

Figure 4-15.
Critical Infrastructure

APC Boundary
Los Angeles City Boundary

Utility Infrastructure

- Communications
- Electric Power
- Hazardous Materials
- Petroleum & Natural Gas
- Potable Water
- Waste Water

Transportation Infrastructure

- Airport Facilities
- Bus Systems
- Bridges
- Light Rail Facilities
- Port / Harbor
- Rail Facilities

0 1.25 2.5 5

Miles

N
W E
S

Map Data Sources:City of Los Angeles, CalTrans, Hazus 3.2, EPA, USDA

Table 4-5. Planning Area Critical Facilities

Category	Central APC	East LA APC	Harbor APC	North Valley APC	South LA APC	South Valley APC	West LA APC	Total
Critical Operating Facilities	14	0	1	0	0	3	2	20
Critical Response Facilities								
Evacuation Centers / Debris Removal	2	1	1	3	1	0	1	9
Fire	17	11	11	17	13	20	17	106
Medical	14	8	1	6	4	11	3	47
Police	6	2	1	4	5	4	2	24
Schools	114	113	43	156	154	163	104	847
Critical Infrastructure—Transportation								
Airports	0	0	0	2	0	3	2	7
Bridges	151	230	70	286	127	190	134	1,188
Bus Systems	4	3	3	0	4	15	1	30
Light Rail	18	4	2	3	8	1	1	37
Port / Harbor	0	0	35	0	0	0	0	35
Railroads	1	1	0	5	0	2	0	9
Critical Infrastructure—Utilities								
Communications	6	5	3	6	5	7	5	37
Electric Power	1	0	3	3	0	1	1	9
Hazardous Materials	28	72	64	132	46	48	18	408
Petroleum & Natural Gas	4	0	32	3	3	6	10	58
Potable Water	4	7	3	27	4	8	14	67
Waste Water	1	4	21	0	2	12	45	85
Overall	385	461	294	653	376	494	360	3,023

4.5.3 Future Trends in Development

The City's General Plan governs land use decision and policy-making. This hazard mitigation plan will work together with the General Plan to support wise land use in the future by providing vital information on the risk associated with hazards within the city. The City of Los Angeles will incorporate by reference the Hazard Mitigation Plan Update in its General Plan. This will ensure that all future trends in development can be established with the benefits of the information on risk and vulnerability to hazards identified in this plan.

According to Southern California Public Radio (KPCC 89.30), the number of residential building permits reported in the Los Angeles metro area sharply decreased between 2004 and 2009, followed by a sharp increase after 2009. Permits for housing construction in the Los Angeles metropolitan area declined in 2016 compared to the previous year, a reversal in what had been a steady post-recession recovery, according to figures from the U.S. Census Bureau. (KPCC, 2017). Figure 4-16 shows the trends in residential development projects in the planning area since 2005.

Source: KPCC, 2017

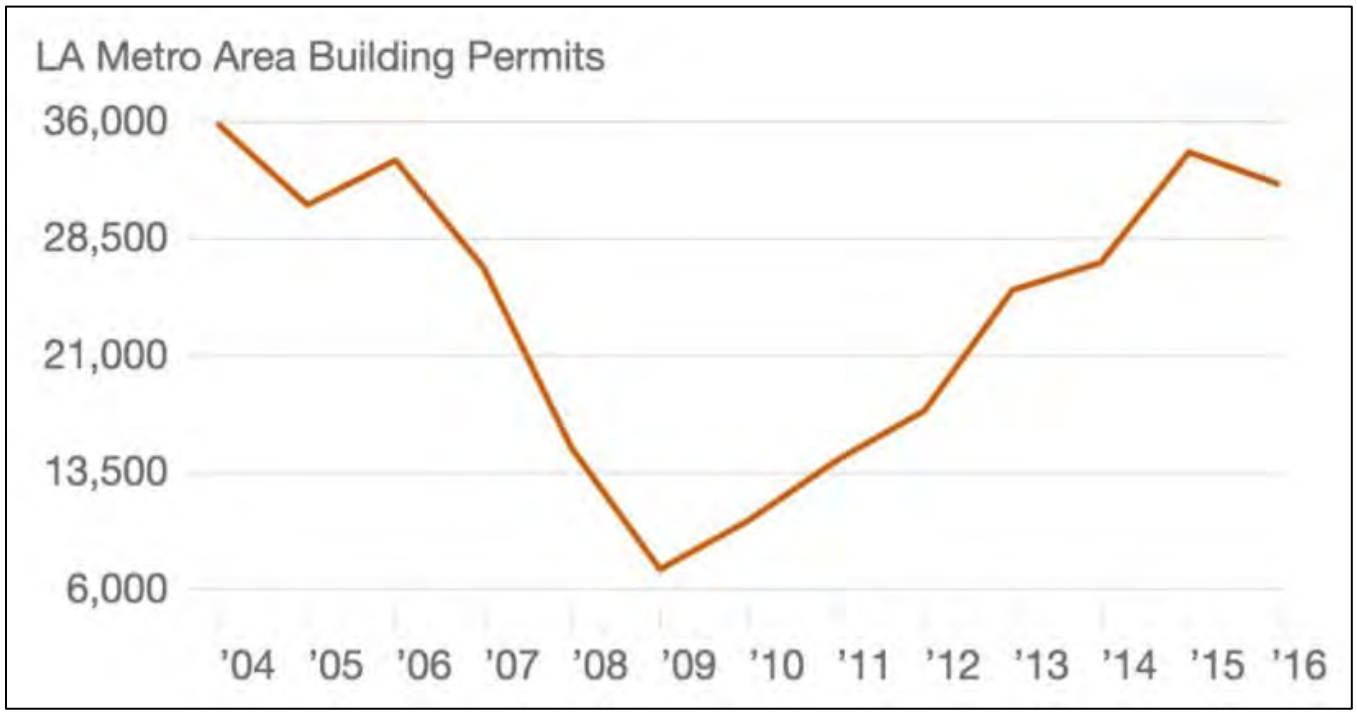


Figure 4-16. Residential Building Permit Trends, 2005 to 2015

4.6 COMMUNITY DEMOGRAPHIC PROFILE

Some populations are at greater risk from hazard events because of decreased resources or physical abilities. Elderly people, for example, may be more likely to require additional assistance. Research has shown that people living near or below the poverty line, the elderly, women, children, ethnic minorities, renters, individuals with disabilities, and others with access and functional needs, all experience more severe effects from disasters than the general population. These vulnerable populations may vary from the general population in risk perception, living conditions, access to information before, during and after a hazard event, capabilities during an event, and access to resources for post-disaster recovery. Indicators of vulnerability—such as disability, age, poverty, and minority race and ethnicity—often overlap spatially and often in the geographically most vulnerable locations. Detailed spatial analysis to locate areas where there are higher concentrations of vulnerable community members would help to extend focused public outreach and education to these most vulnerable residents (Press-Telegram, 2015).

4.6.1 Population Characteristics

Knowledge of the composition of the population and how it has changed in the past and how it may change in the future is needed for making informed decisions about the future. Information about population is a critical part of planning because it directly relates to land needs such as housing, industry, stores, public facilities and services, and transportation. California Department of Finance estimated the City of Los Angeles population to be 4,030,904 as of January 1, 2016.

Population changes are useful socio-economic indicators. A growing population generally indicates a growing economy, while a decreasing population may signify economic decline. Figure 4-17 shows the planning area population change from 1993 to 2016 compared to that of the State of California (California Department of Finance 2017).

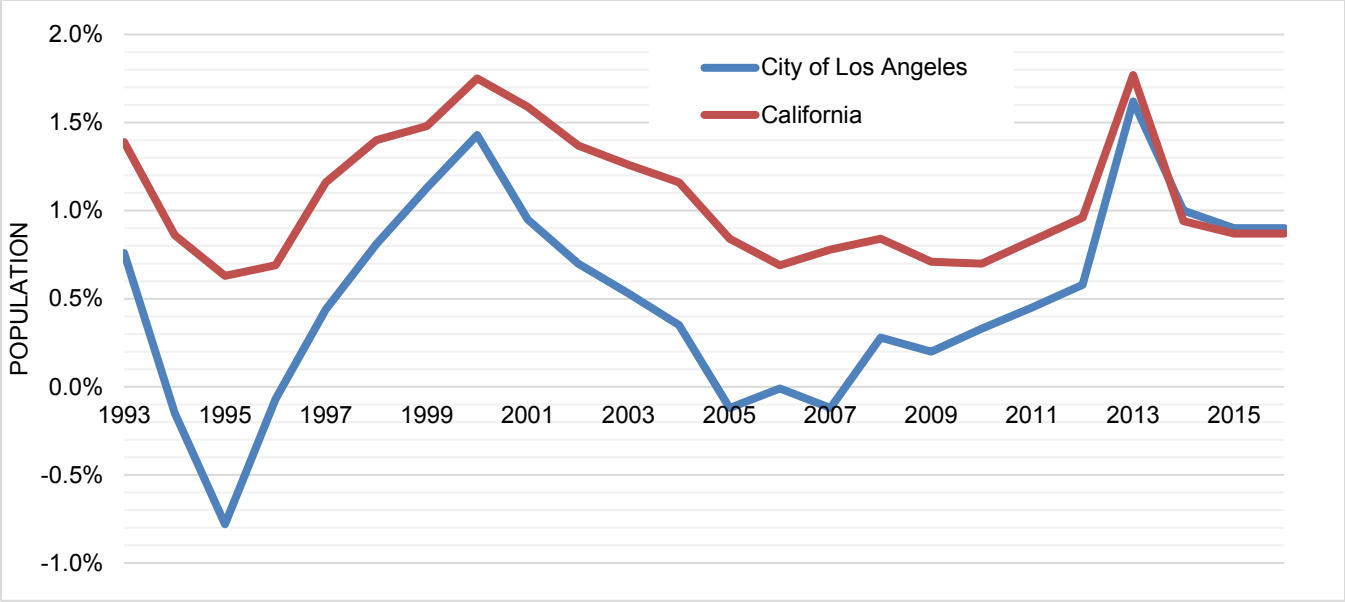


Figure 4-17. California and City of Los Angeles Population Growth

Between 2000 and 2016, California's population grew by 15.89 percent (about 0.93 percent per year) while the planning area's population increased by 9.10 percent (0.54 percent per year). The City and the state both experienced peak population growth in 2000, with the annual growth rate generally slowing from 2000 to 2007. The rate has rapidly increased again since 2007. The City population decreased from 1994 through 1996 and 2005 through 2007. Between 2010 and 2016, the population increased an average of 0.90 percent per year, for a total of 6.28 percent. Table 4-6 shows the population in the planning area from 2000 to 2016.

Table 4-6. Annual Population Data

	City of Los Angeles Population
2000	3,694,742
2001	3,714,515
2002	3,740,481
2003	3,760,410
2004	3,773,549
2005	3,769,131
2006	3,768,645
2007	3,764,063
2008	3,774,497
2009	3,781,952
2010	3,792,621
2011	3,818,120
2012	3,860,986
2013	3,907,519
2014	3,945,037
2015	3,980,423
2016	4,030,904

Source: California Department of Finance, Demographic Research Unit, 2017

4.6.2 Age Distribution

As a group, the elderly are more apt to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences making recovery slower. They are more likely to be vision, hearing, and/or mobility impaired, and more likely to experience mental impairment or dementia. Additionally, the elderly are more likely to live in assisted-living facilities where emergency preparedness occurs at the discretion of facility operators. These facilities are typically identified as "critical facilities" by emergency managers because they require extra notice to implement evacuation. Elderly residents living in their own homes may have more difficulty evacuating their homes and could be stranded in dangerous situations. This population group is more likely to need special medical attention, which may not be readily available during natural disasters due to isolation caused by the event. Specific planning attention for the elderly is an important consideration given the current aging of the American population.

Children under 14 are particularly vulnerable to disaster events because of their young age and dependence on others for basic necessities. Very young children may additionally be vulnerable to injury or sickness; this vulnerability can be worsened during a natural disaster because they may not understand the measures that need to be taken to protect themselves from hazards.

The overall age distribution for the planning area is shown in Figure 4-18. Based on the most recent 5-year estimates from the U.S. Census Bureau's American Community Survey (2011-2015), 11.2 percent of the planning area's population is 65 or older. According to U.S. Census data, 38.6 percent of the over-65 population have disabilities of some kind and 16.2 percent have incomes below the poverty line. The City's population includes 18.1 percent who are 14 or younger. Among children under 18, 32 percent are below the poverty line.

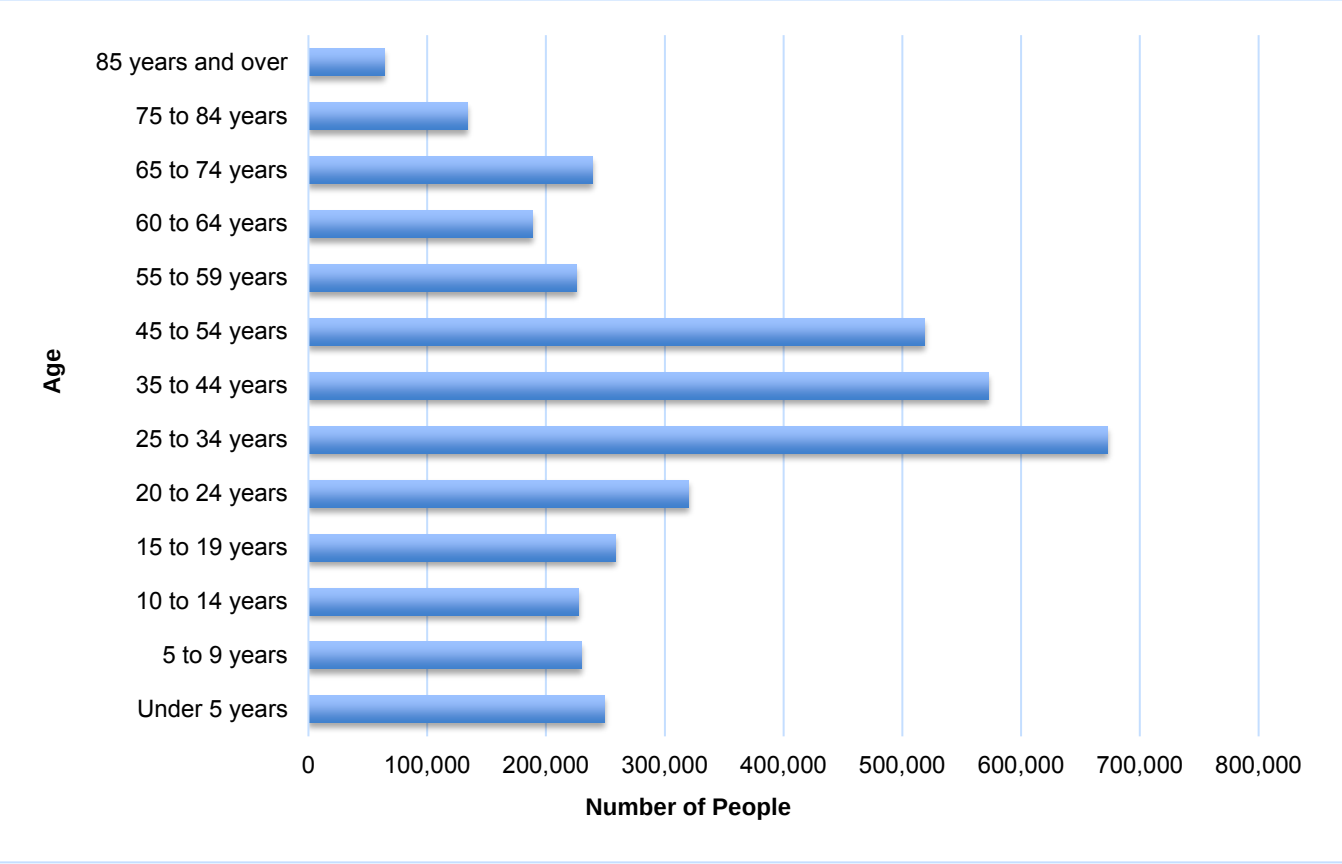


Figure 4-18. Planning Area Age Distribution

4.6.3 Race, Ethnicity and Language

Research shows that racial and ethnic minorities are less likely to be involved in pre-disaster planning and experience higher mortality rates during a disaster event. Post-disaster recovery can be ineffective and is often characterized by cultural insensitivity. Since higher proportions of ethnic minorities live below the poverty line than the majority white population, poverty can compound vulnerability.

Figure 4-19 shows the U.S. Census 2015 racial distribution in the City of Los Angeles based on race categories mandated by U.S. Office of Management and Budget standards. The Census Bureau also reports that 47.8 percent of the planning area population is of Hispanic origin, which indicates the heritage, nationality, lineage, or country of birth of the person or the person's parents or ancestors before arriving in the United States, and may be any race.

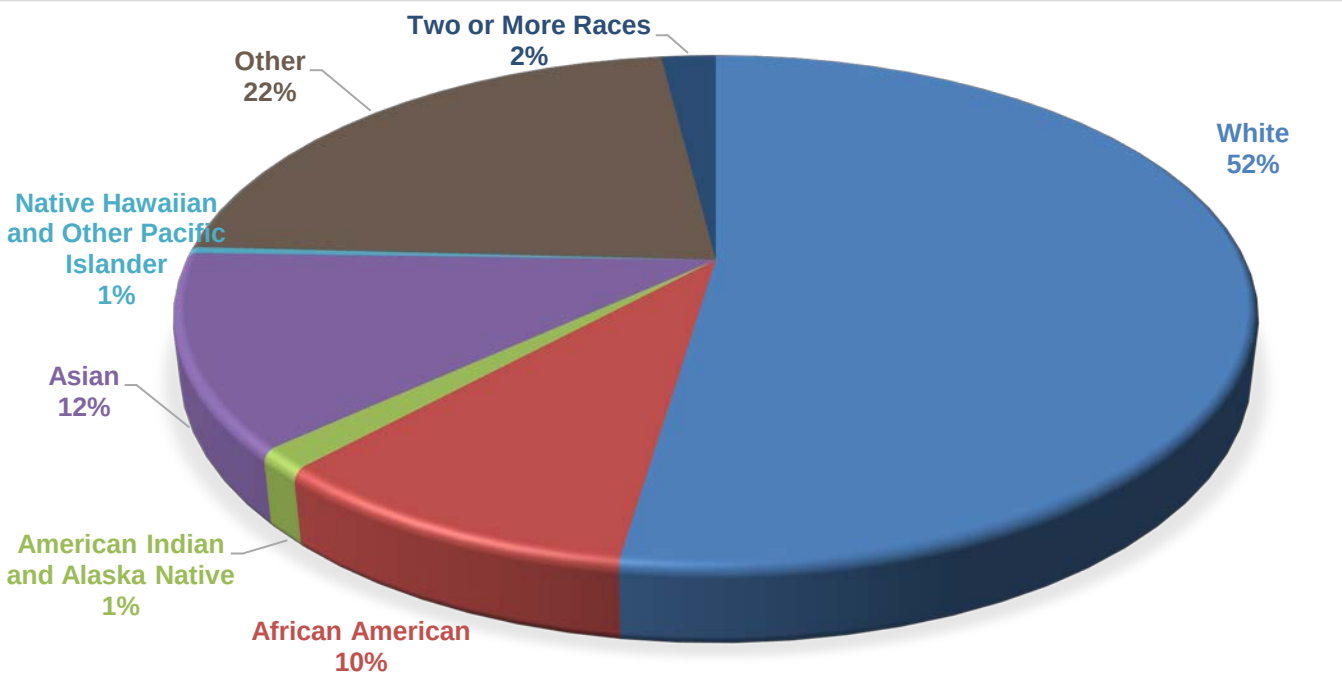


Figure 4-19. Planning Area Race Distribution

The planning area has a 38.2-percent foreign-born population. Other than English, the most commonly spoken language in the planning area is Spanish. The census estimates that 27.7 percent of residents speak English "less than very well."

4.6.4 Individuals with Disabilities or Access and Functional Needs

Individuals with disabilities are more likely to have difficulty responding to a hazard event than the general population. Local government is the first level of response to assist these individuals, and coordination of efforts to meet their access and functional needs is paramount to life safety efforts. It is important for emergency managers to distinguish between functional and medical needs in order to plan for incidents that require evacuation and sheltering. Knowing the percentage of population with a disability gives emergency management personnel and first responders an opportunity to ensure that emergency plans and procedures include considerations for addressing the needs of those residents.

According to the 5-year American Community Survey (2011-2015), there are 378,044 individuals with some form of disability in the City of Los Angeles, representing 9.8 percent of the total.

4.7 ECONOMY

4.7.1 Income

In the United States, individual households are expected to use private resources to prepare for, respond to and recover from disasters to some extent. This means that households living in poverty are automatically disadvantaged when confronting hazards. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in earthquakes and floods than other types of housing. In urban areas, the poor often live in older houses and apartment complexes, which are more likely to be made of un-reinforced masonry, a building type that is particularly susceptible to damage during earthquakes. Furthermore, residents below the poverty level are less likely to have insurance to compensate for losses incurred from natural disasters. This means that residents below the poverty level have a great deal to lose during an event and are the least prepared to deal with potential losses. The events following Hurricane Katrina in 2005 illustrated that personal household economics significantly impact people's decisions on evacuation. Individuals who cannot afford gas for their cars will likely decide not to evacuate.

Based on U.S. Census Bureau estimates, per capita income in the planning area in 2015 was $28,761, and the median household income was $50,205. It is estimated that about 12.8 percent of households receive an income between $100,000 and $149,999 per year, and over 14.9 percent of household incomes are above $150,000 annually. About 22 percent of the households in the planning area make less than $25,000 per year and are therefore below the poverty level. The weighted average poverty threshold for a family of four in 2015 was $24,250; for a family of three, $20,090; for a family of two, $15,930.

4.7.2 Industry, Businesses and Institutions

The City of Los Angeles has the 16th largest economy in the world (LATCB, 2015). The Port of Los Angeles handles tens of billions of dollars in industry sales. According to the Los Angeles Tourism & Convention Board, the total value of two-way trade handled at the Los Angeles Customs District in 2014 was a record $426 billion. The City is also home to the Los Angeles International (LAX), L.A./Ontario International and Van Nuys airports, generating billions of dollars in revenue and transporting millions of passengers.

Los Angeles is well known for its higher education institutions, events, sports centers, urban and outdoor recreational tourist attractions, shopping enclaves, dining destinations, and arts and cultural institutions. Los Angeles is regarded as the entertainment capital of the world and is leading in several growth industries, including the fashion, health services/biomedical, and aerospace/technology industries (LATCB, 2015).

The planning area's economy is strongly based in the education/health care/social service industry (22.2 percent), followed by the professional/scientific/management/administrative industry (15.1 percent), and arts/ entertainment/recreation industry (12.8 percent). Natural resource industries (<1 percent), and public administration (2.8 percent) make up the smallest sources of the local economy. Figure 4-20 shows the breakdown of industry types in the planning area. According to the Los Angeles Tourism & Convention Board, leisure and hospitality is a leading industry in Los Angeles, employing 464,600 individuals in 2014. The apparel, health care, aerospace product and manufacturing, entertainment industries also employ thousands of employees and generate billions of dollars in revenue.

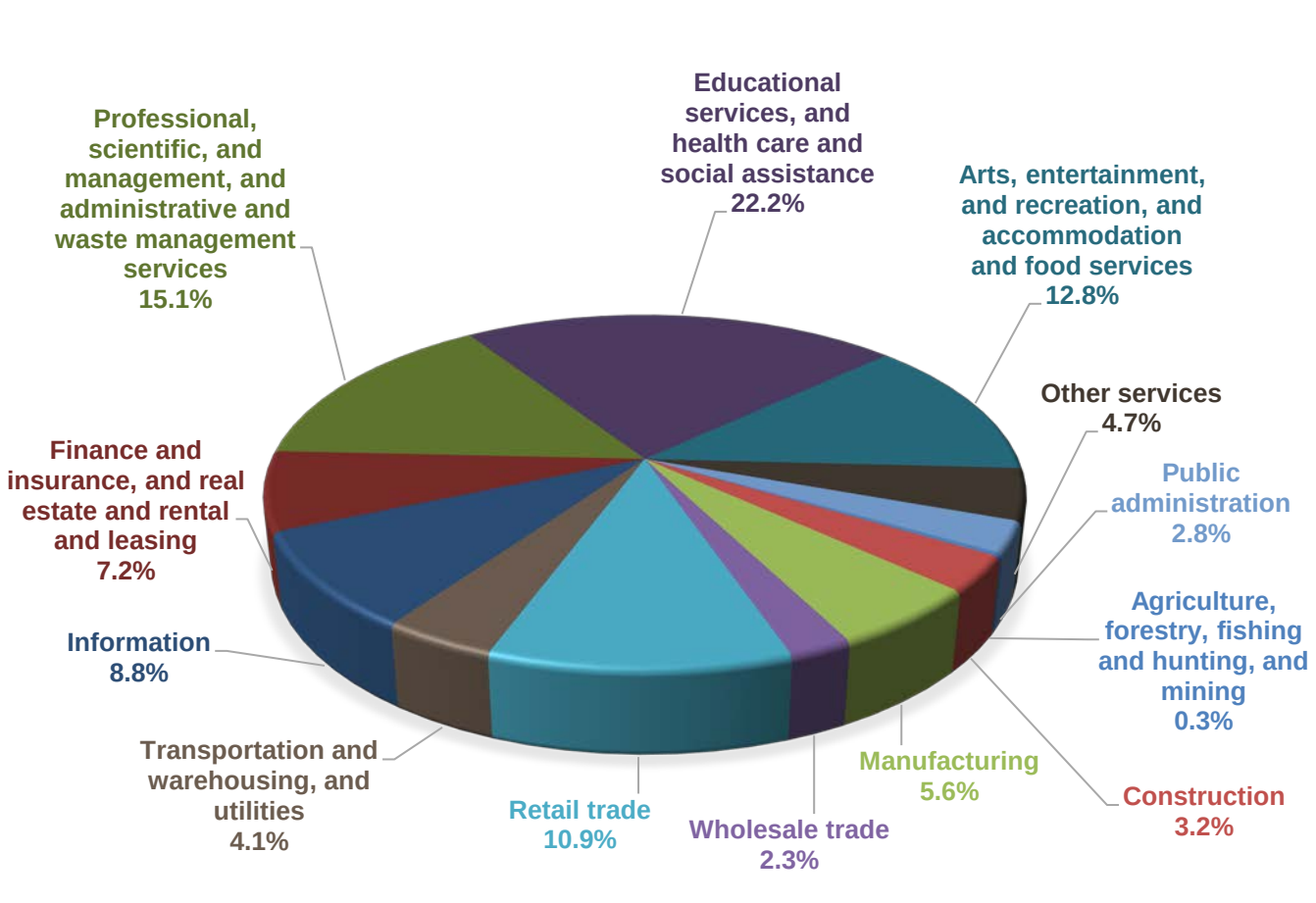


Figure 4-20. Industry in the Planning Area

Online data sources identify the following large employers in Los Angeles County (CA EDD, LA Business Journal, LA Almanac, 2017):

- Government organizations—Los Angeles County, Los Angeles Unified Schools, the City of Los Angeles, the federal government and the State of California
- Universities—The University of California Los Angeles, the University of Southern California and the California Institute of Technology
- Large health-care providers—Kaiser Permanente, Cedars-Sinai Medical Center, Providence Health and Services, Long Beach Memorial Medical Center, Children's Hospital of Los Angeles and Adventist Health
- Large defense contractors—Northrop Grumman Corporation, the Boeing Company, Raytheon Company and Lockheed Martin Corporation
- Major employers in retail—Kroger, Target, The Home Depot, Von's and Costco
- Banks—Bank of America, Wells Fargo, and J.P. Morgan Chase
- Entertainment industry—FX Networks, Walt Disney Company, Warner Bros. Entertainment Inc. and Sony Pictures Entertainment
- Other major employers—VXI Global Solutions call centers, American Apparel, Farmers Insurance Group, UPS, and AT&T Inc.

4.7.3 Employment Trends and Occupations

According to the 5-year American Community Survey (2011-2015), about 66.2 percent of the City of Los Angeles's population 16 years old or older is in the labor force. Of the working-age population, 40.6 percent of men and 59.4 percent of women are in the labor force.

Figure 4-21 compares state and city unemployment trends from 1995 through 2016. The City of Los Angeles unemployment rate was lowest in 2006 at 5.3 percent. The rate peaked at 13.8 percent in 2010, and has declined since then. The City unemployment rate has generally been slightly higher than the statewide rate.

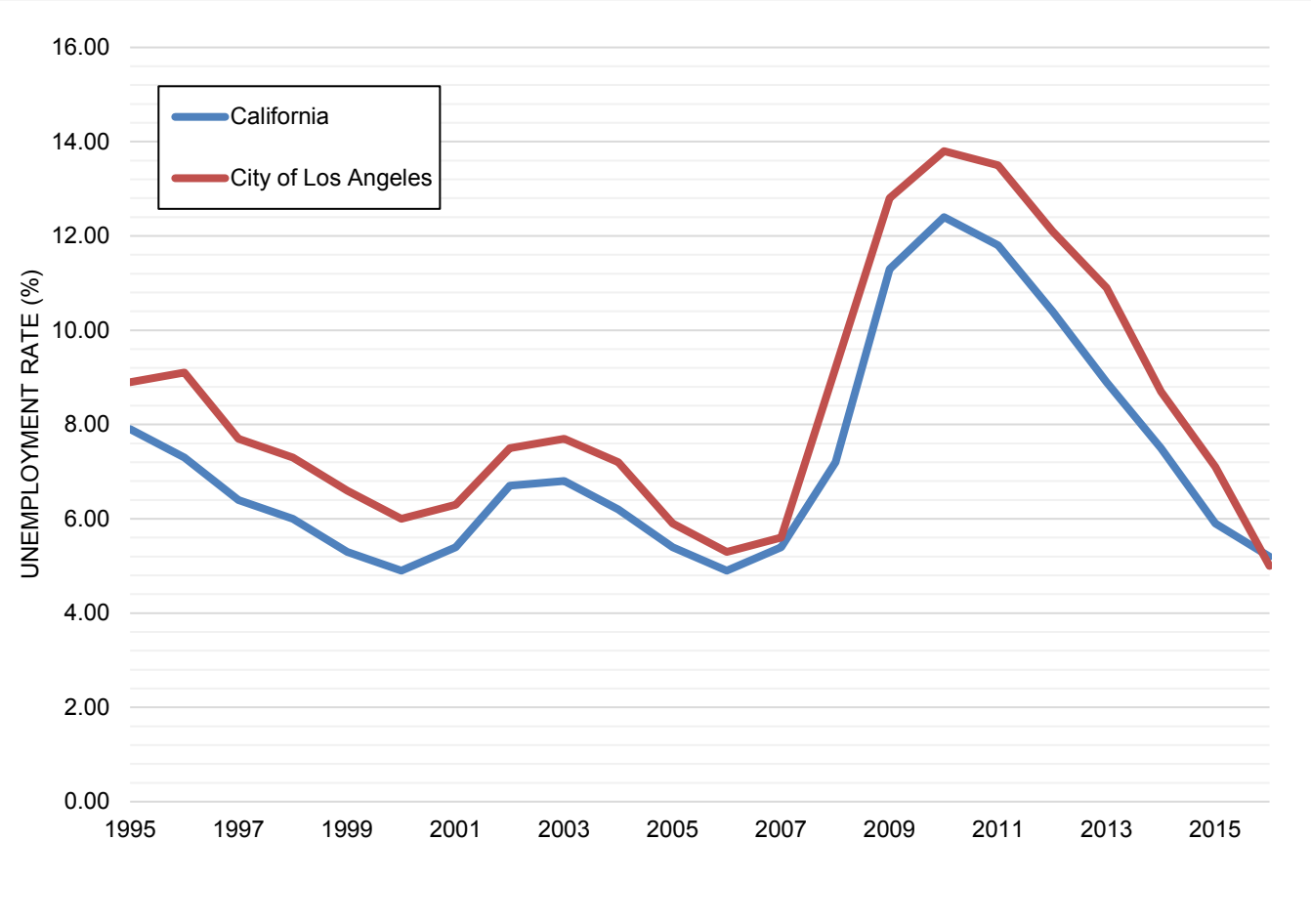


Figure 4-21. California and City of Los Angeles Unemployment Rate

Figure 4-22 shows Census Bureau estimates of employment distribution by occupation category. Management, business, science and arts occupations make up 36 percent of the jobs in the City of Los Angeles. Sales and office occupations make up 23 percent of the local working population.

The U.S. Census estimates that over 67.9 percent of workers in the planning area commute alone (by car, truck or van) to work, and mean travel time to work is 30.1 minutes.

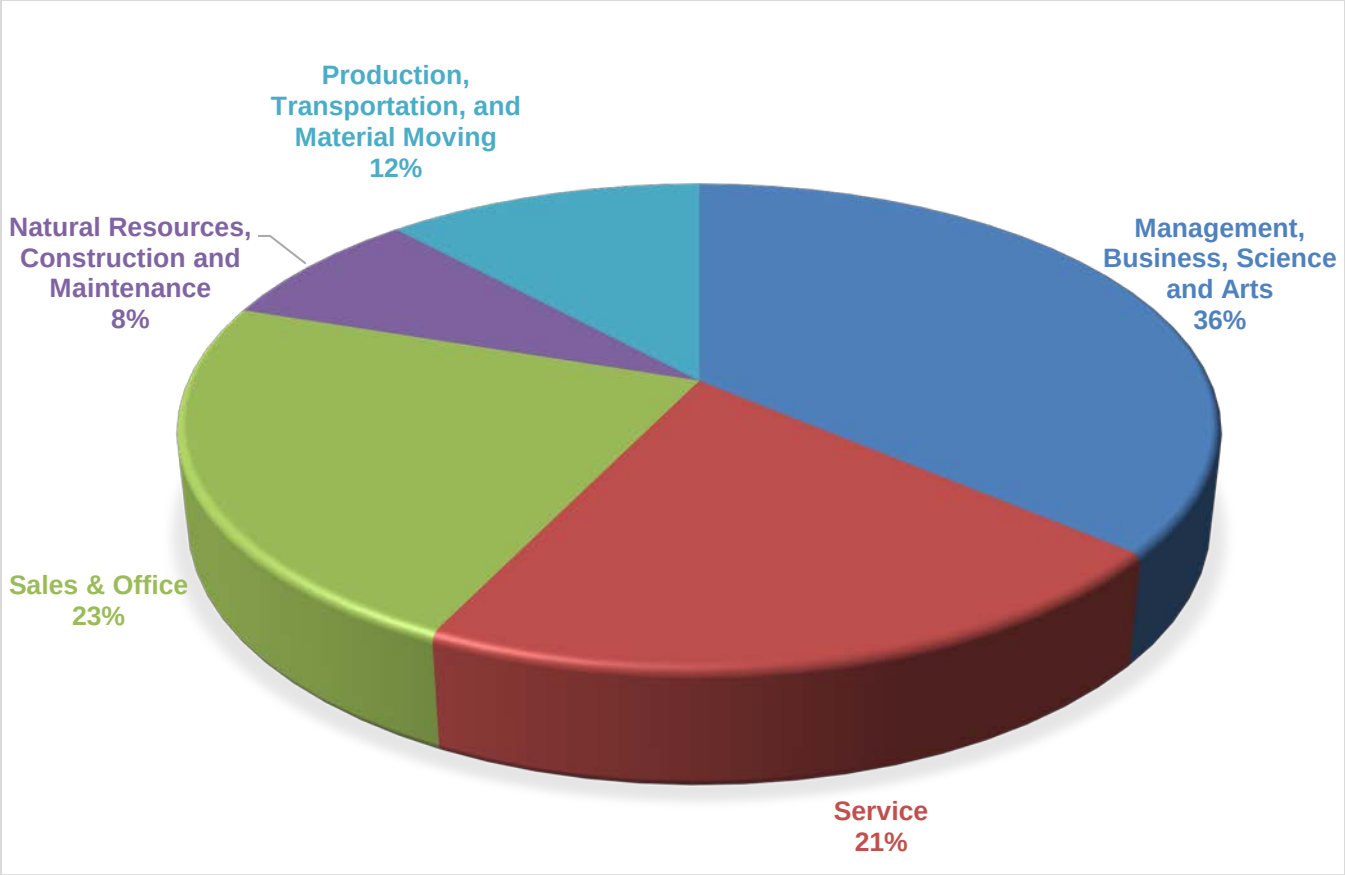


Figure 4-22. Occupations in the City of Los Angeles

4.8 VULNERABLE COMMUNITIES

Nine of the 10 most vulnerable communities in Los Angeles County are located within the City of Los Angeles, according to the Red Cross' PrepareLA Vulnerable Communities Project (American Red Cross, 2014). These communities do not align within the Area Planning Commissions for the City of Los Angeles.

These are Westlake, Historic South-Central, South Park, Central-Alameda, Pico Union, Florence, Watts, Boyle Heights, and Koreatown. They were selected based on eight indicators of vulnerability: race/ethnicity and poverty, single parent head of household, educational attainment, limited English language proficiency, car-less households, age dependency ratio, population density, and the presence of access and functional needs population.

The Office of Environmental Health Hazard Assessment, on behalf of the California Environmental Protection Agency, identified California communities that are disproportionately burdened by many sources of pollution and are socioeconomically disadvantaged. Each of these communities was afforded a CalEnviroScreen score. A significantly above average score was given to each of the City of Los Angeles' most vulnerable communities. The PrepareLA project confirmed the high CalEnviroScreen scores, showing that each of the most vulnerable communities has a high presence of facilities or railway lines that contribute to air pollution. Statistics indicating these communities' vulnerability are summarized in Table 4-7 through Table 4-9. The following sections offer discussions of each individual community.

Table 4-7. Vulnerable Neighborhood Community Assets

Neighborhood	Emergency Response Facilities Assets	Healthcare Facilities Assets	Open Space & Recreation Centers Assets	Community Serving Organization Assets
Westlake	9	20	Recreation facilities near MacArthur Park	30
Historic South-Central	8	11	2	20
South Park	3	3	2	4
Central-Alameda	8	3	4	19
Pico Union	7	5	7	19
Florence	4	4	0	5
Watts	11	3	No information	29
Boyle Heights	17	30	25	42
Koreatown	7	9	4	50

Source: American Red Cross Los Angeles Region (2014). "PrepareLA– Vulnerable Communities Project." Los Angeles, CA.

Table 4-8. Vulnerable Neighborhood Hazards

Neighborhood	CalEnviro-Screen Score	Earthquake Liquefaction Zone Risk	Air Pollutants Risk	Flooding Risk	Extreme Heat Risk
Westlake	71-100%	NE portion of the neighborhood west of Glendale Blvd.	1 hazardous waste facility at NW corner	Around lake at MacArthur Park	Moderate, 13 exceptionally high temperatures/year
Historic South-Central	86-100%	SW corner of the district near Vernon Avenue	2 point source facilities	Low	Moderate, 13 exceptionally high temperatures/year
South Park	86-100%	2/3 of the area	1 railway line, 1 hazardous waste facility in SE portion of the district	Low	Moderate, 13 exceptionally high temperatures/year
Central-Alameda	76-100%	Southern portion	2 hazardous waste facilities, 2 point source facilities, 2 railway lines	Low	Moderate, 13 exceptionally high temperatures/year
Pico Union	76-95%	Low risk	1 point source facility	Low	Moderate, 13 exceptionally high temperatures/year
Florence	86-100%	Entire area	Several railway lines 3 point source facilities	Low	Moderate
Watts	61-100%	Entire area	1 hazardous waste facility, 2 railway lines	Low	Moderate
Boyle Heights	56-90%	Northern portions	Several railway lines, 7 hazardous waste facilities, 6 point source facilities	Low	Moderate
Koreatown	47-79%	Low risk	Low	High	Moderate

Source: American Red Cross Los Angeles Region (2014). "PrepareLA– Vulnerable Communities Project." Los Angeles, CA.

Table 4-9. Vulnerable Neighborhood Race/Ethnicity, Educational Attainment, and Language Ability

Neighborhood	Population	Race/Ethnicity Other Than White	Educational Attainment (HS Diploma or Higher)	Speak English Less Than Very Well/ Non-English Languages
Westlake	104,246	95.2%	54.4%	58.4% (Spanish, Korean, Tagalog)
Historic South-Central	46,892	98.8%	34.9%	58.4% (Spanish, Korean, Thai)
South Park	32,938	98.8%	39.8%	48.5% (Spanish, Korean, Thai)
Central-Alameda	42,124	99.5%	33.6%	48.5% (Spanish, Korean, Thai)
Pico Union	41,545	96.4%	46.5%	59.8% (Spanish, Korean, Tagalog)
Florence	47,839	99.1%	42.5%	44.7% (Spanish, Cambodian, Mon-Kmer)
Watts	39,362	99.3%	46.4%	31.8% (Spanish, Korean, Japanese)
Boyle Heights	89,498	97.8%	45.4%	51.6% (Spanish, Chinese, Tagalog)
Koreatown	108,363	92.5%	69.5%	56.6% (Spanish, Korean, Tagalog)

Source: American Red Cross Los Angeles Region (2014). "PrepareLA– Vulnerable Communities Project." Los Angeles, CA.

4.8.1 Westlake Community

Westlake is a commercial neighborhood in central Los Angeles near MacArthur Park, bordered by Silver Lake, Echo Park, Downtown, Pico-Union, and Koreatown. With over 100,000 residents in 2.72 square miles (46,201 people per square mile), it is the second densest neighborhood in Los Angeles County. The median household income is low, with 67.4 percent below 200 percent of the federal poverty line. The percent of households without access to a vehicle is 35.4 percent. An age dependency ratio of 47 percent means that for every 100 working age adults there are 47 dependents, a rate slightly lower than the city's other vulnerable communities.

4.8.2 Historic South-Central Community

Historic South-Central is 3 miles southwest of Downtown Los Angeles, east of the I-110 freeway and south of the I-10 freeway. Almost 47,000 residents live within in a 2.5-square-mile area, placing it among the city's 20 densest neighborhoods. Historic South-Central's population is more than 77 percent low-income and almost 45 percent single-parent households. Just over one-quarter of all households do not have a car. The number of dependents in the area is slightly higher than average, with 62 dependents for every 100 working age adults.

4.8.3 South Park Community

South Park is just south of Historic South-Central, east of the I-110 freeway and bounded by Vernon Avenue to the north and Slauson Avenue to the south. The neighborhood is home to just under 33,000 people and covers 1.4 square miles. With over 24,000 people per square mile, it is one of Los Angeles County's densest communities. One in five households does not have a vehicle and an age dependency ratio of 68.9 percent means that for every 100 working age adults there are nearly 70 dependents.

4.8.4 Central-Alameda Community

The Central-Alameda district is just east of Historic South-Central and South Park. It is bounded by Central Avenue to the west, Slauson Street to the south, Alameda Street to the East, and Washington Boulevard to the north. The neighborhood has over 42,000 residents and covers 2.2 square miles, placing it among the city's 20 densest neighborhoods. More than two-thirds of households are low-income. Just 33 percent of residents over the age of 25 hold at least a high school diploma. One in five households does not have a vehicle. For every 100 working age adults there are about 66 dependents.

4.8.5 Pico Union Community

The Pico-Union district is immediately south of the Westlake and Koreatown neighborhoods. It is bounded by Olympic Boulevard on the north, the I-110 freeway to the east, and the I-10 freeway to the south. Over 41,000 people reside in its 1.67 square miles, making it one of the County's densest communities. More than 71 percent are low-income. More than half the population over the age of 25 does not hold a high school diploma or its equivalent. Three in 10 households lack a vehicle. There are 52 dependents for every 100 working age adults.

4.8.6 Florence Community

The Florence neighborhood is just south of Historic South-Central and South Park. Just fewer than 48,000 people reside within its 2.8 square miles. Florence has 71.4 percent low-income households, and more than 44 percent are headed by a single parent.

4.8.7 Watts Community

Watts lies north of the I-105 freeway and contains the public housing developments of Imperial Courts, Jordan Downs, and Nickerson Gardens. The area of Watts is 2.1 square miles, with just under 40,000 people, ranking it among the city's 10 densest neighborhoods. Over 71 percent are low-income. Nearly 20 percent of households lack an automobile. The age dependency ratio in Watts is the highest among the most vulnerable communities, with 84 dependents for every 100 working age adults.

4.8.8 Boyle Heights Community

Boyle Heights is a mainly residential neighborhood just east of the Los Angeles River and west of Indiana Street. Over 89,000 people live in its area of 6.5 square miles. Nearly 70 percent of households are low-income and almost 21 percent of households do not have access to a vehicle. The age dependency ratio is high, with almost 70 dependents for every 100 working age adults.

4.8.9 Koreatown Community

Koreatown is just west of Westlake. The district is home to over 108,000 people and covers 2.7 square miles. With a population density of nearly 52,000 people per square mile, it is one of the densest areas of both the City and County of Los Angeles. Nearly 60 percent of households are low-income. Almost 28 percent do not have access to a vehicle. Just fewer than 25 percent of households are headed by a single parent.

4.9 LAWS AND ORDINANCES

Existing laws, ordinances, plans and programs at the federal, state and local level can support or impact hazard mitigation actions identified in this plan. Hazard mitigation plans are required to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process (44 CFR, Section 201.6(b)(3)). The following federal and state programs have been identified as programs that may interface with the actions identified in this plan. Each of these programs enhances capabilities to implement the mitigation actions in this plan or has a nexus with the mitigation actions in this plan. The purpose of this section is to inform a thorough review of local capability to implement the actions, as presented in in Section 4.9.4.

4.9.1 Federal

Disaster Mitigation Act

The DMA is the current federal legislation addressing hazard mitigation planning. It emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Assistance grant funds are available to communities. This plan is designed to meet the requirements of DMA, improving eligibility for future hazard mitigation funds.

Emergency Watershed Program

The USDA Natural Resources Conservation Service (NRCS) administers the Emergency Watershed Protection (EWP) Program, which responds to emergencies created by natural disasters. Eligibility for assistance is not dependent on a national emergency declaration. The program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, windstorms, and other natural occurrences. EWP is an emergency recovery program. Financial and technical assistance are available for the following activities (Natural Resources Conservation Service, 2016):

- Remove debris from stream channels, road culverts, and bridges
- Reshape and protect eroded banks
- Correct damaged drainage facilities
- Establish cover on critically eroding lands
- Repair levees and structures
- Repair conservation practices.

This federal program has objectives similar to those of the Disaster Mitigation Act and could be a funding source for actions identified in this plan.

Emergency Relief for Federally Owned Roads Program

The U.S. Forest Service's Emergency Relief for Federally Owned Roads Program was established to assist federal agencies with repair or reconstruction of tribal transportation facilities, federal lands transportation facilities, and other federally owned roads that are open to public travel and have suffered serious damage by a natural disaster over a wide area or by a catastrophic failure. The program funds both emergency and permanent repairs (Office of Federal Lands Highway, 2016). Eligibility under this program corresponds with some of the goals and objectives for this plan, so this could be a funding source for actions identified in this plan.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study. The study presents water surface elevations for floods of various magnitudes, including the 1-percent annual-chance flood (called the 100-year flood or base flood) and the 0.2-percent annual chance flood (the 500-year flood). Base flood elevations and the boundaries of the 1-percent-annual-chance and 0.2-percent-annual-chance floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principle tool for identifying the extent and location of the flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under the local floodplain management program. In recent years, FIRMs have been digitized as Digital Flood Insurance Rate Maps (DFIRMs), which are more accessible to residents, local government and stakeholders.

Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, they must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 1-percent annual-chance flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened and endangered species.

Full compliance and good standing under the NFIP are prerequisites for all of the FEMA grant programs to which this plan acts as a keyway.

Community Rating System

The Community Rating System (CRS) is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

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

For participating communities, flood insurance premium rates are discounted in increments of 5 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. The CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness.

Figure 4-23 shows the nationwide number of CRS communities by class as of October 2016, when there were 1,391 communities receiving flood insurance premium discounts under the CRS program.

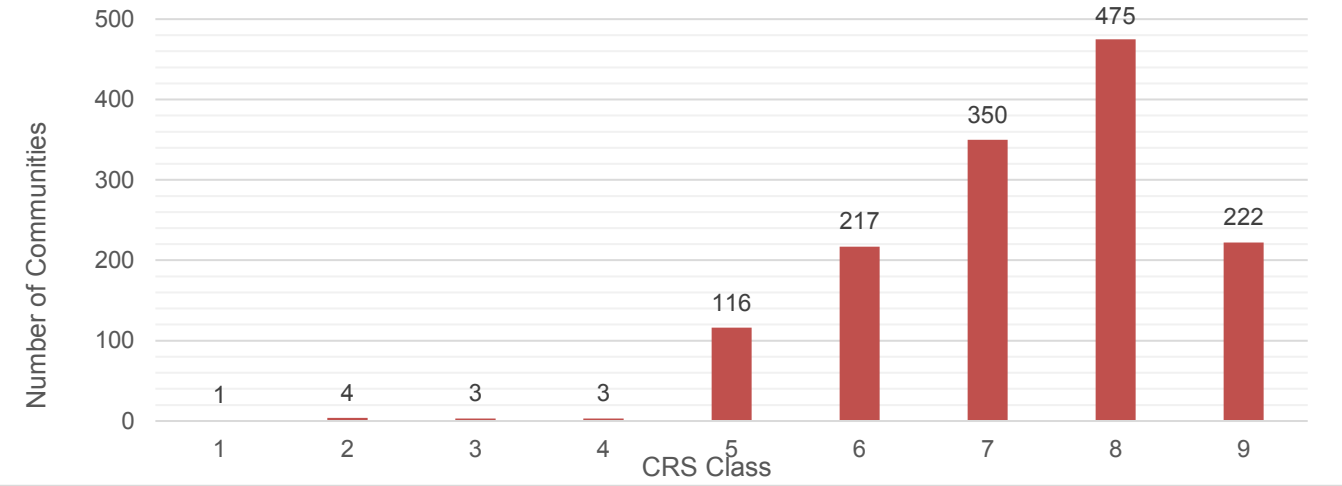


Figure 4-23. CRS Communities by Class Nationwide as of October 2016

CRS activities can help to save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks. The City of Los Angeles has participated in the CRS program since 1991. Many of the programs the City is receiving credit for under the CRS program strive to reduce the impacts from flood-related hazards within the City.

Presidential Executive Orders 11988 and 13690

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. It requires federal agencies to provide leadership and take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health, and welfare, and restore and preserve the natural and beneficial values of floodplains. The requirements apply to the following activities (FEMA, 2015a):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

Executive Order 13690 expands Executive Order 11988 and acknowledges that the impacts of flooding are anticipated to increase over time due to the effects of climate change and other threats. It mandates a federal flood risk management standard to increase resilience against flooding and help preserve the natural values of floodplains. This standard expands management of flood issues from the current base flood level to a higher vertical elevation and corresponding horizontal floodplain. The goal is to address current and future flood risk and ensure that projects funded with taxpayer dollars last as long as intended (Office of the Press Secretary, 2015). All actions identified in this plan will seek full compliance with all presidential executive orders that may interface with the given action.

The Clean Water Act

The federal Clean Water Act (CWA) employs regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's surface waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Evolution of CWA programs over the last decade has included a shift from a program-by-program, source-by-source, pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach, equal emphasis is placed on protecting healthy waters and restoring impaired ones. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining water quality and other environmental goals is a hallmark of this approach.

The CWA is important to hazard mitigation in several ways. There are often permitting requirements for any construction within 200 feet of water of the United States, which may have implications for mitigation projects identified by a local jurisdiction. Additionally, CWA requirements apply to wetlands, which serve important functions related to preserving and protecting the natural and beneficial functions of floodplains and are linked with a community's floodplain management program. Finally, the National Pollutant Discharge Elimination

System is part of the CWA and addresses local stormwater management programs. Stormwater management plays a critical role in hazard mitigation by addressing urban drainage or localized flooding issues within jurisdictions.

Any action identified in this plan that has overlap with the scope of the CWA will need to comply with the act. All FEMA hazard mitigation project grant applications require full compliance with all federal acts that may interface with the action.

Presidential Executive Order 11990

Executive Order 11990 requires federal agencies to provide leadership and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. The requirements apply to the following activities (National Archives, 2016):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

All actions identified in this plan will seek full compliance with all presidential executive orders that may interface with the given action.

Endangered Species Act

The federal Endangered Species Act (ESA) was enacted in 1973 to conserve species facing depletion or extinction and the ecosystems that support them. The act sets forth a process for determining which species are threatened and endangered and requires the conservation of the critical habitat in which those species live. The ESA provides broad protection for species of fish, wildlife and plants that are listed as threatened or endangered. Provisions are made for listing species, as well as for recovery plans and the designation of critical habitat for listed species. The ESA outlines procedures for federal agencies to follow when taking actions that may jeopardize listed species and contains exceptions and exemptions. It is the enabling legislation for the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Criminal and civil penalties are provided for violations of the ESA and the Convention.

Federal agencies must seek to conserve endangered and threatened species and use their authorities in furtherance of the ESA's purposes. The ESA defines three fundamental terms:

- **Endangered** means that a species of fish, animal or plant is "in danger of extinction throughout all or a significant portion of its range." (For salmon and other vertebrate species, this may include subspecies and distinct population segments.)
- **Threatened** means that a species "is likely to become endangered within the foreseeable future." Regulations may be less restrictive for threatened species than for endangered species.
- **Critical habitat** means "specific geographical areas that are…essential for the conservation and management of a listed species, whether occupied by the species or not."

Five sections of the ESA are of critical importance to understanding it:

- **Section 4: Listing of a Species**—The National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) is responsible for listing marine species; the U.S. Fish and Wildlife Service is responsible for listing terrestrial and freshwater aquatic species. The agencies may initiate reviews for listings, or residents may petition for them. A listing must be made "solely on the basis of the best scientific and commercial data available." After a listing has been proposed, agencies receive comment and conduct further scientific reviews for 12 to 18 months, after which they must decide if the listing is

warranted. Economic impacts cannot be considered in this decision, but it may include an evaluation of the adequacy of local and state protections. Critical habitat for the species may be designated at the time of listing.

- **Section 7: Consultation**—Federal agencies must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed or proposed species or adversely modify its critical habitat. This includes private and public actions that require a federal permit. Once a final listing is made, non-federal actions are subject to the same review, termed a "consultation." If the listing agency finds that an action will "take" a species, it must propose mitigations or "reasonable and prudent" alternatives to the action; if the proponent rejects these, the action cannot proceed.
- **Section 9: Prohibition of Take—**It is unlawful to "take" an endangered species, including killing or injuring it or modifying its habitat in a way that interferes with essential behavioral patterns, including breeding, feeding or sheltering.
- **Section 10: Permitted Take**—Through voluntary agreements with the federal government that provide protections to an endangered species, a non-federal applicant may commit a take that would otherwise be prohibited as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). These agreements often take the form of a "Habitat Conservation Plan."
- **Section 11: Citizen Lawsuits**—Civil actions initiated by any citizen can require the listing agency to enforce the ESA's prohibition of taking or to meet the requirements of the consultation process.

Any action identified in this plan that has overlap with the ESA will need to comply with the act. All FEMA hazard mitigation project grant applications require full compliance with all federal acts that may interface with the action.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental impacts of proposed actions and reasonable alternatives to those actions, alongside technical and economic considerations. NEPA established the Council on Environmental Quality (CEQ), whose regulations (40 CFR Parts 1500-1508) set the standard for NEPA compliance. Consideration of environmental impacts and decision-making process is documented in an environmental impact statement or environmental assessment. Environmental impact assessment requires the evaluation of reasonable alternatives to a proposed action, solicitation of input from organizations and individuals that could be affected, and the unbiased presentation of direct, indirect, and cumulative environmental impacts. Any action identified in this plan that has overlap with the scope of NEPA will need to comply with the act. All FEMA hazard mitigation project grant applications require full compliance with all federal acts that may interface with the action.

National Incident Management System

The National Incident Management System (NIMS) is a systematic approach for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards. The NIMS provides a flexible but standardized set of incident management practices. Incidents typically begin and end locally, and they are managed at the lowest possible geographical, organizational, and jurisdictional level. In some cases, success depends on the involvement of multiple jurisdictions, levels of government, functional agencies, and emergency responder disciplines. These cases necessitate coordination across a spectrum of organizations. Communities using NIMS follow a comprehensive national approach that improves the effectiveness of emergency management and response personnel across the full spectrum of potential hazards (including natural hazards, technological hazards, and human-caused hazards) regardless of size or complexity. Although participation is voluntary, federal departments and agencies are required to make adoption of NIMS by local and state jurisdictions a condition to receive federal preparedness grants and awards.

Hazard mitigation is one of the four phases of emergency management (preparedness, response, recovery and mitigation), and this plan is a viable support tool for any of these phases. Since NIMS is a response function, information in the hazard mitigation plan can support the implementation and update of all NIMS-compliant plans within the City.

Americans with Disabilities Act

The Americans with Disabilities Act (ADA) seeks to prevent discrimination against people with disabilities in employment, transportation, public accommodation, communications, and government activities. Title II of the ADA deals with compliance with the Act in emergency management and disaster-related programs, services, and activities. It applies to state and local governments as well as third parties, including religious entities and private nonprofit organizations. Any action identified in this plan that has overlap with the scope of the ADA will need to comply with the act. All FEMA hazard mitigation project grant application require full compliance with all federal acts that may interface with the action.

The ADA has implications for sheltering requirements and public notifications. During an emergency alert, officials must use a combination of warning methods to ensure that all residents have all necessary information. Those with hearing impairments may not hear radio, television, sirens, or other audible alerts, while those with visual impairments may not see flashing lights or other visual alerts. Two technical documents for shelter operators address physical accessibility needs of people with disabilities, as well as medical needs and service animals.

The ADA intersects with disaster preparedness programs in regards to transportation, social services, temporary housing, and rebuilding. Persons with disabilities may require additional assistance in evacuation and transit (e.g., vehicles with wheelchair lifts or paratransit buses). Evacuation and other response plans should address the unique needs of residents. Local governments may be interested in implementing a special-needs registry to identify the home addresses, contact information, and needs for residents who may require more assistance.

Civil Rights Act of 1964

The Civil Rights Act of 1964 prohibits discrimination based on race, color, religion, sex or nation origin and requires equal access to public places and employment. The Act is relevant to emergency management and hazard mitigation in that it prohibits local governments from favoring the needs of one population group over another. Local government and emergency response must ensure the continued safety and well-being of all residents equally, to the extent possible. Any action identified in this plan that has overlap with the Civil Rights Act will need to comply with the act. All FEMA hazard mitigation project grant application require full compliance with all federal acts that may interface with the action.

Community Development Block Grant Disaster Resilience Program

In response to disasters, Congress may appropriate additional funding for the U.S. Department of Housing and Urban Development Community Development Block Grant programs to be distributed as Disaster Recovery grants (CDBG-DR). These grants can be used to rebuild affected areas and provide seed money to start the recovery process. CDBG-DR assistance may fund a broad range of recovery activities, helping communities and neighborhoods that otherwise might not recover due to limited resources. CDBG-DR grants often supplement disaster programs of the Federal Emergency Management Agency, the Small Business Administration, and the U.S. Army Corps of Engineers. Housing and Urban Development generally awards noncompetitive, nonrecurring CDBG-DR grants by a formula that considers disaster recovery needs unmet by other federal disaster assistance programs. To be eligible for CDBG-DR funds, projects must meet the following criteria:

- Address a disaster-related impact (direct or indirect) in a presidentially declared county for the covered disaster

- Be a CDBG-eligible activity (according to regulations and waivers)
- Meet a national objective.

Incorporating preparedness and mitigation into these actions is encouraged, as the goal is to rebuild in ways that are safer and stronger. The CDGB-DR program is a potential alternative source of funding for actions identified in this plan.

Army Corps of Engineers Programs

The U.S. Army Corps of Engineers has several civil works authorities and programs related to flood risk and flood hazard management:

- The Floodplain Management Services program offers 100-percent federally funded technical services such as development and interpretation of site-specific data related to the extent, duration and frequency of flooding. Special studies may be conducted to help a community understand and respond to flood risk. These may include flood hazard evaluation, flood warning and preparedness, or flood modeling.
- For more extensive studies, the Corps of Engineers offers a cost-shared program called Planning Assistance to States and Tribes. Studies under this program generally range from $25,000 to $100,000 with the local jurisdiction providing 50 percent of the cost.
- The Corps of Engineers has several cost-shared programs (typically 65 percent federal and 35 percent non-federal) aimed at developing, evaluating and implementing structural and non-structural capital projects to address flood risks at specific locations or within a specific watershed:

  - The Continuing Authorities Program for smaller-scale projects includes Section 205 for Flood Control, with a $7 million federal limit and Section 14 for Emergency Streambank Protection with a $1.5 million federal limit. These can be implemented without specific authorization from Congress.
  - Larger scale studies, referred to as General Investigations, and projects for flood risk management, for ecosystem restoration or to address other water resource issues, can be pursued through a specific authorization from Congress and are cost-shared, typically at 65 percent federal and 35 percent non-federal.
  - Watershed management planning studies can be specifically authorized and are cost-shared at 50 percent federal and 50 percent non-federal.

- The Corps of Engineers provides emergency response assistance during and following natural disasters. Public Law 84-99 enables the Corps to assist state and local authorities in flood fight activities and cost share in the repair of flood protective structures. Assistance is provided in the flowing categories:

  - **Preparedness—**The Flood Control and Coastal Emergency Act establishes an emergency fund for preparedness for emergency response to natural disasters; for flood fighting and rescue operations; for rehabilitation of flood control and hurricane protection structures. Funding for Corps of Engineers emergency response under this authority is provided by Congress through the annual Energy and Water Development Appropriation Act. Disaster preparedness activities include coordination, planning, training and conduct of response exercises with local, state and federal agencies.
  - **Response Activities—**PL 84-99 allows the Corps of Engineers to supplement state and local entities in flood fighting urban and other non-agricultural areas under certain conditions (Engineering Regulation 500-1-1 provides specific details). All flood fight efforts require a project cooperation agreement signed by the public sponsor and the sponsor must remove all flood fight material after the flood has receded. PL 84-99 also authorizes emergency water support and drought assistance in certain situations and allows for “advance measures” assistance to prevent or reduce flood damage conditions of imminent threat of unusual flooding.

- **Rehabilitation—**Under PL 84-99, an eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the federal system owner, and at 20-percent cost to the eligible non-federal system owner. All systems considered eligible for PL 84-99 rehabilitation assistance have to be in the Rehabilitation and Inspection Program prior to the flood event. Acceptable operation and maintenance by the public levee sponsor are verified by levee inspections conducted by the Corps on a regular basis. The Corps has the responsibility to coordinate levee repair issues with interested federal, state, and local agencies following natural disaster events where flood control works are damaged.

All of these authorities and programs are available to the City of Los Angeles to support any intersecting mitigation actions.

4.9.2 State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was enacted in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The Alquist-Priolo Earthquake Fault Zoning Act's main purpose is to prevent construction of buildings used for human occupancy on the surface trace of active faults. Before a new project is permitted, cities and counties require a geologic investigation to demonstrate that proposed buildings will not be constructed on active faults. The act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards, such as liquefaction or seismically induced landslides. The law requires the State of California geologist to establish regulatory zones around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their use in planning and controlling new or renewed construction. Local agencies must regulate most development projects within the zones. Projects include all land divisions and most structures for human occupancy. All seismic hazard mitigation actions identified in this plan will seek full compliance with the Alquist-Priolo Earthquake Fault Zoning Act.

California General Planning Law

California state law requires that every county and city prepare and adopt a comprehensive long-range plan to serve as a guide for community development. The general plan expresses the community's goals, visions, and policies relative to future land uses, both public and private. The general plan is mandated and prescribed by state law (Cal. Gov. Code §65300 et seq.), and forms the basis for most local government land use decision-making.

The plan must consist of an integrated and internally consistent set of goals, policies, and implementation measures. In addition, the plan must focus on issues of the greatest concern to the community and be written in a clear and concise manner. City actions, such as those relating to land use allocations, annexations, zoning, subdivision and design review, redevelopment, and capital improvements, must be consistent with the plan.

The City of Los Angeles has a general plan that is currently compliant with this law and has committed to integrating this mitigation plan with its general plan through other provisions referenced below (AB-2140 and SB-379).

California Environmental Quality Act

The California Environmental Quality Act (CEQA) was passed in 1970, shortly after the federal government passed the National Environmental Policy Act, to institute a statewide policy of environmental protection. CEQA requires state and local agencies in California to follow a protocol of analysis and public disclosure of the potential environmental impacts of development projects. CEQA makes environmental protection a mandatory part of every California state and local agency's decision making process.

CEQA establishes a statewide environmental policy and mandates actions all state and local agencies must take to advance the policy. For any project under CEQA's jurisdiction with potentially significant environmental impacts, agencies must identify mitigation measures and alternatives by preparing an environmental impact report and may approve only projects with no feasible mitigation measures or environmentally superior alternatives.

All discretionary actions require environmental review pursuant to CEQA. However, the CEQA guidelines list classes of projects that have been determined to not have a significant effect on the environment—referred to as categorical exemptions. These include feasibility and planning studies for possible future action. Planning processes such as hazard mitigation planning meet the criteria for this exemption, so the City of Los Angeles has determined that this plan update is categorically exempt from the formal CEQA protocol. The City will initiate the formal CEQA protocol on any project recommended in this plan that requires adherence to this protocol at the initiation of the project. Any project action identified in this plan will seek full CEQA compliance upon implementation.

Assembly Bill 162: Flood Planning

This California State Assembly bill passed in 2007 requires cities and counties to address flood-related matters in the land use, conservation, and safety and housing elements of their general plans. The land use element must identify and annually review the areas covered by the general plan that are subject to flooding as identified in floodplain mapping by either FEMA or the state Department of Water Resources (DWR). Upon the next revision of the housing element on or after January 1, 2009, the conservation element of the general plan must identify rivers, creeks, streams, flood corridors, riparian habitat, and land that may accommodate floodwater for the purposes of groundwater recharge and stormwater management. The safety element must identify information regarding flood hazards including:

- Flood hazard zones
- Maps published by FEMA, DWR, the U.S. Army Corps of Engineers, the Central Valley Flood Protection Board, California Office of Emergency Services (Cal OES), etc.
- Historical data on flooding
- Existing and planned development in flood hazard zones.

The general plan must establish goals, policies and objectives to protect from unreasonable flooding risks including:

- Avoiding or minimizing the risks of flooding new development
- Evaluating whether new development should be located in flood hazard zones
- Identifying construction methods to minimize damage.

Assembly Bill (AB) 162 establishes goals, policies and objectives to protect from unreasonable flooding risks. It establishes procedures for the determination of available land suitable for urban development, which may exclude lands where FEMA or DWR has determined that the flood management infrastructure is not adequate to avoid the risk of flooding.

The City of Los Angeles has developed a Comprehensive Flood Hazard Management Plan that was most recently updated in 2016 and is fully complaint with this bill and FEMA's CRS program. The flood management plan is considered to be fully integrated by reference in this hazard mitigation plan.

Assembly Bill 2140: General Plans—Safety Element

This bill provides that the state may allow for more than 75 percent of public assistance funding under the California Disaster Assistance Act only if the local agency is in a jurisdiction that has adopted a local hazard mitigation plan as part of the safety element of its general plan. The local hazard mitigation plan needs to include

elements specified in this legislation. In addition this bill requires Cal OES to give federal mitigation funding preference to cities and counties that have adopted local hazard mitigation plan. The intent of the bill is to encourage cities and counties to create and adopt hazard mitigation plans.

Assembly Bill 70: Flood Liability

This bill provides that a city or county may be required to contribute a fair and reasonable share to compensate for property damage caused by a flood to the extent that it has increased the state's exposure to liability for property damage by unreasonably approving new development in a previously undeveloped area that is protected by a state flood control project, unless the city or county meets specified requirements.

Assembly Bill 32: The California Global Warming Solutions Act

This bill addresses greenhouse gas emissions. It identifies the following potential adverse impacts of global warming:

> "… the exacerbation of air quality problems, a reduction in the quality and supply of water to the state from the Sierra snowpack, a rise in sea levels resulting in the displacement of thousands of coastal businesses and residences, damage to marine ecosystems and the natural environment, and an increase in the incidences of infectious diseases, asthma, and other human health-related problems."

AB 32 establishes a state goal of reducing greenhouse gas emissions to 1990 levels by 2020 (a reduction of approximately 25 percent from forecast emission levels) with further reductions to follow. The law requires the state Air Resources Board to do the following:

- Establish a program to track and report greenhouse gas emissions.
- Approve a scoping plan for achieving the maximum technologically feasible and cost-effective reductions from sources of greenhouse gas emissions.
- Adopt early reduction measures to begin moving forward.
- Adopt, implement and enforce regulations—including market mechanisms such as "cap and-trade" programs—to ensure that the required reductions occur.

The Air Resources Board recently adopted a statewide greenhouse gas emissions limit and an emissions inventory, along with requirements to measure, track, and report greenhouse gas emissions by the industries it determined to be significant sources of greenhouse gas emissions.

Assembly Bill 2800: Climate Change—Infrastructure Planning

This California State Assembly bill passed in 2016. Until July 1, 2020, it requires state agencies to take into account the current and future impacts of climate change when planning, designing, building, operating, maintaining, and investing in state infrastructure. The bill requires agencies to establish a Climate-Safe Infrastructure Working Group by July 1, 2017, for the purpose of examining how to integrate scientific data concerning projected climate change impacts into state infrastructure engineering, and maintaining the group until July 1, 2020.

Senate Bill 97: Guidelines for Greenhouse Gas Emissions

Senate Bill 97, enacted in 2007, amended CEQA to clearly establish that greenhouse gas emissions and the effects of greenhouse gas emissions are appropriate subjects for CEQA analysis. It directed the Governor's Office of Planning and Research to develop draft CEQA guidelines for the mitigation of greenhouse gas emissions or their effects by July 1, 2009 and directed the California Natural Resources Agency to certify and adopt the CEQA Guidelines by January 1, 2010.

Senate Bill 1000: General Plan Amendments—Safety and Environmental Justice Elements

Senate Bill 1000, adopted in 2016, amends California's Planning and Zoning Law in two ways:

- The original law established requirements for initial revisions of general plan safety elements to address flooding, fire, and climate adaptation and resilience. It also required subsequent review and revision as necessary based on new information. Senate Bill 1000 specifies that the subsequent reviews and revision based on new information are required to address only flooding and fires (not climate adaptation and resilience).
- Senate Bill 1000 adds a requirement that, upon adoption or revision of any two other general plan elements on or after January 1, 2018, an environmental justice element be adopted for the general plan or environmental justice goals, policies and objectives be incorporated into other elements of the plan.

Senate Bill 1241: General Plans: Safety Element—Fire Hazard Impacts

In 2012, Senate Bill 1241 passed requiring that all future general plans address fire risk in state responsibility areas and very high fire hazard severity zones in their safety element. In addition, the bill requires cities and counties to make certain findings regarding available fire protection and suppression services before approving a tentative map or parcel map.

Senate Bill 379: General Plans: Safety Element—Climate Adaptation

Senate Bill (SB) 379 builds upon the flood planning inclusions into the safety and housing elements and the hazard mitigation planning safety element inclusions in general plans outlined in AB 162 and AB 2140, respectively. SB 379 focuses on a new requirement that cities and counties include climate adaptation and resiliency strategies in the safety element of their general plans beginning January 1, 2017. In addition, this bill requires general plans to include a set of goals, policies and objectives, and specified implementation measures based on the conclusions drawn from climate adaptation research and recommendations.

This update process for this hazard mitigation plan was conducted with the intention of full compliance with this bill. However, at the time of the update, there was no clear guidance from the state on what constitutes full compliance or what protocol is to be used to determine compliance. When such guidance has been established, the City will submit this plan or its subsequent updates to the state for review and approval.

California State Building Code

California Code of Regulations Title 24 (CCR Title 24), also known as the California Building Standards Code, is a compilation of building standards from three sources:

- Building standards that have been adopted by state agencies without change from building standards contained in national model codes
- Building standards that have been adopted and adapted from the national model code standards to meet California conditions
- Building standards authorized by the California legislature that constitute extensive additions not covered by the model codes adopted to address particular California concerns.

The state Building Standards Commission is authorized by California Building Standards Law (Health and Safety Code Sections 18901 through 18949.6) to administer the processes related to the adoption, approval, publication, and implementation of California's building codes. These building codes serve as the basis for the design and construction of buildings in California. The national model code standards adopted into Title 24 apply to all occupancies in California except for modifications adopted by state agencies and local governing bodies. Since 1989, the Building Standards Commission has published new editions of Title 24 every three years.

On January 1, 2014, California Building Code Accessibility Standards found in Chapter 11B incorporated the 2010 Americans with Disabilities Act (ADA) Standards as the model accessibility code for California. The purpose for this incorporation was to ensure consistency with federal guidelines. As a result of this incorporation, the California standards will fully implement and include 2010 ADA Standards within the California Building Code while maintaining enhanced levels of accessibility already provided by existing California accessibility regulations. The City has adopted building codes that are in full compliance with the California State Building Code.

Standardized Emergency Management System

CCR Title 19 establishes the Standardized Emergency Management System (SEMS) to standardize the response to emergencies involving multiple jurisdictions. SEMS is intended to be flexible and adaptable to the needs of all emergency responders in California. It requires emergency response agencies to use basic principles and components of emergency management. Local governments must use SEMS by December 1, 1996 in order to be eligible for state funding of response-related personnel costs under CCR Title 19 (Sections 2920, 2925 and 2930). Individual agencies' roles and responsibilities contained in existing laws or the state emergency plan are not superseded by these regulations. This hazard mitigation plan is considered to be a support document for all phases of emergency management, including those associated with SEMS.

State of California Multi-Hazard Mitigation Plan

Under the DMA, California must adopt a federally approved state multi-hazard mitigation plan to be eligible for certain disaster assistance and mitigation funding. The intent of the *State of California Multi-Hazard Mitigation Plan* is to reduce or prevent injury and damage from hazards in the state through the following:

- Documenting statewide hazard mitigation planning in California
- Describing strategies and priorities for future mitigation activities
- Facilitating the integration of local and tribal hazard mitigation planning activities into statewide efforts
- Meeting state and federal statutory and regulatory requirements.

The plan is an annex to the *State Emergency Plan*, and it identifies past and present mitigation activities, current policies and programs, and mitigation strategies for the future. It also establishes hazard mitigation goals and objectives. The plan will be reviewed and updated annually to reflect changing conditions and new information, especially information on local planning activities.

Under 44 CFR Section 201.6, local hazard mitigation plans must be consistent with their state's hazard mitigation plan. In updating this plan, the Steering Committee reviewed the California State Hazard Mitigation Plan to identify key relevant state plan elements (see Section 3.6).

California Coastal Management Program

The California Coastal Management Program under the California Coastal Act requires each city or county lying wholly or partly within the coastal zone to prepare a Local Coastal Plan. The specific contents of such plans are not specified by state law, but they must be certified by the Coastal Commission as consistent with policies of the Coastal Act (Public Resources Code, Division 20). The Coastal Act has provisions relating to geologic hazards, but does not mention tsunamis specifically. Section 30253(1) of the Coastal Act, states that new development shall minimize risks to life and property in areas of high geologic, flood, and fire hazard. Development should be prevented or limited in high hazard areas whenever possible. However, where development cannot be prevented or limited, land use density, building value, and occupancy should be kept at a minimum. There are identified coastal zones in Los Angeles, and the City has developed a local coastal plan to address them. Any mitigation project identified in this plan that intersects the mapped coastal zone will be consistent with the recommendations of the City's coastal plan.

Governor's Executive Order S-13-08

Governor's Executive Order S-13-08 enhances the state's management of climate impacts from sea level rise, increased temperatures, shifting precipitation and adverse weather events. It required the following key actions:

- Initiate California's first statewide climate change adaptation strategy to assess expected climate change impacts, identify where California is most vulnerable, and recommend adaptation policies by early 2009. This effort will improve coordination within state government so that better planning can more effectively address climate impacts on human health, the environment, the state's water supply and the economy.
- Request that the National Academy of Science establish an expert panel to report on sea level rise impacts in California, to inform state planning and development efforts.
- Issue interim guidance to state agencies for how to plan for sea level rise in designated coastal and floodplain areas for new projects.
- Initiate a report on critical infrastructure projects vulnerable to sea level rise.

Los Angeles Regional Water Quality Control Board

The Los Angeles Regional Water Quality Control Board protects ground and surface water quality in the Los Angeles region. It is one of nine regional boards statewide under the California Environmental Protection Agency. The board conducts the following activities to protect ground and surface waters under its jurisdiction (California State Water Resources Control Board, 2015):

- Address region-wide and specific water quality concerns through updates of the Water Quality Control Plan (Basin Plan) for the Los Angeles Region.
- Prepare, monitor compliance with, and enforce waste discharge requirements.
- Implement and enforce local stormwater control efforts.
- Regulate cleanup of contaminated sites that have polluted groundwater or surface water or could do so.
- Enforce water quality laws, regulations, and waste discharge requirements.
- Coordinate with other public agencies and groups that are concerned with water quality.
- Inform and involve the public on water quality issues.

4.9.3 City of Los Angeles

This section identifies locally sponsored programs, plans, and studies that can support or enhance the core capabilities of the City and the mitigation actions identified in this plan. Many were put in place by the City in response to the federal and state programs described in Sections 4.9.1 and 4.9.2. Each can be leveraged by the City to support or enhance the implementation of actions identified in Chapter 23 of this plan. These programs, plans and studies are to be considered in addition to the core capabilities identified in Section 4.9.4, and they are hereby integrated into this hazard mitigation plan by reference. Mitigation actions identified in the programs, plans and studies are considered to be fully integrated into this hazard mitigation plan by reference.

General Plan

The Los Angeles General Plan is a comprehensive set of purposes, policies and programs to guide the future form and development of the City. The plan is approved by the City Council and the Mayor and adopted by the Planning Commission. The General Plan is both a strategic and long-term document, broad in scope and specific in nature. It is implemented by decisions that direct the allocation of public resources and that shape private development, which affects the lives of the residents and business community. The General Plan is prepared and maintained by the Department of City Planning and must comply with the California General Planning Law. The law requires specific planning elements, including land use, circulation, housing, conservation, open space, noise, safety, and air quality. The City of Los Angeles' General Plan consists of the following elements:

- Plan for a Healthy LA: A Health and Wellness Element of the General Plan, March 2015
- The Citywide General Plan Framework: An Element of the General Plan, August 2001
- Air Quality Element: An Element of the City of Los Angeles General Plan, November 1992
- Conservation Element of the City of Los Angeles General Plan, September 2001
- The Housing Element 2013 – 2021 of the City of Los Angeles General Plan, December 2013
- Noise Element of the City of Los Angeles General Plan, February 1999
- The Open Space Element of the City of Los Angeles General Plan, June 1973
- Service Systems Element of the City of Los Angeles General Plan, Unknown Date
- Safety Element of the City of Los Angeles General Plan, November 1996
- Mobility Plan 2035, An Element of the General Plan, September 2016 (used to be Transportation Plan)
- The Land Use Element of the General Plan, July 2003 (consisting of 35 community plans)

The Safety Element addresses protection from unreasonable risks associated with natural disasters, including fire and rescue, stormwater and inundation, slope failure and subsidence, seismic events, and hazardous materials. The Safety Element includes the Emergency Operations Organization and other interagency coordination, the California State safety element requirements, and emergency response, disaster recovery and hazard mitigation.

The Department of City Planning is reviewing all of the General Plan elements and establishing a suggested schedule for updating those plans that are still pending as well as developing a sequence for updating other existing elements. New laws, requirements, resources, and research that affect general planning include SB 375 (sustainable communities strategies), SB 5 (flood management), SB 743 (vehicle miles traveled), SB 244 (island or fringe communities), AB 52 (tribal consultation), and AB 2140 (local hazard mitigation plans).

Comprehensive Zoning Code

The Zoning Code regulates all land, building, structures, and uses within the City of Los Angeles. Since 2013, the City has been in the process of creating a new zoning code for the 21st century. The original zoning regulations were developed in 1946 and had not been revised since then. A new initiative called, “Plan re:code LA” is the City’s latest effort to update the zoning code with an engaged community vision, policies and implementation strategies, alignment with various adopted plans, land use and zoning maps, and address the issues of unique neighborhoods with needs that differ by neighborhood.

Los Angeles Municipal Code Chapter 1, Article 2, also known as the Comprehensive Zoning Plan of the City of Los Angeles, coordinates all City zoning regulations and provisions in order to regulate the location and use of buildings, structures and land. The goals of the Comprehensive Zoning Plan are to encourage the most appropriate use of land; to stabilize the value of property; to provide adequate open spaces; to prevent and fight fires; to prevent undue concentration of population; to lessen street congestion; to facilitate adequate provisions for transportation, water, sewerage, schools, parks and other public requirements; and to promote health, safety and the general welfare in accordance with the General Plan. It includes designation of zones that allow for floodplains and flood control facilities and presents design standards including those that deal with flood prevention and control.

Multi-Hazard Related Activities of City Departments

Several city departments perform activities and collect data related to hazard mitigation issues. The following is a summary of key city activities related to hazard and risk management:

- Department of Public Works, Bureau of Engineering
    - Maintain FEMA Flood Insurance Rate Map data.
    - Maintain a map of hillside areas.

- Maintain records of drainage complaints. Complaints are investigated by staff engineers or maintenance crews. Complaints have been entered into a database and geo-coded for display on the GIS.
- Maintain a list of known deficiencies. A project is identified to address each deficiency, so the deficiency list serves as a list of proposed projects. The projects can also be displayed on the GIS.
- Assess infrastructure damage through field investigations after major storms.
- Prepare geotechnical reports related to geologically unstable areas.
- Maintain a database of FEMA Repetitive Loss Properties.

- Department of Public Works

  - Assess infrastructure damage through field investigations after major hazard incidents.
  - Identify areas in need of frequent maintenance of the flood control system.
  - Provide post-disaster debris clearance.

- Department of Building and Safety

  - Identify mud-prone and landslide areas throughout the City.
  - Track the number of building permits issued in flood risk areas.
  - Lead the Safety Assessment Program using volunteers and mutual aid building inspectors in safety evaluation of the built environment in the aftermath of a disaster.

- Planning Department

  - Maintain demographic, building, land use and zoning data.
  - Provide hazard descriptions of fire and rescue, stormwater, inundation and other water action, slope failure and subsidence, seismic events, and hazardous materials and phases of disasters such as hazard mitigation, and multi-hazard emergency response and disaster recovery provided by the Safety Element of the General Plan.
  - Maintain tsunami maps, dam failure inundation maps and landslide hazard identification maps from the safety element of the General Plan (input from the State Division of Mines and Geology and the State Office of Emergency Services).
  - Assess City policy in maintaining open space and the effectiveness of regulatory and preventive standards in preventing flood damage.
  - Maintain list of natural and beneficial areas within the City (wetlands, riparian areas, sensitive areas, and habitat for rare or endangered species).

- Emergency Management Department

  - Establish and maintain a comprehensive citywide planning, training/exercise and coordination effort for mitigation, preparedness, response and recovery for multi-hazard incidents.
  - Activate and operate the City Emergency Operations Center for coordination of all-hazards incidents.
  - Maintain emergency operations plans and associated hazard-specific and functional support annexes for the City to respond to events.
  - Chair a City Tsunami Task Force, with recommendations for community outreach, educational programs, and tsunami signage in hazard areas.
  - Provide disaster awareness and emergency preparedness information to the public.
  - Provide emergency public information regarding emergency alert and warning, notifications, evacuations, and sheltering for the public and City personnel.

- Port of Los Angeles

- Maintain tsunami signage program.
- Evacuate vessels for the safety of crew members.
- Evacuate Port facilities and the Port area.
- Procure and maintain emergency supplies and equipment.
- Establish damage assessment and prioritization procedures.
- Identify shelter facilities.
- Provide employee emergency preparedness training.

- Department of Water and Power

  - Implement necessary planning in the design, construction, reconstruction and maintenance of water and power systems to carry out hazard and risk mitigation measures.
  - Security and Emergency Management Division to oversee security and emergency preparedness strategies, programs, and measures for the department.
  - Develop an Urban Water Management Plan every five years to comply with California's Urban Water Management Planning Act.

- Los Angeles Housing and Community Investment Department (HCID)

  - Systematic Code Enforcement Program—Under this award-winning proactive program, inspectors have legal authority from the City for code enforcement over all multi-family rental properties in the city. Building and Safety does not do this; HCID does. On a four-year cycle, on a schedule coordinated with every landlord, HCID systematically inspects all multi-family properties in the city on a variety of codes (building, plumbing, electrical and mechanical, health and safety, etc.) to ensure that life and fire safety systems are working and the property meets habitability standards.
  - Lead Hazard Remediation Program—This program provides grants to property owners to make their properties lead-safe and to eliminate health and safety hazards. The grants are primarily targeted to low-income families with children under the age of six. The program also provides education regarding the dangers of lead-based paint and health and safety hazards.

City of Los Angeles Resilience Program

The City of Los Angeles is committed to addressing resilience by strengthening the city's physical, social, and economic foundations. The Mayor's Office has adopted far-reaching strategies to develop the tools the City needs to rebound from major crises—including storms, earthquakes, and economic recessions—if and when they come. Led by the Mayor's office, the City's resilience program is based on plans and programs summarized below.

100 Resilient Cities

In 2013, the City of Los Angeles was selected as an inaugural member of 100 Resilient Cities network pioneered by the Rockefeller Foundation, an organization that helps cities confront 21st century challenges. The network gives cities tools to develop a road map to resilience:

- Financial and logistical guidance for establishing an innovative new position in city government—a Chief Resilience Officer—to lead the city's resilience efforts
- Expert support for development of a robust resilience strategy
- Connection with service providers and others who can help implement resilience strategies
- Membership in a global network of member cities that share best practices and support pioneering resilience.

Through these actions, the 100 Resilient Cities network aims to build urban resilience and establish guidelines for resilience among governments, non-governmental organizations, the private sector, and individual residents.

Resilience by Design

Released in December 2014, Resilience by Design addresses Los Angeles' greatest earthquake vulnerabilities, including building retrofitting and steps to secure the water supply and communications infrastructure. The report presents recommendations of the Mayoral Seismic Safety Task Force. These recommendations suggest strategic solutions to protect the lives of residents; improve the capacity of the City to respond to earthquakes; prepare the City to recover quickly from earthquakes; and protect the economy of the City and all of Southern California. The Mayoral Seismic Task Force evaluated four areas of seismic vulnerability: pre-1980 "non-ductile reinforced concrete" buildings: pre-1980 "soft-first story" buildings; water system infrastructure (including impact on firefighting capability); and telecommunications infrastructure.

The Sustainable City pLAn

The Sustainable City pLAn is a road map for a Los Angeles that is environmentally healthy, economically prosperous, and equitable in opportunity for all—now and over the next 20 years. The pLAn focuses on both short-term results and long-term goals to transform the City. The pLAn provides the following:

- A vision for Los Angeles' future—Presents a clear vision and details specific long-term outcomes to be achieved over the next two decades in 14 key aspects of the environment, the economy and measures of social equity.
- A pathway to short-term results that lay the foundation for long-term outcomes—Creates a set of near-term, back-to-basics outcomes by 2017 that create a foundation to achieve transformational change by 2025 and 2035.
- A framework to build out policies—Lays out strategies and priority initiatives that will be developed and detailed to deliver the tangible outcomes in the pLAn.
- A platform for collaboration—Creates a platform for collaboration to identify, create, and strengthen programs, policies, and partnerships that cut across bureaucratic boundaries to improve the city and neighborhoods.
- A set of tools to help manage Los Angeles—Provides the Mayor with a set of tools to ensure implementation and empower the men and women who work for the City.
- A dashboard of sustainability metrics to transparently measure progress—Identifies and tracks clear metrics to measure progress and share how everyone—in city operations, and as Angelenos—is doing along with way.
- A pathway for engaging our residents—Builds on leadership throughout Los Angeles, while providing Angelenos ways and opportunities to participate in creating tangible improvements to their lives, their neighborhoods, and the entire city.

Enhanced Watershed Management Plans

In order to improve water quality, comply with water quality mandates and address water supply issues, cities and community stakeholders throughout Los Angeles County are working to develop Enhanced Watershed Management Plans for each of the county's four watersheds—Ballona Creek, Dominguez Channel, Santa Monica Bay and Los Angeles River. The efforts are being led by a Watershed Management Group for each watershed.

Each plan will identify projects to improve water quality, promote water conservation, enhance recreational opportunities, manage flood risk, improve local aesthetics, and support public education. Each will outline water quality priorities, watershed control measures, reasonable assurance analysis, project scheduling and the monitoring, assessment and adaptive management of projects. The plans are to be submitted to the Los Angeles Regional Water Quality Control Board by June 28, 2015 (City of Los Angeles Stormwater Program, 2015).

Greater Los Angeles County Region Integrated Regional Water Management Plan

Municipalities and groups across the Greater Los Angeles County Region collaborated to develop an Integrated Regional Water Management Plan in 2006 that focuses on water resource management. The plan identifies solutions over the next 20 years to reduce dependence on imported water, clean up local groundwater and stormwater, enhance in-stream water quality, improve habitat, and expand parks and open space. The plan can support development of local funding sources and help local jurisdictions comply with regulatory mandates. It provides a tool for achieving planning targets for the region and improving the sustainability of water resources and ecological health of local watersheds. More sustainable water resources will improve the quality of life for all communities. (Los Angeles County Department of Public Works, 2015)

Los Angeles County Flood Control District

The Los Angeles County Flood Control Act (ACT) was adopted by the State Legislature in 1915, after a disastrous regional flood took a heavy toll on lives and property. The Act established the Los Angeles County Flood Control District and empowered it to provide flood protection, water conservation, recreation and aesthetic enhancement within its boundaries. The Flood Control District is governed, as a separate entity, by the County of Los Angeles Board of Supervisors.

In 1984, the Flood Control District entered into an operational agreement with the Los Angeles County Department of Public Works transferring planning and operational activities to the Department of Public Works. Watershed Management Division is the planning and policy arm of the Flood Control District. Public Works Flood Maintenance and Water Resources Divisions, respectively, oversee its maintenance and operational efforts.

The Flood Control District encompasses more than 3,000 square miles, 85 cities and approximately 2.1 million land parcels. It includes the vast majority of drainage infrastructure within incorporated and unincorporated areas in every watershed, including 500 miles of open channel, 2,800 miles of underground storm drains, and an estimated 120,000 catch basins. The District includes portions of the City of Los Angeles.

U.S. Army Corps of Engineers Los Angeles River Ecosystem Restoration Feasibility Study

The City of Los Angeles, in conjunction with the U.S. Army Corps of Engineers, prepared the Final Integrated Feasibility Report, which includes the Final Feasibility Report and Environmental Impact Statement/Environmental Impact Report for the proposed Los Angeles River Ecosystem Restoration Project. The City Council adopted the Study in June 2016.

Prior to the recent report, the Los Angeles River Ecosystem Restoration Integrated Feasibility Report documented an ongoing study that was initiated in 2003 to determine whether there is a federal interest in ecosystem restoration along the Los Angeles River within the City of Los Angeles. The study included a hydraulic analysis along the proposed project's 11-mile extent that produced a set of floodplain maps. The purpose of the hydraulic analysis was to produce baseline and with-project snapshots of potential impacts that an ecosystem restoration plan might have on the flood conveyance capacity of the river.

Los Angeles River Revitalization Master Plan

The following content is excerpted from the Los Angeles River Revitalization Master Plan (City of Los Angeles, 2015).

The Los Angeles River flows 51 miles through some of the most diverse communities in Southern California. It stretches 32 miles within the City of Los Angeles, from Owensmouth in the upper reaches of the northwest San Fernando Valley, all the way to the border with Vernon at the southern end of downtown. The river is typically dry during summer, but can fill with fast-flowing waters during the rainy season.

Community leaders, elected officials, residents, environmental groups, recreational groups, and others have explored ways to restore the river's natural benefits while maintaining flood protection and safety. In 2002, the Los Angeles City Council Ad Hoc Committee on the Los Angeles River was created to encourage community involvement in river improvements and to help coordinate river-related projects in the City. As a result of the Ad Hoc River Committee's efforts, the City began the preparation of a Revitalization Master Plan that would identify proposals to make the Los Angeles River a "front door" to the City, supporting diverse civic activities. The Ad Hoc River Committee established the following goals for the Los Angeles River Revitalization Plan:

- Establish environmentally sensitive guidelines for improving communities along the river by providing open space, housing, retail spaces, and places for public institutions.
- Improve the environment, enhance water quality, improve water resources, and improve the ecological functioning of the river.
- Provide public access to the river.
- Provide significant recreation space and open space, and improve natural habitats.
- Preserve and enhance the flood control features of the river.
- Foster community awareness of and pride in the Los Angeles River.

The 18-month revitalization planning process looked at improvements along the river that would enhance neighborhoods, protect wildlife, promote the health of the river, and leverage economic development. The finished master plan outlines a 20-year blueprint for development and management of the Los Angeles River to be implemented by the City of Los Angeles. It calls for an extensive community engagement effort that will include public workshops at key project milestones, participation in neighborhood and community events, and an interactive web site (www.lariver.org).

The City of Los Angeles Floodplain Management Plan (2015)

Recent history has demonstrated how the City of Los Angeles can be significantly impacted by flooding. On November 12, 2003, 5.6 inches of precipitation fell during a 4-hour period over the Watts area of Los Angeles and portions of the City of Carson, causing significant flooding in areas not previously considered at risk for flooding. National Weather Service records show a total of 37.25 inches of rain at the downtown Los Angeles Civic Center during the rainy season of 2004-2005—the second highest recorded seasonal rainfall (the highest was 38.18 inches in 1883-1884). In 2014, Hurricane Marie brought one of the largest hurricane-related surf events in decades to Southern California, leading to overall losses of $20 million. Hurricane Marie tied for the sixth most-intense Pacific hurricane on record.

Even though the City of Los Angeles has adopted multiple mitigation and flood control projects and plans, it is constantly seeking additional ways to mitigate flood impacts in the community. Additionally, as a participant in the Community Rating System, the City can use an updated floodplain management plan as a key step toward significant reductions in flood insurance premiums.

Administered by the City of Los Angeles Department of Public Works Bureau of Engineering, the *2015 City of Los Angeles Floodplain Management Plan* provides a blueprint for flood risk reduction and management for the City. The plan is centered upon a comprehensive flood hazard risk assessment that looks at coastal, riverine, urban drainage, dam failure and tsunami hazards as well as a forward look at the possible increase in risk to these hazards caused by global climate change. The plan identifies and prioritizes 80 flood risk reduction actions to be implemented over a 5-year performance period. Progress reports on the status of the implementation of the actions in the plan are prepared by the Bureau of Engineering annually.

4.9.4 Capability Assessment

The planning team performed an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of an agency's mission, programs and policies, and evaluates its capacity to carry them out. It presents a toolkit for implementation of the hazard mitigation plan.

The assessment identifies potential gaps in core capabilities, and filling those gaps may eventually become actions in the plan. Assessment findings were shared with city departments as they developed the action plans shown in Chapter 23. If a department identified an opportunity to add or expand a capability, then doing so has been identified as a mitigation action. The City views each core capability to be fully adaptable as needed to meet the best interests of the City. Every code can be amended, and every plan can be updated. This adaptability is considered to be an overarching City capability that is acknowledged by this reference.

An assessment of legal and regulatory capabilities is presented in Table 4-10. The column labeled "Integration Opportunity" in this table identifies capabilities that can support or be supported by components of this plan. Where "yes" is indicated in this column, the City has considered actions to integrate these capabilities with the plan.

Table 4-10. Legal and Regulatory Capability

	Local Authority	Other Jurisdiction Authority	State Mandated	Integration Opportunity?
Codes, Ordinances & Requirements				
Building Code	Yes	No	Yes	No
Comment: City of Los Angeles Municipal Code, Chapter IX, Article I, amended by Ordinance No. 182,850, effective 1/3/2014 Ordinance No. 183893 Establish mandatory standards for earthquake hazard reduction in existing wood-frame buildings with soft, weak, or open-front walls and existing non-ductile concrete buildings. Signed 10/13/2015, effective 11/22/2015.				
Zoning Code	Yes	No	Yes	No
Comment: City of Los Angeles Municipal Code, Chapter I, Article 2 and Article 3, amended by Ordinance No. 138,800, effective 6/13/1969				
Subdivisions	Yes	No	Yes	No
Comment: City of Los Angeles Municipal Code, Chapter I, Article 7, added by Ordinance No. 122,064, effective 6/14/1962				
Stormwater Management	Yes	Yes, LA County	Yes	Yes
Comment: City of Los Angeles Municipal Code, Chapter VI, Article 4.4, Section 64.70, Article and Section added by Ordinance. No. 172,176, effective 10/1/1998. *Integration Opportunity*: City-owned facilities constructed under this code may be eligible for FEMA HMA grants. All future updates to this plan should consider eligible stormwater management activities as potential actions for this plan.				
Post-Disaster Recovery	Yes	No	No	Yes
Comment: City of Los Angeles, Administrative Code, Division 8, Chapter 3, Section 8.61 amended by Ordinance No. 165,083, effective 9/4/1989 *Integration Opportunity*: The City should inform the next update to this code using all of this plan's information on risk and vulnerability associated with the hazards assessed.				
Real Estate Disclosure	No	No	Yes	No
Comment: State of California Natural Hazards Disclosure Act, effective 6/1/1998 (California Civil Code Section 1002.6c)				
Growth Management	Yes	Yes	Yes	Yes
Comment: City of Los Angeles Municipal Code, Article 1.5, Section 11.5.6 General Plan, amended by Ordinance 173,268, effective 7/1/2000, Operational 7/1/2000. Other jurisdictional authority is with the Southern California Association of Governments. *General Planning Law – Cal. Gov. Code §65300 et seq.* *Integration Opportunity*: See comments below for the General Plan				

	Local Authority	Other Jurisdiction Authority	State Mandated	Integration Opportunity?
Site Plan Review	Yes	No	No	No
Comment: City of Los Angeles, Municipal Code, Chapter I, Article 6.1, Section 16.05, Renumbered and amended by Ordinance No. 166,127, effective 9/23/1990; operational 10/13/1990.				
Environmental Protection	No	Yes, LA County	Yes	No
Comments: County of Los Angeles has authority for Environmental Protection				
Flood Damage Prevention	Yes	No	Yes	No
Comments: *Flood Hazard Specific Plan*, ordinance No. 172081, effective 7/3/1998.				
Emergency Management	Yes	No	Yes	Yes
Comments: Emergency Operations Ordinance No. 153772, signed 1980 established a multi-agency Emergency Operations Organization. It is under the director of Mayor and administration of an Emergency Operations Board. ***Integration Opportunity***: The City of LA Emergency Management Department is an integral part of the multi-agency Emergency Operations Organization created by this code. LAEMD is also the lead for this mitigation plan. Therefore this integration has already occurred.				
Climate Change	Yes	Yes	Yes	Yes
Comments: *Los Angeles' Sustainable City pLAn*, 2015. SB 97 directs California Environmental Quality Act (CEQA) Guidelines to address greenhouse gas emissions. Other state policies include AB 32, and SB 375, SB 379 and regulations of the Climate Action Plan. Los Angeles County adopted the AB 32 *Community Climate Action Plan* as part of *Los Angeles County General Plan 2035* on 10/ 6/2015. ***Integration Opportunity***: The "Sustainable City pLAn" has been integrated by reference into this plan (see Section 4.9.3). All future updates to this plan will continue to use this plan as a source document. Additionally, any future update to the Sustainable City pLAn will look to this mitigation plan for information that can support its update.				
Planning Documents				
General Plan	Yes	No	Yes	Yes
Comment: Consists of a framework last adopted in 2001, 11 citywide elements adopted from 1991 through 2016, and land use elements for 35 community plan areas, adopted from 1981 through 2000. ***Integration Opportunity***: Based on directives from AB-2140, SB-379 and SB-1000, the City will fully integrate this mitigation plan into the safety element of its general plan upon its next update.				
Capital Improvement Plan	Yes	No	No	Yes
What types of capital facilities does the plan address? City buildings and projects (fire facilities/fire stations, animal shelters, police facilities, seismic retrofit program of bridges, construction projects such as neighborhood city halls, Chicago Building, Police SID Tech Lab, El Pueblo Capital Program, youth recreational and cultural facilities, street and transportation projects, clean stormwater, recharge groundwater and provide cleaner beaches projects, zoo exhibits). Public housing, community investments.				
Comment: City of Los Angeles Capital Improvement Program, 2008-09 to 2012-13 (last version available online) ***Integration Opportunity***: This integration is ongoing. In the development of the action plan for this update, the City reviewed its capital improvement plan to identify actions that are eligible for FEMA grant funding. All future updates to the City's capital improvement plans will look to this plan to potentially leverage FEMA grant funding for project implementation.				
Floodplain Plan	Yes	No	No	Yes
Comment: City of Los Angeles Floodplain Management Plan, Adopted 10/7/2015. ***Integration Opportunity:*** The latest version of the City of Los Angeles Floodplain Management Plan was incorporated by reference into this plan update. Information from the floodplain management plan informed the flood hazard risk assessment for this plan, and actions from the floodplain management plan have been included in this plan.				
Stormwater Plans	Yes	Yes	Yes	No
Comment: *Standard Urban Stormwater Mitigation Plan*, adopted by the State Regional Water Quality Control Board in 2000, *Enhanced Watershed Management Plan* under development				
Habitat Conservation Plan	Yes	No	No	No

	Local Authority	Other Jurisdiction Authority	State Mandated	Integration Opportunity?
Comment: *Greater Los Angeles County Open Space for Habitat and Recreation Plan, 2012.* In 2000, the Port of Los Angeles and Port of Long Beach created a biological survey of the Los Angeles-Long Beach Harbor habitat conditions and marine biological communities "Biological Baseline Surveys". Updated in 2013-2014.				
Economic Development Plan	Yes	No	No	No
Comment: *Economic Development in Los Angeles: A New Approach for a World Class City*, December 2012, Chapter 7 of framework element of the *Los Angeles General Plan, Los Angeles County Strategic Plan for Economic Development 2010-2014*				
Shoreline Management Plan	Yes	No	Yes	No
Comment: *Local Coastal Program Land Use Plan*, Venice				
Community Wildfire Protection Plan	No	No	No	No
Comments: *Santa Monica Mountains Community Wildfire Protection Plan*, 2010				
Response/Recovery Planning				
Comprehensive Emergency Management Plan	Yes	No	Yes	No
Comment: *Emergency Operation Master Plan and Procedures*, September 2006 ***Integration Opportunity***: Although there is no viable way to integrate this mitigation plan into the EOP, information in the hazard mitigation plan on risk and vulnerability can inform future updates to the EOP.				
Threat & Hazard Identification & Risk Assessment	Yes	No	No	Yes
Comments: Los Angeles / Long Beach Urban Area Security Initiative ***Integration Opportunity***: Information on risk and vulnerability contained in this plan can inform future updates to the City's THIRA.				
Terrorism Plan	Yes	No	No	No
Comments: Los Angeles Operational Area Terrorism Plan; City of Los Angeles Police Department Counter-Terrorism and Special Operations Bureau				
Post-Disaster Recovery Plan	Yes	No	No	Yes
Comment: Annex to the *Emergency Operations Master Plan, Recovery and Reconstruction Plan*, September 2006 ***Integration Opportunity:*** Information on risk and vulnerability contained in this plan can inform future updates to the City's Post-Disaster Recovery Plan.				
Continuity of Operations Plan	Yes	No	Yes	Yes
Comment: The City Council has provided for the preservation of the City government in the event of an emergency (City of Los Angeles Administrative Code, Section 8.25), The alternates to key positions in the regular departments and agencies of government, or of business and industry, are shown in the *City's Continuity of Operations/Continuity of Government Plan* (COOP/COG) and department emergency plans, executive or administrative orders or the equivalent issued by department or agency authorities. ***Integration Opportunity***: Information on risk and vulnerability contained in this plan can inform future updates to the City's Continuity of Operations/Continuity of Government Plan.				
Public Health Plan	No	Yes, LA County	No	No
Comments: *Community Health Improvement Plan, 2015-2020;* Prehospital Care Policy Ref. No. 842.1 Minimum EMS Resource Guidelines for Mass Gatherings and Special Events				

An assessment of administrative and technical capabilities is presented in Table 4-11. An assessment of fiscal capabilities is presented in Table 4-12. Classifications under various community mitigation programs are presented in Table 4-13. Development and permitting capabilities are presented in Table 4-14. Information on NFIP compliance is presented in Table 4-15. An assessment of education and outreach capabilities is presented in Table 4-16. The community's adaptive capacity for the impacts of climate change is presented in Table 4-17.

Table 4-11. Administrative and Technical Capability

Staff/ Personnel Resources	Available (Y or N)	Department or Agency (Positions)
Planners or engineers with knowledge of land development and land management practices	Yes	Department of City Planning
Engineers or professionals trained in construction practices related to buildings and/or infrastructure	Yes	Department of Building and Safety
Planners or engineers with an understanding of natural hazards	Yes	Department of Public Works, Bureau of Engineering and Bureau of Sanitation
Floodplain manager	Yes	City Engineer, Bureau of Engineering
Surveyors	Yes	Department of Public Works, City Engineer
Personnel skilled or trained in GIS Applications	Yes	City of Los Angeles Survey Division
Scientist familiar with local natural hazards	Yes	Various, including Bureau of Engineering and City Planning
Emergency manager	Yes	Emergency Management Department and all other departments (Fire, Police, Public Works, Building & Safety, City Planning, Water and Power, Port of Los Angeles, World Airports, etc.)
Grant writers	Yes	Emergency Management Department, General Manager
Staff with expertise or training in benefit/cost analysis	Yes	Department of City Planning

Table 4-12. Fiscal Capability

Financial Resources	Accessible or Eligible to Use (Y or N)
Community Development Block Grants	Yes
Capital Improvements Project Funding	Yes
Authority to Levy Taxes for Specific Purposes	Yes
User Fees for Water, Sewer, Gas or Electric Service	Yes
Incur Debt through General Obligation Bonds	Yes
Incur Debt through Special Tax Bonds	Yes
Incur Debt through Private Activity Bonds	Yes
Withhold Public Expenditures in Hazard-Prone Areas	Yes
State-Sponsored Grant Programs	Yes
Development Impact Fees for Homebuyers or Developers	Yes

Table 4-13. Community Classifications

	Participating?	Classification	Date Classified
Community Rating System	Yes	Class 7	1991
Building Code Effectiveness Grading Schedule	Yes	2/2	2014
Public Protection	Yes	Class 1	1947
Firewise	No	—	—
Storm Ready	Yes	NOAA	January 27, 2012
Tsunami Ready	Yes	NOAA	January 27, 2012

Table 4-14. Development and Permitting Capability

Criterion	Response
Does your jurisdiction issue development permits? • If no, who does? If yes, which department?	Yes
Does your jurisdiction have the ability to track permits by hazard area?	Yes (Flood Hazard Only)
Does your jurisdiction have a buildable lands inventory?	Yes

Table 4-15. National Flood Insurance Program Compliance

Criterion	Response
What local department is responsible for floodplain management?	Department of Public Works
Who is your floodplain administrator? (department/position)	City Engineer
Are any certified floodplain managers on staff in your jurisdiction?	No
What is the date of adoption of your flood damage prevention ordinance?	Ordinance No. 172081, Effective July 3, 1998
When was the most recent Community Assistance Visit or Community Assistance Contact?	August 19, 2015. Next Community Assistance Visit tentatively scheduled for August 2017
Does your jurisdiction have any outstanding NFIP compliance violations that need to be addressed? • If so, please state what they are	No
Do your flood hazard maps adequately address the flood risk within your jurisdiction? • If no, please state why	The City constantly works with federal, state and regional agencies to prepare accurate flood hazard maps based on best available data. The City understands that floodplains are dynamic so current mapping may not always reflect true flood risk.
Does your floodplain management staff need any assistance or training to support its floodplain management program? • If so, what type of assistance/training is needed?	City floodplain management personnel always seek opportunities to enhance their floodplain management capabilities
Does your jurisdiction participate in the Community Rating System (CRS)? • If so, is your jurisdiction seeking to improve its CRS Classification? ..... • If not, is your jurisdiction interested in joining the CRS program?	Yes

Table 4-16. Education and Outreach

Criteria	Response
Do you have a Public Information Officer or Communications Office?	The City has multiple personnel that serve this capacity of each department of City government
Do you have personnel skilled or trained in website development?	Each City department has a website with personnel dedicated to its development and maintenance
Do you have hazard mitigation information available on your website? • If yes, please briefly describe.	Yes The City has established a hazard mitigation planning website within the Emergency Management Department website at: http://emergency.lacity.org/hazard-mitigation-plan
Do you utilize social media for hazard mitigation education and outreach? • If yes, please briefly describe.	The City has extensive social media capability that includes Facebook, Twitter, and Nextdoor
Do you have any resident boards or commissions that address issues related to hazard mitigation?	The City has identified 96 Neighborhood Councils that could facilitate this capability.
Do you have any other programs already in place that could be used to communicate hazard-related information? • If yes, please briefly describe.	Yes Community Emergency Response Team, Volunteer programs
Do you have any established warning systems for hazard events?	Yes
• If yes, please briefly describe.	The City has some warning capacity for severe weather, flood and tsunami. See the City's 2015 Flood Hazard Management Plan for more detailed descriptions of these capabilities.

Table 4-17. Adaptive Capacity for Climate Change

Adaptive Capacity Assessment Question	Jurisdiction Rating
Technical Capacity	
Jurisdiction-level understanding of potential climate change impacts	Medium
Comment: This hazard mitigation plan has provided the City with a better understanding	
Jurisdiction-level monitoring of climate change impacts	Low
Comment: None provided.	
Technical resources to assess proposed strategies for feasibility and externalities	Low
Comment: None provided.	
Jurisdiction-level capacity for development of greenhouse gas emissions inventory	Low
Comment: None provided.	
Capital planning and land use decisions informed by potential climate impacts	Low
Comment: None provided.	
Participation in regional groups addressing climate risks	Medium
Comment: None provided.	
Implementation Capacity	
Clear authority/mandate to consider climate change impacts during public decision-making processes	Medium
Comment: None provided.	
Identified strategies for greenhouse gas mitigation efforts	Medium
Comment: None provided.	
Identified strategies for adaptation to impacts	Medium
Comment: None provided.	
Champions for climate action in local government departments	Low
Comment: None provided.	
Political support for implementing climate change adaptation strategies	Medium
Comment: None provided.	
Financial resources devoted to climate change adaptation	Low
Comment: None provided.	
Local authority over sectors likely to be negative impacted	Low
Comment: None provided.	
Public Capacity	
Local residents knowledge of and understanding of climate risk	Low
Comment: None provided.	
Local residents support of adaptation efforts	Low
Comment: None provided.	
Local residents' capacity to adapt to climate impacts	Low
Comment: None provided.	
Local economy current capacity to adapt to climate impacts	Low
Comment: None provided.	
Local ecosystems capacity to adapt to climate impacts	Low
Comment: None provided.	

PART 2—RISK ASSESSMENT

5. HAZARDS OF CONCERN, RISK ASSESSMENT METHODOLOGY

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from identified hazards. It allows emergency management personnel to establish early response priorities by identifying potential hazards and vulnerable assets. The process focuses on the following elements:

- **Hazard identification**—Use all available information to determine what types of hazards may affect a jurisdiction, how often they can occur, and their potential severity.
- **Exposure identification—**Estimate the total number of people and properties in the jurisdiction that are likely to experience a hazard event if it occurs.
- **Vulnerability identification and loss estimation**—Assess the impact of hazard events on the people, property, environment, economy and lands of the region, including estimates of the cost of potential damage or cost that can be avoided by mitigation.

The risk assessment for this hazard mitigation plan update evaluates the risk of natural hazards prevalent in the planning area and meets requirements of the Disaster Mitigation Act (44 CFR, Section 201.6(c)(2)). To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual properties.

5.1 IDENTIFIED HAZARDS OF CONCERN

The Steering Committee considered the full range of natural hazards that could affect the planning area and then listed hazards that present the greatest concern. The process incorporated a review of state and local hazard planning documents as well as information on the frequency of, magnitude of, and costs associated with hazards that have struck the planning area or could do so. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, this plan addresses the following hazards of concern (presented in alphabetical order; the order of listing does not indicate the hazards' relative severity):

- Adverse weather
- Climate change and sea-level rise
- Dam failure
- Drought
- Earthquake
- Flood
- Landslide
- Tsunami
- Wildland/Urban Interface Fire
- Human-caused hazards.

5.2 RISK ASSESSMENT TOOLS

5.2.1 Mapping

National, state, county, and city databases were reviewed to locate available spatially based data relevant to this planning effort. Maps were produced using geographic information system (GIS) software to show the spatial extent and location of hazards when such datasets were available. Data used for this plan update represents the best science currently available. All data used was approved by the City of Los Angeles for use in this plan update. These maps are included in the hazard profile chapters of this document. Sources and methods used to generate the maps are described in Appendix B.

5.2.2 Hazus

Overview

FEMA developed the standardized GIS-based software program Hazards U.S. (Hazus) to estimate losses caused by earthquakes, hurricanes and floods and identify areas that face the highest risk and potential for loss. Hazus is used to support risk assessments, mitigation planning, and emergency planning and response. It provides a wide range of inventory data, such as demographics, building stock, critical facilities, and transportation and utility infrastructure, and multiple models to estimate potential losses from natural disasters. The program maps and calculates hazard data and damage and economic loss estimates for buildings and infrastructure. Its advantages include the following:

- Provides a consistent methodology for assessing risk across geographic and political entities.
- Provides a way to save data so that they can readily be updated as population, inventory, and other factors change and as mitigation planning efforts evolve.
- Facilitates review of mitigation plans because it helps to ensure that FEMA methodologies are incorporated.
- Supports grant applications by calculating benefits using FEMA definitions and terminology.
- Produces hazard data and loss estimates that can be used in communication with local stakeholders.
- Is administered by the local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

Levels of Detail for Evaluation

Hazus provides default data for inventory, vulnerability, and hazards; these default data can be supplemented with local data to provide a more refined analysis. The model can carry out three levels of analysis:

- **Level 1**—All of the information needed to produce an estimate of losses is included in the software's default data. These data are derived from national databases and describe in general terms the characteristic parameters of the planning area.
- **Level 2**—More accurate estimates of losses require more detailed information about the planning area. To produce Level 2 estimates of losses, detailed information is required about local geology, hydrology, hydraulics, and building inventory, as well as data about utilities and critical facilities. This information is needed in a GIS format.
- **Level 3**—This level of analysis generates the most accurate estimate of losses. It requires detailed engineering and geotechnical information to customize it for the planning area.

5.3 RISK ASSESSMENT APPROACH

The risk assessments in this plan describe the risks associated with each hazard of concern identified. The following steps were used to define the risk of each hazard:

- **Identify and profile each hazard**—The following information is given for each hazard:
  - The local history of previous events associated with the hazard
  - Geographic areas most affected by the hazard
  - Estimated event frequency
  - A qualitative assessment of the potential severity of events associated with the hazard
  - Warning time likely to be available for response.
- **Determine exposure to each hazard**—Exposure was assessed by overlaying hazard maps with an inventory of structures, facilities, and systems to decide which of them would be exposed to each hazard.
- **Assess the vulnerability of exposed facilities**—Vulnerability of exposed structures and infrastructure was evaluated by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard.

5.3.1 Dam Failure, Earthquake, Tsunami, Sea Level Rise and Flood

The following hazards were evaluated using Hazus:

- **Flood**—A Level 2 user-defined analysis was performed for general building stock in flood zones and for critical facilities and infrastructure. Current flood mapping for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance and 0.2-percent-annual-chance flood events. To estimate damage that would result from a flood, Hazus uses pre-defined relationships between flood depth at a structure and resulting damage, with damage given as a percent of total replacement value. Curves defining these relationships have been developed for damage to structures and for damage to typical contents within a structure. By inputting flood depth data and known property replacement cost values, dollar-value estimates of damage were generated.
- **Dam Failure**—A Level 2 analysis was run using the flood methodology described above.
- **Sea Level Rise**—A Level 2 analysis was run using the flood methodology described above.
- **Tsunami**—A modified Level 2 analysis was run using the flood methodology described above.
- **Earthquake**—A Level 2 analysis was performed to assess earthquake exposure and vulnerability for five scenario events:
  - A Magnitude 7.2 event on the Newport-Inglewood Fault with an epicenter 32 miles southeast of downtown Los Angeles.
  - A Magnitude 7.3 event on the Palos Verde Fault with an epicenter 55 miles south southeast of downtown Los Angeles.
  - A Magnitude 7.0 event on the Puente Hills Fault with an epicenter 11.5 miles northeast of downtown Los Angeles.
  - A Magnitude 7.8 event on the San Andreas Fault with an epicenter 150 miles east southeast of downtown Los Angeles.
  - A Magnitude 6.8 event on the Santa Monica Fault with an epicenter 9.5 miles northwest of downtown Los Angeles.

5.3.2 Drought

The risk assessment methodologies used for this plan focus on damage to structures. The risk assessment for drought was more limited and qualitative than the assessment for the other hazards of concern because drought does not affect structures.

5.3.3 All Other Assessed Hazards

Historical datasets were not adequate to model future losses for most of the hazards of concern. However, areas and inventory susceptible to some of the hazards of concern were mapped by other means, and exposure was evaluated. A qualitative analysis was conducted for other hazards using the best available data and professional judgment.

5.4 SOURCES OF DATA USED IN HAZUS MODELING

5.4.1 Building and Cost Data

Replacement cost values and detailed structure information derived from parcel and tax assessor data provided by the City of Los Angeles were loaded into Hazus. When available, an updated inventory was used in place of the Hazus defaults for critical facilities and infrastructure.

Replacement cost is the cost to replace the entire structure with one of equal quality and utility. Replacement cost is based on industry-standard cost-estimation models published in *RS Means Square Foot Costs* (RS Means, 2017). It is calculated using the RS Means square foot cost for a structure, which is based on the Hazus occupancy class (i.e., multi-family residential or commercial retail trade), multiplied by the square footage of the structure from the tax assessor data. The construction class and number of stories for single-family residential structures also factor into determining the square-foot costs.

5.4.2 Hazus Data Inputs

The following hazard datasets were used for the Hazus Level 2 analysis conducted for the risk assessment:

- **Flood**—The effective Digital Flood Insurance Rate Map (DFIRM) for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance and 0.2-percent-annual-chance flood events. For the City's 2015 Floodplain Management Plan, the DFIRM floodplain boundaries and base flood elevation information, and Los Angeles County's 5-foot digital elevation model data, were used to generate flood depth grids. These depth grids were updated with Letter of Map Revision data issued since 2015, and integrated into the Hazus model for this plan.
- **Dam Failure**—For the City's 2015 Floodplain Management Plan, dam inundation area data provided by the County, and the County's 5-foot digital elevation model were used to develop depth grids. These depth grids were integrated into the Hazus model for this plan. Inundation areas for the following dams were included: Lower Franklin No.2, Los Angeles Reservoir, Mulholland, Pacoima, Sepulveda, Silver Lake, Devils Gate, Eagle Rock, Elysian, Encino, Big Tijunga No. 1, Green Verdugo, Greystone Reservoir, Hansen, Lopez, Palos Verdes Reservoir, Riviera Reservoir, Santa Ynez Canyon, Stone Canyon, and Upper Franklin.
- **Tsunami**—For the City's 2015 Floodplain Management Plan, tsunami inundation zone data, provided by the California Department of Conservation, and the County's 5-foot digital elevation model were used to develop depth grids. These depth grids were integrated into the Hazus model for this plan.
- **Sea Level Rise**—Depth grids for sea level rises of 25-cm and 150-cm with 100-year storm surge provided by the U.S. Geological Survey (USGS) were integrated into the Hazus model. This Coastal Storm Modeling System data is identified by California's Cal-Adapt program as a sea level rise data resource.

- **Earthquake**—Earthquake shake maps prepared by the USGS were used for the analysis of this hazard. Landslide susceptibility data from the California Geological Survey and the City's liquefaction zones data were also integrated into the Hazus model.

5.4.3 Other Local Hazard Data

Locally relevant information on hazards was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, emergency management specialists, and others. Data sources for specific hazards were as follows:

- **Landslide**—Susceptibility to deep-seated landslides data were provided by the California Geological Survey, dated 2011. Areas categorized as very high (source data Category X) and high (Categories VII, VIII, and IX) were used in the exposure analysis. This data was approved by the Building and Safety Division as the appropriate data to use for this assessment.
- **Adverse Weather**—No GIS format adverse weather area datasets were identified for the City of Los Angeles.
- **Wildfire**—Fire severity data was acquired from California Department of Forestry and Fire Protection (CAL FIRE).
- **Climate Change**—Climate change related projections, data and visualization tools were provided by Cal-Adapt, an online resource that provides information on how climate change might affect local communities in California, unless otherwise indicated. The data available on Cal-Adapt is from a variety of organizations in the scientific community and represents peer-reviewed science.

5.4.4 Data Source Summary

Table 5-1 summarizes the data sources used for the risk assessment for this plan.

5.5 LIMITATIONS

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

- Approximations and simplifications necessary to conduct a study
- Incomplete or outdated inventory, demographic or economic parameter data
- The unique nature, geographic extent, and severity of each hazard
- Mitigation measures already employed
- The amount of advance notice residents have to prepare for a specific hazard event.
- The liquefaction zones data used in the earthquake analysis did not include the level of liquefaction susceptibility information required by the Hazus model. For the purpose of the analysis, it was assumed that areas within the zones had a moderate susceptibility.

These factors can affect loss estimates by a factor of two or more. Therefore, potential exposure and loss estimates are approximate and should be used only to understand relative risk. Over the long term, the City of Los Angeles will collect additional data to assist in estimating potential losses associated with other hazards.

Table 5-1. Hazus Model Data Documentation

Data	Source	Date	Format
Building footprints	City of Los Angeles	2014	Digital (GIS) format
Address points	City of Los Angeles	2016	Digital (GIS) format
Property parcels (includes tax roll data such as use code, year built, number of stories, and square footage)	Los Angeles County	2015	Digital (GIS) format
Soft-story apartments	City of Los Angeles	2016	Digital (spreadsheet) format
Building replacement cost	RS Means	2017	Paper format
Demographic data	FEMA Hazus version 3.2	2010	Digital (GIS and tabular) format
Population data	U.S. Census Bureau American Community Survey 5-Year Population Estimates	2015	Digital (tabular) format
Flood depth grids (created from FEMA effective DFIRM data)	2015 City of Los Angeles Floodplain Management Plan	2015	Digital (GIS) format
Letters of Map Revision	FEMA	2016	Digital (GIS) format
Tsunami inundation depth grids (created from CA Dept. of Conservation data)	2015 City of Los Angeles Floodplain Management Plan	2015	Digital (GIS) format
Earthquake shake maps	USGS Earthquake Hazards Program website	2012-2015	Digital (GIS) format
Susceptibility to Deep-Seated Landslides	CA Geological Survey	2011	Digital (GIS) format
Liquefaction zones	Los Angeles County (via City of Los Angeles GIS data portal)	2016	Digital (GIS) format
National Earthquake Hazard Reduction Program Soils	California Department of Conservation	2008	Digital (GIS) format
Dam inundation depth grids (created from Los Angeles County data)	2015 City of Los Angeles Floodplain Management Plan	2015	Digital (GIS) format
Coastal Storm Modeling System sea level rise data (version 3.0 Phase 2)	U.S. Geological Survey	2017	Digital (GIS) format
Fire Hazard Severity Zones in Local Responsibility Area	CA Dept. of Forestry and Fire Protection	2008	Digital (GIS) format
Digital Elevation Model (5ft resolution)	Los Angeles County	2006	Digital (GIS) format
General Plan Land Use	City of Los Angeles	2015	Digital (GIS) format
Critical Facilities and Assets			
Critical facilities inventory	2015 City of Los Angeles Floodplain Management Plan	2015	Digital (GIS) format
Big 20 buildings	City of Los Angeles	2017	Digital (text) format
Locations/Points of Interest	Los Angeles County	2016	Digital (GIS) format
Hospitals	Los Angeles County	2011	Digital (GIS) format
County-owned facilities	Los Angeles County	2016	Digital (GIS) format
Port of Los Angeles berths, docks, slips	Los Angeles County	2014	Digital (GIS) format

6. ADVERSE WEATHER

6.1 GENERAL BACKGROUND

Adverse weather refers to any dangerous meteorological phenomenon with the potential to cause damage, serious social disruption, or loss of human life. It includes thunderstorms, high winds, tornadoes, waterspouts, extreme temperatures, fog, ice storms, and dust storms.

Adverse weather can be categorized into two groups: systems that form over wide geographic areas are classified as general adverse weather; those with a more limited geographic area are classified as localized adverse weather. Adverse weather, technically, is not the same as extreme weather, which refers to unusual weather events at the extremes of the historical distribution for a given area.

The most common adverse weather events in Los Angeles are extreme heat, high winds, and tornadoes. These are described in the following sections. Flooding and beach erosion issues associated with adverse weather are discussed in Chapter 10.

DEFINITIONS

Extreme Heat—Temperatures that hover 10 degrees or more above the average high temperature for a region and last for several weeks. Humid or muggy conditions occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Extremely dry and hot conditions can lead to dust storms and low visibility.

Severe Local Storm—Small atmospheric systems, including tornadoes, thunderstorms, windstorms, ice storms and snowstorms. Typically, major impacts from a severe local storm are on transportation infrastructure and utilities. These storms may cause a great deal of destruction and even death, but their impact is generally confined to a small area.

Thunderstorm—Any rain event that includes thunder and lightning. A typical thunderstorm is about 15 miles in diameter and lasts about 30 minutes.

Tornado—Tornadoes are funnel clouds of varying sizes that touch ground. They can affect an area up to three-quarters of a mile wide, with a path of varying length. Tornadoes are measured using the Fujita Scale ranging from F0 to F5, or the Enhanced Fujiti Scale.

Windstorm—A storm featuring violent winds. Windstorms are generally short-duration events involving straight-line winds or gusts of over 50 mph, strong enough to cause property damage.

6.1.1 Extreme Heat

Extreme heat is defined as temperatures that hover 10 ºF or more above the average high temperatures for a region for several weeks. In Los Angeles, the summers are hot, but the combination of high temperature and high humidity, which are requirements for the National Weather Service (NWS) to declare a heat emergency, are relatively rare.

According to the *California Climate Adaptation Strategy*, heat waves have claimed more lives in California than all other declared disaster events combined. Despite this history, not a single heat emergency was proclaimed at the state or federal level between 1960 and 2016. Heat emergencies are often slow to develop and usually hurt vulnerable populations. It could take a number of days of oppressive heat for a heat wave to have a significant or quantifiable impact in Los Angeles. Heat waves do not strike victims immediately, but rather their cumulative effects slowly take the lives of vulnerable populations.

Los Angeles is experiencing more heat waves and more extreme heat days. Heat waves have increased by more than three per century and extreme heat days have increased by 23 per century. Both have more than tripled over the past 100 years as a consequence of the steady warming of Los Angeles. The average annual maximum temperature in Los Angeles has warmed by 5.0°F, and the average annual minimum temperature has warmed by 4.2°F. The greatest rate of change was during the summer for both maximum and minimum temperature, with late

fall and early winter having the least rates of change. There was also an increase in heat wave duration. Heat waves lasting longer than six days occurred regularly after the 1970s but were nonexistent from 1906 until 1956, when the first six-day heat wave was recorded (Tamrazian et al. 2008).

Because of its expansive urban size, Los Angeles is identified as an urban heat island (UHI). UHIs develop in urban areas where natural surfaces are paved with asphalt or covered by buildings. Radiation from the sun is absorbed by these surfaces during the day and re-radiated at night, raising ambient temperatures. UHIs have high nighttime minimum temperatures compared to neighboring areas. Waste heat from air conditioners, vehicles, and other equipment contributes to the UHI effect.

6.1.2 High Winds

High winds are generally short-duration events involving straight-line winds or gusts of over 50 mph, strong enough to cause property damage. High winds or a windstorm are especially dangerous in areas with significant tree stands and areas with exposed property, poorly constructed buildings, manufactured housing units, major infrastructure, and above-ground utility lines. A windstorm can topple trees and power lines, cause damage to residential, commercial and critical facilities, and leave tons of debris in its wake.

Types of Damaging Winds

Damaging winds are classified as those exceeding 60 mph. Damage from such winds accounts for half of all adverse weather reports in the lower 48 states and is more common than damage from tornadoes. Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles. There are seven types of damaging winds:

- **Straight-line winds—**Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts—**A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts—**A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts—**A small concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes, with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.
- **Gust front**—A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- **Derecho—**A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word “derecho” is of Spanish origin and means “straight ahead.” Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- **Bow Echo—**A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.

Santa Ana Winds

Santa Ana winds are a principal feature of Los Angeles weather. These are offshore winds, usually warm, blowing from the mountains to the coast, and occurring principally in fall and winter, with a frequency peaking in December. Santa Ana winds are marked by light coastal winds, clean air and low humidity. They may last from a day to over a week. The Santa Ana condition is usually one of warm temperatures when the rest of the United States is in the grip of winter. High pressure builds over the Great Basin in fall and winter as cold air travels into that region from Canada. When the surface pressure gradient reaches or exceeds 10 millibars, as measured from Tonopah, Nevada, to Los Angles, wind gusts can reach 70 mph in the mountains and below passes and canyons near Los Angeles.

Santa Ana winds broadly affect the Los Angeles area. Winds tend to channel below specific passes and canyons, coming in gust clusters. High winds may blow in one neighborhood, while a few blocks away there are only gentle warm breezes. Offshore winds from the northeast or east must reach 30 mph or more below passes and canyons to reach minimum criteria for Santa Ana wind advisories. Typically wind speeds are in the 40 to 55 mph range, and in extreme cases, winds can gust locally to over 100 mph.

6.1.3 Tornadoes

A tornado is a violently rotating column of air extending between, and in contact with, a cloud and the surface of the earth. Tornadoes are often (but not always) visible as a funnel cloud. On a local-scale, tornadoes are the most intense of all atmospheric circulations and wind can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long. Figure 6-1, adapted from FEMA, illustrates the potential impacts and damage from tornadoes of different magnitude. Tornadoes can occur throughout the year at any time of day but are most frequent in the spring during the late afternoon.

In 2007, NWS began rating tornadoes using the Enhanced Fujita Scale (EF-scale). The EF-scale is a set of wind estimates (not measurements) based on damage. It uses 3-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to 28 indicators. These estimates vary with height and exposure. Standard measurements are taken by weather stations in openly exposed area. Table 6-1 describes the EF-scale ratings (NOAA 2007).

Table 6-1. The Fujita Scale and Enhanced Fujita Scale

Fujita (F) Scale			Derived		Operational Enhanced Fujita (EF) Scale	
F Number	Fastest ¼ mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)	EF Number	3-second gusts (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

The south coastal region of California, including the Los Angeles area, has the greatest incidence of tornadoes in the state. The cause of most Los Angeles area tornadoes is the terrain of the basin—specifically the natural curvature of the shoreline and the location of the coastal mountains. Tornadoes in the Los Angeles area are typically less severe than those in other parts of the country. They are typically not high in intensity and are short-lived. There is no record of a Los Angeles tornado causing a fatality, and the state has never proclaimed a state of emergency or had a federal disaster declared as the result of a tornado. Nevertheless, the frequency of tornadoes and the density of the Los Angeles urban area make tornadoes a relevant hazard for the City.

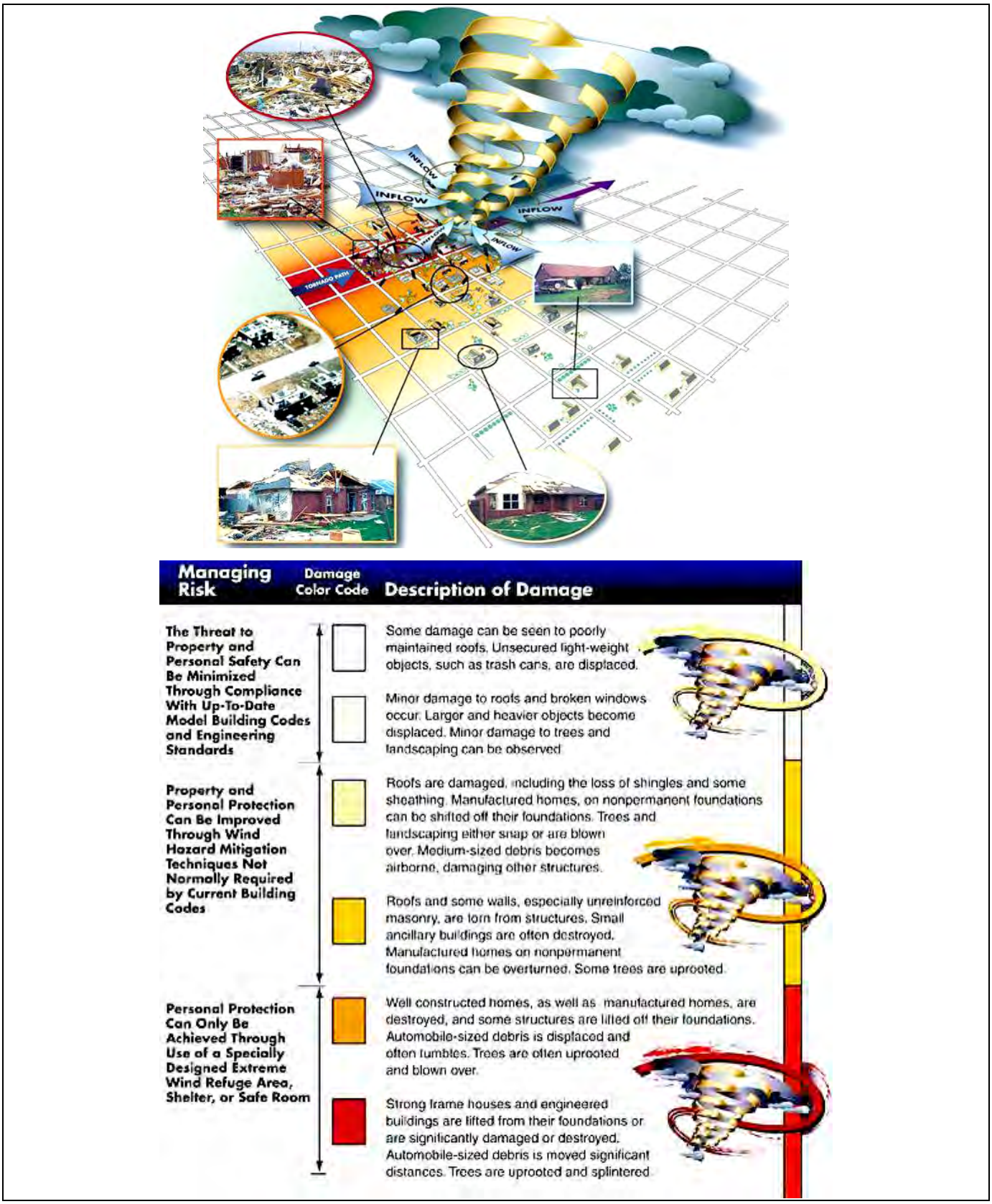


Figure 6-1. Potential Impact and Damage from a Tornado

6.2 HAZARD PROFILE

6.2.1 Past Events

Los Angeles has not been included in any federal declarations for extreme heat, high winds or tornado. According to the Western Regional Climate Center, the planning area averages 20 days a year with temperatures exceeding 90°F, and those days may be included in a heat wave event. A storm event database maintained by NOAA's National Centers for Environmental Information (NCEI) lists three excessive heat events in the planning area:

- **July 2006**—In July 2006, California and Nevada were impacted by a heat wave that was unprecedented with respect to the magnitude and duration of high temperatures, especially high nighttime minimums; great areal extent, as it simultaneously impacted both northern and Southern California; and very high humidity levels (Los Angeles Times, 25 July 2006). The events are credited with 163 deaths in California. A temperature of 119ºF was recorded in Woodland Hills, with high humidity.
- **August 30 – September 3, 2007**—The combination of above normal temperatures and relative humidity produced excessive heat across the planning area. Eight fatalities occurred related to the heat. Heat index values were between 105 and 112 degrees.
- **June 20 – 21, 2008**—The combination of strong high pressure centered over Arizona and weak offshore flow generated extreme heat conditions across Central and Southern California. Across many sections of the area, afternoon temperatures climbed to between 100ºF and 114ºF, setting numerous high temperature records. The extreme heat resulted in several power outages due to excessive electrical use.

Los Angeles County has experienced both high wind and thunderstorm wind events. The strongest winds, from the north, are Santa Ana winds in winter. As an example of the impacts from high wind storms, a windstorm on Nov. 30, 2011 left 300,000 customers without power, some over one week. The NCEI storm events database lists the following wind events from 1996 to 2016:

- 173 high wind events, with 96 categorized as damaging winds events
- 25 thunderstorm events, with 7 categorized as damaging wind events.

According to NCEI storm events database, Los Angeles County experienced 35 tornadoes from 1970 through 2016, with 34 injuries and over $60 million in property damage. The recorded tornado events are rated as F0 (25 events), EF0 (two events), F1 (six events), and the strongest recorded F2 (three events). The following are notable tornado events in the City of Los Angeles:

- **March 1, 1983**—An F2 tornado touched down in South-Central Los Angeles. It caused approximately $25 million in damage, including 100 homes, and injured 30 people. It stopped about 1 mile before reaching the Los Angeles civic center area.
- **December 12, 2014**—An EF0 tornado developed in south Los Angeles. The tornado damaged the roof of an apartment complex, two residential roofs and a steel billboard.

6.2.2 Location

Adverse weather events have the potential to happen anywhere in the planning area. Extreme heat events may be exacerbated in the City where reduced air flow, reduced vegetation, and increased generation of waste heat can contribute to temperatures that are several degrees higher than in surrounding less urbanized areas. High wind events affect an entire region.

6.2.3 Frequency

The adverse weather events for the planning area are often related to high winds associated with winter storms and thunderstorms. Based on a record of 103 damaging wind events (over 60 mph) in 21 years, the planning area will continue to experience these on an annual basis.

Even though the NCEI storm events database lists only two documented past events for extreme heat, Steering Committee members for this update report that extreme heat days occur a few days each year during summer.

Tornadoes may occur in any month and at any hour of the day, but they occur with the greatest frequency from November through March. There are only three recorded F2 tornado events from 1970 to 2016, therefore on average, a considerable tornado may occur every six years. There is a 68 percent chance of a light to moderate tornado occurring in any year.

6.2.4 Severity

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon, but can occur. Roads may become impassable due to flooding, downed trees, or a landslide. Power lines may be downed due to high winds, and services such as water or phone may not be able to operate without power. Physical damage to homes and facilities can be caused by wind or flooding.

Extreme heat can cause heat exhaustion, in which the body becomes dehydrated, resulting in an imbalance of electrolytes. Without intervention, heat exhaustion can lead to collapse and heatstroke. Heatstroke occurs when perspiration cannot occur and the body overheats. Without intervention, heatstroke can lead to confusion, coma, and death. Extreme heat is the primary weather-related cause of death in the U.S. In a 10-year record of weather fatalities across the nation from (2006-2015), excessive heat claimed more lives each year than floods, lightning, tornadoes, and hurricanes. In 2015, heat claimed 25 lives, though none of them were in California (NWS 2016b). Extreme heat events do not typically impact buildings; however, losses may be associated with the UHI effect and overheating of HVAC systems. These extreme heat events can lead to drought, impact water supplies, and lead to an increase in heat-related illnesses and deaths.

High winds are a frequent problem in the planning area and have been known to damage utilities. The wind speed given in wind warnings issued by the NWS is for a one-minute average; gusts may be 25 to 30 percent higher.

Tornadoes generally have low intensity in the planning area, but if a major tornado were to strike the dense planning area, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings may be damaged or destroyed. California ranks 32nd among states for frequency of tornadoes, 44th for the frequency of tornados per square mile, 36th for injuries, and 31st for cost of damage. The state has no reported deaths from tornadoes.

6.2.5 Warning Time

Meteorologists can often predict the likelihood of severe storms. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time. NOAA issues watch, warning, and advisory information for extreme heat, high winds, and tornadoes.

The NWS is producing experimental forecasts called HeatRisk to assess the heat risk to local thresholds in California, Nevada, Utah, and Arizona (see Figure 6-2). The numeric (0-4) and color (green, yellow, orange, red and magenta) scales are similar to the NWS air quality index.

Source: NWS, 2017

Numerical Value	Meaning	Who/What is at Risk?	How Common is this Heat?	For those at risk, what actions can be taken?
0	• Level of heat poses **little to no risk**	• No elevated risk	Very Common	• No additional preventative actions should be necessary.
1	• Heat of this type is **tolerated by most**; however there is a **low risk for sensitive groups** to experience health effects	• Primarily those who are extremely sensitive to heat	Very Common	• Increase hydration • Reduce time spent outdoors or stay in the shade when the sun is strongest • Open windows at night and use fans to bring cooler air inside buildings
2	• **Moderate risk for members of heat sensitive groups** to experience health effects • **Some risk for the general population who are exposed to the sun and are active** • For those without air conditioning, **living spaces can become uncomfortable during the day**, but should cool below dangerous levels at night	• Primarily heat sensitive groups, especially those without effective cooling or hydration • Some transportation and utilities sectors	• Fairly common most locations • Very common in southern regions of country	• Reduce time in the sun between 10 a.m. and 4 p.m. • Stay hydrated • Stay in a cool place during the heat of the day • Move outdoor activities to cooler times of the day • Open windows at night and use fans to bring cooler air inside buildings and circulate air
3	• **High Risk for much of the population who are 1) exposed to the sun and active or 2) are in a heat sensitive group** • **Dangerous to anyone without proper hydration or adequate cooling** • **Poor air quality** is possible • **Power interruptions may occur** as electrical demands increase	• Much of the population, especially those who are heat sensitive and anyone without effective cooling or hydration • Most transportation and utilities sectors	• Uncommon most northern locations • Fairly common in southern regions of country	• Try to avoid being outdoors in the sun between 10 a.m. and 4 p.m. • Stay hydrated • Stay in a cool place especially during the heat of the day • If you have access to air conditioning, use it. Fans may not be adequate • Cancel outdoor activities during the heat of the day
4	• **Very High Risk for entire population** • **Very dangerous to anyone without proper hydration or adequate cooling.** • **This is a multi-day excessive heat event.** Prolonged heat is dangerous to anyone not prepared. • **Poor air quality** is likely. • **Power outages are increasingly likely** as electrical demands may reach critical levels.	• Entire population is at risk. • For heat sensitive groups, especially people without effective cooling, **this level of heat can be deadly**. • Most transportation and utilities sectors	• Rare most locations • Occurs up to a few times a year in southern regions of country, especially the Desert Southwest	• Avoid being outdoors in the sun between 10 a.m. and 4 p.m. • Stay hydrated • Stay in a cool place, including overnight • If you have access to air conditioning, use it. Fans will not be adequate • Cancel outdoor activities during the heat of the day

Figure 6-2. NWS HeatRisk Forecasting System

The NWS continues to issue excessive heat watches, excessive heat warnings and heat advisories to warn of an extreme heat event (a "heat wave") within the next 36 hours. If NWS forecasters predict an excessive heat event beyond 36 hours, then the NWS will issue messaging in the form of a special weather statement, partner emails and social media out between the three- to seven-day timeframe. The NWS will use the HeatRisk output (Figure 6-2) to determine if an excessive heat watch/warning or heat advisory is warranted. The NWS issues the following types of heat-related advisories:

- **Heat Advisory**—Tied to events where HeatRisk output is on the orange/red (Level 2-3) thresholds (orange will not be an automatic heat advisory).
- **Excessive Heat Watch/Warning**— Tied to events where HeatRisk output is on the red/magenta (Level 3-4) thresholds.

These advisories are intended to raise the public's awareness to prevent heat illnesses from occurring. If significantly hot weather is forecasted, the NWS will issue an excessive heat watch generally two to three days in advance. An excessive heat watch is a way to give the public and emergency officials a warning that extreme temperatures are expected. If significantly hot temperatures remain in the forecast for 24 to 28 hours, the excessive heat watch will be upgraded to an excessive heat warning, indicating that extreme heat has either arrived or is expected soon.

6.3 SECONDARY IMPACTS

A secondary impact of extreme heat is poor air quality, which can occur during summer months, when stagnant atmospheric conditions trap humid air and pollutants near the ground and closer to residents. Ozone, a major component of smog, is created in the presence of sunlight via reactions between chemicals in gasoline vapors and industrial smoke stacks. Hot weather can increase ozone levels. High ozone levels often cause or worsen respiratory problems. The longer a given heat wave lasts and the hotter the temperature is, the greater the risk of adverse impacts on human health or infrastructure. Additionally, climate change is likely to bring hotter temperatures, more hot days, and more frequent heat waves. As the population ages and climate change brings more extreme heat events, rates of heat-related impairments and deaths may rise.

High winds and tornadoes may cause loss of power if utility service is disrupted. Debris carried by high winds can also result in injury or property damage. Tornadoes may cause fires resulting from damage to natural gas infrastructure. Hazardous materials may be released if a structure is damaged that stores such materials or if such a material is in transport.

6.4 EXPOSURE

6.4.1 Population

It can be assumed that all residents of Los Angeles are exposed to some extent to extreme heat, high winds, and tornadoes.

6.4.2 Property

According to the Los Angeles County Assessor, there are 746,352 buildings within the census tracts that define the planning area. Most of these buildings are residential. All of these buildings are considered to be exposed to the adverse weather hazard. The frequency and degree of damage will depend on specific locations. Typically the only impact extreme heat has on general building stock is increased demand on air conditioning equipment, which may cause strain on electrical systems.

6.4.3 Critical Facilities and Infrastructure

Extreme heat poses a risk to ground transportation infrastructure. For instance, high temperatures can cause railroad tracks and wires, and pavement and joints on roads and bridges to crack, buckle, or sag, resulting in service disruptions, potentially hazardous travel conditions, and the need for costly repairs.

Power outages or roaming blackouts may occur as a result of extreme heat events that strain and overheat circuits. During a blackout, all critical facilities and infrastructure that are reliant upon electricity for power will be severely impacted unless they are connected to a backup power source. Additional facilities on higher ground may also be exposed to wind damage or damage from falling trees.

6.4.4 Environment

The environment is highly exposed to adverse weather events. Natural habitats and park areas are exposed to the elements and risk damage and destruction. Prolonged extreme heat can degrade landscape quality, lakes and vegetation. High winds and tornadoes can cause entire trees to topple.

6.5 VULNERABILITY

6.5.1 Population

According to the EPA, those at greater risk to the adverse effects of excessive heat events are individuals with physical or mobility constraints, cognitive impairments, economic constraints, and social isolation. Such populations include the elderly, young children, low income people, people with life-threatening illnesses and those who are overweight. Power outages can be life threatening to those dependent on electricity for life support. Outdoor recreational users may also be more vulnerable to adverse weather events.

The homeless are particularly vulnerable to extreme heat during the summer when increased humidity keeps nighttime temperatures above 80°F. The cumulative effects over several days of continuous exposure to heat, without relief, put the homeless at serious risk of heat stroke or worse. Others at significant risk are low income populations who do not have access to air conditioning. This population, like the homeless, would lack nighttime relief from the heat, elevating their risk of heat stroke or other complications.

6.5.2 Property

All property is vulnerable to adverse weather, but structures in poor condition or in vulnerable locations may risk the most damage. Northern portions of the City are more vulnerable to high Santa Ana winds, and buildings in higher elevations and on ridges may be more prone to wind damage in general. Homes near mature trees or overhead power lines may be more susceptible to wind damage and blackouts.

It is estimated that 92 percent of residential structures in Los Angeles were built without the influence of a building code with provisions for wind loads. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse.

Loss estimations for the adverse weather hazard are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 6-2 lists the loss estimates by Area Planning Commission (APC) within the City of Los Angeles.

Table 6-2. Loss Potential for Adverse Weather

Area Planning Commission	Total Building Value (Structure and Contents)	10% of Total Building Value	30% of Total Building Value	50% of Total Building Value
Central	$191,217,052,041	$19,121,705,204	$57,365,115,612	$95,608,526,020
East Los Angeles	$66,257,497,608	$6,625,749,761	$19,877,249,282	$33,128,748,804
Harbor	$40,999,775,796	$4,099,977,580	$12,299,932,739	$20,499,887,898
North Valley	$115,609,300,175	$11,560,930,017	$34,682,790,052	$57,804,650,087
South Los Angeles	$98,455,728,673	$9,845,572,867	$29,536,718,602	$49,227,864,337
South Valley	$145,505,548,380	$14,550,554,838	$43,651,664,514	$72,752,774,190
West Los Angeles	$109,858,703,574	$10,985,870,357	$32,957,611,072	$54,929,351,787
Total	$767,903,606,246	$76,790,360,625	$230,371,081,874	$383,951,803,123

6.5.3 Critical Facilities and Infrastructure

Incapacity and loss of roads are the primary transportation failures resulting from adverse weather, mostly associated with secondary impacts. High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, and disrupting ingress and egress.

6.5.4 Environment

The vulnerability of the environment to adverse weather is the same as the exposure.

6.6 FUTURE TRENDS IN DEVELOPMENT

All future development will be affected by adverse storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The City of Los Angeles has adopted the International Building Code in response to California mandates. This code is equipped to deal with the impacts of adverse weather events. Land use policies identified in the City's general plan also address many of the secondary impacts of the adverse weather hazard. With these tools, the City of Los Angeles is well equipped to deal with future growth and the associated impacts of adverse weather.

6.7 SCENARIO

Although extreme heat and high winds occur on an annual basis, secondary impacts can be significant for the densely populated City of Los Angeles. A worst-case event would involve prolonged high winds during a winter storm accompanied by an EF3 tornado. Such an event would have both short-term and longer-term effects. Initially, schools and roads would be closed due to power outages caused by the tornado event. The tornado would cause structural damage, injury, fatalities and displacement of people from their homes.

6.8 ISSUES

Important issues associated with an adverse weather in the planning area include the following:

- Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to adverse weather events such as windstorms.
- The UHI of Los Angles makes the homeless and vulnerable communities susceptible to heat exhaustion.
- The City may need to open cooling/warming stations during extreme temperature events.
- Redundancy of power supply and communications equipment must be evaluated.
- The capacity for backup power generation is limited.

- Dead or dying trees as a result of drought conditions are more susceptible to falling during severe storm events.
- Adverse weather events are likely to increase as a result of climate change impacts, including the potential for extreme heat.

7. DAM FAILURE

7.1 GENERAL BACKGROUND

7.1.1 Causes of Dam Failure

Dam failures in the United States typically occur in one of four ways:

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
- Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

The remaining 6 percent of U.S. dam failures are due to miscellaneous causes. Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage. The most likely disaster-related causes of dam failure in the Los Angeles vicinity are earthquakes, excessive rainfall, and landslides.

Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

DEFINITIONS

Dam—Any artificial barrier, together with appurtenant works, that does or may impound or divert water, and that either (a) is 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier (or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse) to the maximum possible water storage elevation; or (b) has an impounding capacity of 50 acre-feet or more. (CA Water Code, Division 3.)

Dam Failure—An uncontrolled release of impounded water due to structural deficiencies in dam.

Emergency Action Plan—A formal document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize property damage and loss of life. The plan specifies actions the dam owner should take to alleviate problems at a dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show emergency management authorities the critical areas for action in case of an emergency.

High Hazard Dam—Dams where failure or improper operation will probably cause loss of human life.

Significant Hazard Dam—Dams where failure or improper operation will result in no probable loss of human life but can cause economic loss, environmental damage or disruption of lifeline facilities, or can impact other concerns. Significant hazard dams are often located in rural or agricultural areas but could be located in areas with population and significant infrastructure.

7.1.2 Regulatory Oversight

National Dam Safety Act

Potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program requires a periodic engineering analysis of the majority of dams in the country; exceptions include the following:

- Dams under jurisdiction of the Bureau of Reclamation, Tennessee Valley Authority, or International Boundary and Water Commission
- Dams constructed pursuant to licenses issued under the Federal Power Act
- Dams that the Secretary of the Army determines do not pose any threat to human life or property.

The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect lives and property of the public. The National Dam Safety Program is a partnership among the states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most of the dams in the United States.

California Division of Safety of Dams

California's Division of Safety of Dams (DSOD) monitors the dam safety program at the state level and maintains a working list of dams in the state. When a new dam is proposed, DSOD engineers and geologists inspect the site and the subsurface. Upon submittal of an application, the DSOD reviews the plans and specifications prepared by the owner to ensure that the dam is designed to meet minimum requirements and that the design is appropriate for the known geologic conditions. After approval of the application, the DSOD inspects all aspects of the construction to ensure that the work is done in accordance with the approved plans and specifications. After construction, the DSOD inspects each dam to ensure that it is performing as intended and is not developing problems. The DSOD periodically reviews the stability of dams and their major appurtenances in light of improved design approaches and requirements, as well as new findings regarding earthquake hazards and hydrologic estimates in California. Over 1,200 dams are inspected by DSOD engineers on a yearly schedule to ensure performance and maintenance of dams (California DSOD, 2017).

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers operates and maintains approximately 700 dams nationwide. It is also responsible for safety inspections of federal and non-federal dams in the United States that meet size and storage limitations specified in the National Dam Safety Act. The Corps of Engineers has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety. The Corps maintains the National Inventory of Dams that contains information about a dam's location, size, purpose, type, last inspection and regulatory facts (U.S. Army Corps of Engineers, 2017). Table 7-1 provides the most recent inspection dates for the dams in Los Angeles County and in City of Los Angeles that can impact the city.

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) cooperates with a large number of federal and state agencies to ensure and promote dam safety. More than 3,000 dams are part of regulated hydroelectric projects in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important.

Table 7-1. Los Angeles County Dam Inspection Dates

Dam Name	Inspection Date	Dam Name	Inspection Date
10th and Western	09/04/2014	Lopez[a]	03/04/2014
Big Tujunga	02/04/2015	Los Angeles Reservoir[a]	08/22/2014
Devils Gate	10/14/2014	Lower Franklin #2[a]	09/30/2014
Diederich Reservoir	09/04/2014	Lower Van Norman Bypass	08/22/2014
Eagle Rock[a]	09/16/2014	Mulholland[a]	09/16/2014
Elysian[a]	09/16/2014	Pacoima	11/05/2014
Encino[a]	09/10/2014	Palos Verdes Reservoir	01/21/2015
Glen Oaks 968	09/04/2014	Riviera Reservoir[a]	09/03/2014
Green Verdugo	09/17/2014	Santa Ynez Canyon[a]	09/17/2014
Greystone	09/03/2014	Sepulveda	02/12/2015
Hansen Rec Lake[a]	03/21/2014	Silver Lake[a]	09/30/2014
Ivanhoe	Not Available	Solano	06/21/2011
Laguna Reg. Basin	10/14/2014	Stone Canyon[a]	09/10/2014
		Upper Franklin Dam	07/27/2006

a. Dams located within Los Angeles city limits

Source: National Inventory of Dams, https://catalog.data.gov/dataset/national-inventory-of-dams, 2017

FERC inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent engineer approved by the FERC must inspect and evaluate projects with dams higher than 32.8 feet (10 meters) or with a total storage capacity of more than 2,000 acre-feet.

FERC monitors and evaluates seismic research and applies it in investigating and performing structural analyses of hydroelectric projects. FERC also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

7.2 HAZARD PROFILE

7.2.1 Past Events

According to the 2013 California State Hazard Mitigation Plan, there have been nine dam failures in the state since 1950, some of which occurred in Los Angeles County. Overtopping caused two of the failures, and the others were caused by seepage or leaks. The historical record indicates that California has had about 45 failures of non-federal dams. The failures occurred for a variety of reasons, the most common being overtopping. Other reasons include shortcomings in the dams or an inadequate assessment of surrounding geomorphologic characteristics. The sections below describe significant dam failure events directly relevant to the City of Los Angeles.

St. Francis Dam, 1928

The most catastrophic dam failure in California's history was that of the St. Francis Dam in Los Angeles County in March 1928. This failure resulted in the deaths of more than 450 people and destruction of nearly 1,000 homes and buildings. Numerous roads and bridges were destroyed or damaged beyond repair. The DSOD came into existence as a direct result of this catastrophe.

Baldwin Hills Reservoir Collapse, 1963

On December 14, 1963, the dam at the head of Cloverdale Road broke in the Baldwin Hills section of Los Angeles. Lost homes, ruined property, and even death resulted from a river of rushing water from the broken dam. Automobiles, fragments of houses, and chunks of concrete were carried along the flood's path and deposited on the ruins of Village Green. Eighteen persons were rescued by helicopter and flown out to a safety.

1971 Earthquake

In 1971, a magnitude 6.7 earthquake had the following impacts on dams in the Los Angeles area:

- Perched above the densely populated San Fernando Valley, the 142-foot-high, 2,100-foot-long Lower San Fernando Dam held a reservoir 1.6 miles long and as much as 130 feet deep and supplied 80 percent of the City's water supply. The quake shook loose a massive slide in the upstream slope of the Lower San Fernando Dam that lowered the crest about 30 feet and carried away much of upstream concrete facing of the dam. Resulting severe damage of the dam forced 80,000 residents to evacuate homes in an 11-square-mile area down the valley while the water behind the earthen dam was lowered over a three-day period. The damage was so heavy that the dam could not be repaired to safely hold its water supply in the event of another large earthquake. The $33 million Los Angeles Dam and Reservoir was built in 1975-76 about 3,000 feet up the valley from the old Lower San Fernando Dam, and the old dam was reconstructed to provide a holding basin for stormwater and to back up the new dam.
- Several thousand people were evacuated from homes south of Van Norman Dam in Mission Hills when Van Norman Lake reportedly sank 1 foot. A 60-foot section of the concrete dam at the lake's southern edge collapsed, and portions were reported as still crumbling during the evacuation. The dam holds back more than 6 billion gallons of water and is the largest in the City's water system.
- Cracks were reported in the Hansen Dam on Sepulveda Boulevard in Lakeview Terrace.

1994 Northridge Earthquake

Thirteen dams in the greater Los Angeles area moved or cracked during the 1994 Northridge Earthquake. The most seriously damaged was the Pacoima Dam, about 8 miles from the epicenter. However, none were severely damaged, in part due to completion of retrofitting pursuant to the 1972 State Dam Safety Act. The Los Angeles Dam showed only minor deformation and superficial cracking.

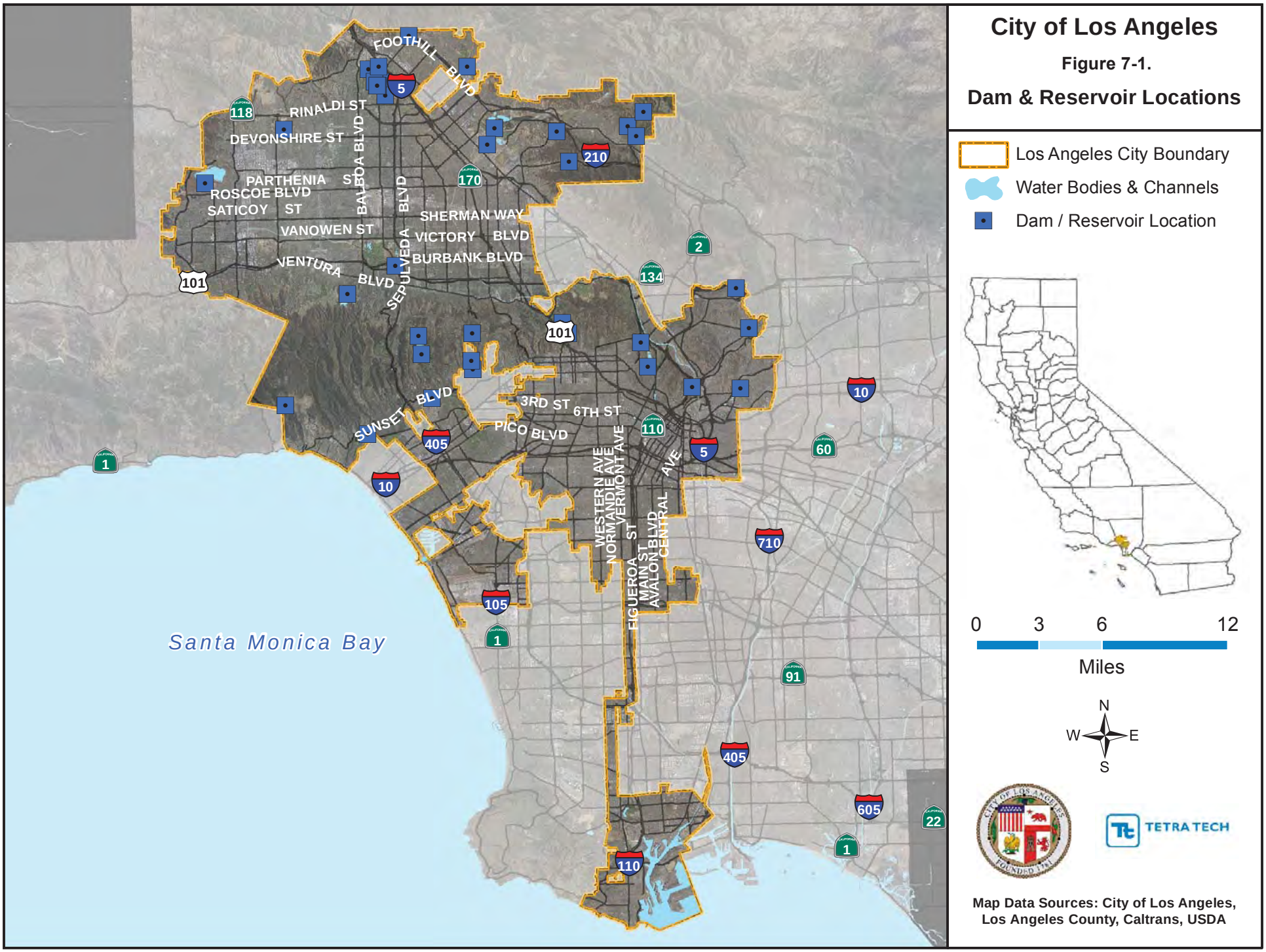
7.2.2 Location

According to the California DSOD, there are 90 dams in Los Angeles County. Table 7-2 lists the dams that have the potential to impact the City of Los Angeles should they fail. Dam locations are shown in Figure 7-1.

Table 7-2. Dams in Los Angeles County with Potential to Impact City of Los Angeles

Name	Hazard Class[a]	Water Course	Owner	Year Built	Dam Type[d]	Crest Length (feet)	Height (feet)	Storage Capacity (acre-feet)	Drainage area (sq. mi.)
10th and Western	1A	Off stream	City of Glendale	1924	ERTH	725	28	46	1.03
Big Tujunga	1A	Big Tujunga Creek	Los Angeles County	1931	VARA	505	220	5,750	81.7
Devils Gate	1A	Arroyo Seco	Los Angeles County	1920	GRAV	252	108	2,600	29.7
Diederich Res	1A	Off stream	City of Glendale	1950	ERTH	100	60	174	0
Eagle Rock[b]	1A	Off Stream	City of Los Angeles	1953	ERTH	495	113	254	0
Elysian[b]	1A	Los Angeles River Tributary	City of Los Angeles	1943	ERTH	480	71	167	0.08
Encino[b]	1A	Encino Creek	City of Los Angeles	1924	ERTH	1,850	168	9789	1.4
Glen Oaks 968	1A	Off Stream	City of Glendale	1949	ERTH	220	62	28	0
Green Verdugo	1A	Tujunga Wash Tributary	City of Los Angeles	1953	ERTH	452	118	99	0.04
Greystone	1A	Off Stream	City of Beverley Hills	1970	RECT	1,140	75	60	0
Hansen Rec Lake[b]	1A	Off Stream	City of Los Angeles	1999	ERTH	3,600	50	85	0.01
Ivanhoe[c]	N/A	Off stream	City of Los Angeles	1906	ERTH	430	458	180	N/A
Laguna Reg. Basin	1A	Laguna Wash	Los Angeles County	1970	ERTH	380	43	310	5.55
Lopez[b]	1A	Arroyo Grande Creek	San Luis Obispo County	1969	ERTH	1,120	166	52,500	70
Los Angeles Res[b]	1A	San Fernando Creek	City of Los Angeles	1977	ERTH	3,415	130	10,000	9
Lower Franklin No. 2[b]	1A	Franklin Canyon	City of Los Angeles	1982	ERTH	410	49	920	1.12
Lower Van Norman Bypass[c]		Off stream	City of Los Angeles	1970	ERTH	600	78	240	0.03
Mulholland[b]	1A	Weid Canyon	City of Los Angeles	1924	GRAV	933	195	4,036	1
Pacoima	1A	Pacoima Creek	Los Angeles County	1929	VARA	640	365	3,777	27.8
Palos Verdes Res	1A	LA Harbor Tributary	Metropolitan Water District	1939	ERTH	2,150	82	1,100	1
Riviera Res. [b]	1A	Off Stream	City of Santa Monica	1962	RECT	1,280	40	76	0
Santa Ynez Canyon[b]	1A	Santa Ynez Canyon Tributary	City of Los Angeles	1968	ERTH	455	157	356	0.23
Sepulveda	1A	Los Angeles River	Corps of Engineers	1941	CONC	15,270	57	--	--
Silver Lake[b]	1A	Ballona Creek Tributary	City of Los Angeles	1906	ERRK	760	43	2,020	0.12
Solano[c]	N/A	Off stream	City of Los Angeles	1904	ERTH	915	620	17	0.99
Stone Canyon[b]	1A	Stone Canyon Creek	City of Los Angeles	1924	ERTH	1,150	188	10,372	1.4
Upper Franklin	N/A	N/A	National Park Service	1915	ERTH	260	40	150	N/A

a. Downstream Hazard Class 1A: > 300 lives at risk, 1B: 31 to 300 lives at risk, 1C: 7 to 30 lives at risk.
b. Dams located within Los Angeles city limits
c. No inundation mapping available for these dams
d. Dam Type: ERTH = earth fill; VARA = arch; GRAV = gravity; RECT = reinforced concrete tank; CONC = concrete; ERRK = rock fill
Source: California DWR, 2015.



City of Los Angeles

Figure 7-1.

Dam & Reservoir Locations

Los Angeles City Boundary

Water Bodies & Channels

Dam / Reservoir Location

0 3 6 12

Miles

N
W E
S

Map Data Sources: City of Los Angeles, Los Angeles County, Caltrans, USDA

Over one third of the land area and population in the City is potentially threatened by dam failure. Inundation maps have been developed for all of these dams. These maps are the basis for the dam failure risk analysis contained in this chapter, but they are not available to the public and are not included in this plan for security purposes. City emergency management officials have access to the data to support response or recovery from a dam failure event. Questions regarding probable exposure to dam failure inundation should be directed to the City of Los Angeles Emergency Management Department.

7.2.3 Frequency

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides and excessive rainfall and snowmelt. There is a "residual risk" associated with dams that remains after safeguards have been implemented. The residual risk is associated with events beyond those that the facility was designed to withstand. However, the probability of dam failure is low in today's regulatory environment.

7.2.4 Severity

Dam failure can be catastrophic to all life and property downstream. The U.S. Army Corps of Engineers developed the classification system shown in Table 7-3 for the hazard potential of dam failures. The rating system is based on the potential consequences of a dam failure; it does not address the probability of such failures.

Table 7-3. Corps of Engineers Hazard Potential Classification

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss of life potential based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.
c. Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: U.S. Army Corps of Engineers, 1995

7.2.5 Warning Time

Warning time for dam failure depends on the cause of the failure. In case of extreme precipitation or snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until the reservoir is empty or the breach resists further erosion. Concrete dams also tend to begin with a partial breach. The time of breach formation ranges from a few minutes to a few hours (U.S. Army Corps of Engineers, 1997). The City of Los Angeles has established protocols for flood warning and response to imminent dam failure in the flood warning portion of its adopted emergency operations plan.

7.3 SECONDARY IMPACTS

Dam failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary impacts of dam failure are landslides around the reservoir perimeter, bank erosion on the rivers, and destruction of downstream habitat.

7.4 EXPOSURE

Exposure to the dam failure hazard was assessed by use of spatial analysis. Dam inundation areas for which inundation mapping was available were combined into a single inundation area. The combined dam failure inundation area includes the following dams:

- Big Tijunga No. 1
- Devils Gate
- Eagle Rock
- Elysian
- Encino
- Green Verdugo
- Greystone Res
- Hansen Rec Lake
- Lopez
- Los Angeles Reservoir
- Lower Franklin No. 2
- Mulholland
- Pacoima
- Palos Verdes Res
- Riviera Res
- Santa Ynez Canyon
- Sepulveda
- Silver Lake
- Stone Canyon
- Upper Franklin.

This area was overlaid with planning area general building stock. The flood module of the Hazus risk assessment platform was used to assess dam failure. Hazus uses census data at the block level and FEMA floodplain data, which has a level of accuracy acceptable for planning purposes. Where possible, the Hazus data for this risk assessment was enhanced using GIS data from local, state and federal sources.

7.4.1 Population

All populations in a dam failure inundation zone would be exposed to the risk of a dam failure. The potential for loss of life is affected by the capacity and number of evacuation routes available to populations living in areas of potential inundation. The estimated population living in the mapped inundation areas within the planning area is 1,553,114 or 39.8 percent of the total planning-area population.

7.4.2 Property

Structures

Based on assessor parcel data, the Hazus model estimated that there are 292,601 structures within the combined dam failure inundation area. The Hazus-derived value of exposed buildings by Area Planning Commission (APC) is summarized in Table 7-4. This methodology estimated $340 billion worth of building-and-contents exposure to dam failure inundation, representing 44.4 percent of the total replacement value of the planning area.

Land Use

Some land uses are more vulnerable to dam failure inundation, such as single-family homes, while others are less vulnerable, such as agricultural land or parks. Table 7-5 shows the existing land use of all parcels in the combined dam inundation area, including those in public/open space uses, for the planning area. Open space uses make up about 12 percent of the combined dam inundation area. These are favorable, lower-risk uses for dam inundation areas. The amount of the dam inundation area contains vacant, developable land is not known. This would be valuable information for gauging the future development potential of the dam inundation area.

Table 7-4. Exposure and Value of Structures in Dam Failure Inundation Areas

Area Planning Commission	Number of Buildings Exposed	Value of Structures Exposed	Value of Contents Exposed	Total (Structure and Contents) Exposed	% of Total Value Exposed
Central	39,314	$54,215,144,986	$43,066,508,136	$97,281,653,123	50.9%
East Los Angeles	8,285	$8,718,646,162	$7,929,448,885	$16,648,095,048	25.1%
Harbor	584	$1,125,941,991	$1,203,290,913	$2,329,232,904	5.7%
North Valley	58,199	$25,981,401,490	$19,728,119,922	$45,709,521,412	39.5%
South Los Angeles	79,092	$41,294,490,165	$31,497,066,083	$72,791,556,249	73.9%
South Valley	77,847	$45,352,442,478	$30,253,996,760	$75,606,439,238	52.0%
West Los Angeles	28,550	$17,984,324,642	$12,555,856,543	$30,540,181,185	27.8%
Total	291,871	$194,672,391,915	$146,234,287,243	$340,906,679,158	44.4%

Table 7-5. General Plan Land Use in Dam Failure Inundation Areas

Land Use	Combined Dam Inundation Area	
	Area (acres)	% of total
Agriculture	0.0	0.00%
Commercial	6,713.3	9.24%
Government	6,951.2	9.57%
Industrial	10,533.5	14.50%
Multi-Family Residential	15,705.2	21.61%
Open Space	9,068.9	12.48%
Parking	8.9	0.01%
Single Family Residential	23,680.9	32.59%
Total	72,661.8	100.00%

7.4.3 Critical Facilities

Table 7-6 summarizes the number of the planning area's critical facilities that are in the mapped inundation areas.

Table 7-6. Critical Facilities and Infrastructure in Dam Failure Inundation Areas

APC	Critical Operating Facilities	Critical Response Facilities	Critical Infrastructure—Transportation	Critical Infrastructure—Utilities	Total
Central	5	65	69	32	171
East Los Angeles	0	13	66	33	112
Harbor	0	1	11	15	27
North Valley	0	76	125	82	283
South Los Angeles	0	127	86	55	268
South Valley	2	87	138	63	290
West Los Angeles	1	35	49	21	106
Total	8	404	544	301	1,257

7.4.4 Environment

Reservoirs held behind dams affect many ecological aspects of a river. River topography and dynamics depend on a wide range of flows, but rivers below dams often experience long periods of very stable flow conditions or saw-tooth flow patterns caused by releases followed by no releases. Water releases from dams usually contain very little suspended sediment; this can lead to scouring of river beds and banks.

The environment would be exposed to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways. This could result in destruction of downstream habitat and could have detrimental effects on many species of animals, especially endangered species such as salmon.

7.5 VULNERABILITY

7.5.1 Population

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable time frame. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television or radio emergency warning system. A geographic analysis of demographics using the Hazus model identified populations vulnerable to the dam failure hazard as follows:

- **Economically Disadvantaged Populations**—It is estimated that 55 percent of the households within the combined dam inundation areas are economically disadvantaged, defined as having household incomes of $50,000 or less.
- **Population over 65 Years Old**—It is estimated that 9 percent of the population in the census blocks that intersect the combined dam inundation areas are over 65 years old.
- **Population under 16 Years Old**—It is estimated that 24 percent of the population within census blocks located in or near the combined dam inundation areas are under 16 years of age.

7.5.2 Property

Vulnerable properties are those closest to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. This includes all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

It is estimated that there could be up to $108 billion of losses from dam failures affecting the planning area. This represents 14.1 percent of the total replacement value of the planning area. Table 7-7 summarizes the loss estimates for dam failure. The Hazus analysis also estimated the amount of debris that would be caused by a dam failure in the planning area, as summarized in Table 7-8.

7.5.3 Critical Facilities

Table 7-9 summarizes the Hazus results for potential damage from dam failure to critical facilities in the dam failure inundation area.

Table 7-7. Loss Estimates for Dam Failure

Area Planning Commission	Buildings Impacted	Value of Structures Damaged	Value of Contents Damaged	Total Value (Structure and Contents) Damaged	% of Total Value Damaged
Central	23,496	$11,764,854,423	$16,104,622,969	$27,869,477,392	14.6%
East Los Angeles	6,022	$2,033,175,464	$2,448,366,240	$4,481,541,704	6.8%
Harbor	454	$84,369,803	$132,082,642	$216,452,445	0.5%
North Valley	36,582	$5,787,154,365	$6,162,016,744	$11,949,171,110	10.3%
South Los Angeles	75,892	$15,432,886,043	$18,745,359,132	$34,178,245,175	34.7%
South Valley	60,165	$11,133,349,064	$9,737,597,319	$20,870,946,383	14.3%
West Los Angeles	17,907	$4,636,020,393	$4,300,107,899	$8,936,128,292	8.1%
Total	220,518	$50,871,809,556	$57,630,152,946	$108,501,962,501	14.1%

Table 7-8. Estimated Debris

Area Planning Commission	Debris to Be Removed (tons) from Combined Dam Inundation
Central	1,712,077
East Los Angeles	336,748
Harbor	4,376
North Valley	949,319
South Los Angeles	3,448,095
South Valley	1,717,866
West Los Angeles	893,068
Total	9,061,549

Table 7-9. Potential Damage to Critical Facilities in Dam Failure Inundation Area

	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Critical Operating Facilities	3	9.52	41.88
Critical Response Facilities	227	N/A	N/A
Critical Infrastructure—Transportation	275	3.35	43.38
Critical Infrastructure—Utilities	134	30.38	47.90
Total/Average	639	14.42	44.39

7.5.4 Environment

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals, especially endangered species such as the Santa Ana sucker and arroyo chub. The extent of the vulnerability of the environment is the same as the exposure of the environment.

7.6 FUTURE TRENDS IN DEVELOPMENT

Dam failures are low-probability, high-consequence events. Because of this, it is not typically practical for local governments to regulate new development in dam failure inundation areas. Land use will be directed by the City of Los Angeles General Plan and zoning ordinance adopted under state law. The safety element of the General Plan establishes standards and plans for the protection of the community from hazards. Dam failure is currently

not addressed as a stand-alone hazard in the safety element, but flooding is. The City of Los Angeles has established comprehensive policies regarding sound land use in identified flood hazard areas. Most of the areas vulnerable to the more severe impacts from dam failure intersect the mapped flood hazard areas. Flood-related policies in the general plan will help to reduce the risk associated with the dam failure hazard for all future development in the City. Any new development outside of a flood hazard area will most likely not include provisions that would mitigate the impacts from a dam failure.

While probability of dam failure is low, probability of flooding associated with changes in dam operational parameters in response to extreme rainfall events is higher. Dam designs and operations are developed based on hydrographs from historical records. If these hydrographs change significantly over time due to effects of climate change, current dam designs and operations may become overwhelmed. Specified release rates and impound thresholds may have to be changed, which could result in increased discharges downstream of these facilities, thus increasing probability and severity of flooding.

7.7 SCENARIO

An earthquake in the region could lead to liquefaction of soils around a dam. This could occur without warning during any time of the day. Human activity such as a terrorist attack also could trigger a catastrophic failure of a dam that impacts the planning area.

7.8 ISSUES

The most significant issue associated with dam failure involves the properties and populations in the inundation zones. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failure. These events are frequently associated with other natural hazard events such as earthquakes, landslides or adverse weather, which limits their predictability and compounds the hazard. Important issues associated with dam failure hazards include the following:

- California's AB 2800 enacts legislation that will require engineers and climate scientists to collaborate to help the state design and build infrastructure that will withstand the unavoidable impacts of a changing climate.
- Federally regulated dams have an adequate level of oversight and sophistication in the development of emergency action plans for public notification in the unlikely event of failure. However, the protocol for notification of downstream residents of imminent failure needs to be tied to local emergency response planning.
- Mapping for federally regulated dams is already required and available; however, mapping for non-federal-regulated dams that estimates inundation depths is needed to better assess the risk associated with dam failure from these facilities.
- Most dam failure mapping required at federal levels requires determination of the probable maximum flood. While the probable maximum flood represents a worst-case scenario, it is generally the event with the lowest probability of occurrence. For non-federal-regulated dams, mapping of dam failure scenarios that are less extreme than the probable maximum flood but have a higher probability of occurrence can be valuable to emergency managers and community officials downstream of these facilities. This type of mapping can illustrate areas potentially impacted by more frequent events to support emergency response and preparedness.
- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- Addressing security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.

8. DROUGHT

8.1 GENERAL BACKGROUND

Drought is a significant decrease in water supply relative to what is "normal" in a given location. A part of the climate cycle of most regions, drought originates from a deficiency of precipitation over an extended period of time, usually a season or more. This leads to a water shortage for some activity, group or environmental sector.

Determination of when drought begins is based on impacts on water users and assessments of the available water supply, including water stored in surface reservoirs or groundwater basins. Different water agencies have different criteria for defining drought. Some issue drought watch or drought warning announcements. The California water code does not include a statutory definition of drought; however, the code frequently focuses on drought conditions during times of water shortages (California Code of Regulations (CCR) 2016).

DEFINITIONS

Drought—The cumulative impacts of long periods of dry weather. These can include deficiencies in surface and subsurface water supplies and general impacts on health, well being, and quality of life.

Meteorological drought—Precipitation at levels below normal over a period of time. Meteorological measurements are the first indicators of drought and are usually region-specific.

Agricultural Drought—Inadequate soil moisture to meet the needs of a particular crop at a particular time.

Hydrological Drought—Deficiencies in surface and subsurface water supplies.

Socioeconomic Drought—Drought impacts on health, wellbeing, and quality of life.

8.1.1 Monitoring Drought

The National Oceanic and Atmospheric Administration has developed several indices to measure drought impacts and severity and to map their extent and locations:

- The ***Palmer Crop Moisture Index*** measures weekly short-term drought to quantify drought impacts on agriculture during the growing season. Figure 8-1 shows this index for the week ending March 11, 2017.
- The ***Palmer Z Index*** measures monthly short-term drought. Figure 8-2 shows this index for February 2017.
- The ***Palmer Drought Index*** measures the duration and intensity of long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during a given month is dependent on the current weather patterns plus the cumulative patterns of previous months. Weather patterns can change quickly from a long-term drought pattern to a long-term wet pattern, and the Palmer Drought Index can respond fairly rapidly. Figure 8-3 shows this index for March 11, 2017.
- The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The ***Palmer Hydrological Drought Index*** quantifies long-term hydrological effects. It responds more slowly to changing conditions than the Palmer Drought Index. Figure 8-4 shows this index for February 2017.
- While the Palmer indices consider precipitation, evapotranspiration and runoff, the ***Standardized Precipitation Index*** considers only precipitation. In the Standardized Precipitation Index, an index of zero indicates the median precipitation amount; the index is negative for drought and positive for wet conditions. The Standardized Precipitation Index is computed for time scales ranging from one month to 24 months. Figure 8-5 shows the 24-month Standardized Precipitation Index map for March 2015 through February 2017.

Source: NOAA, NWS. 2017

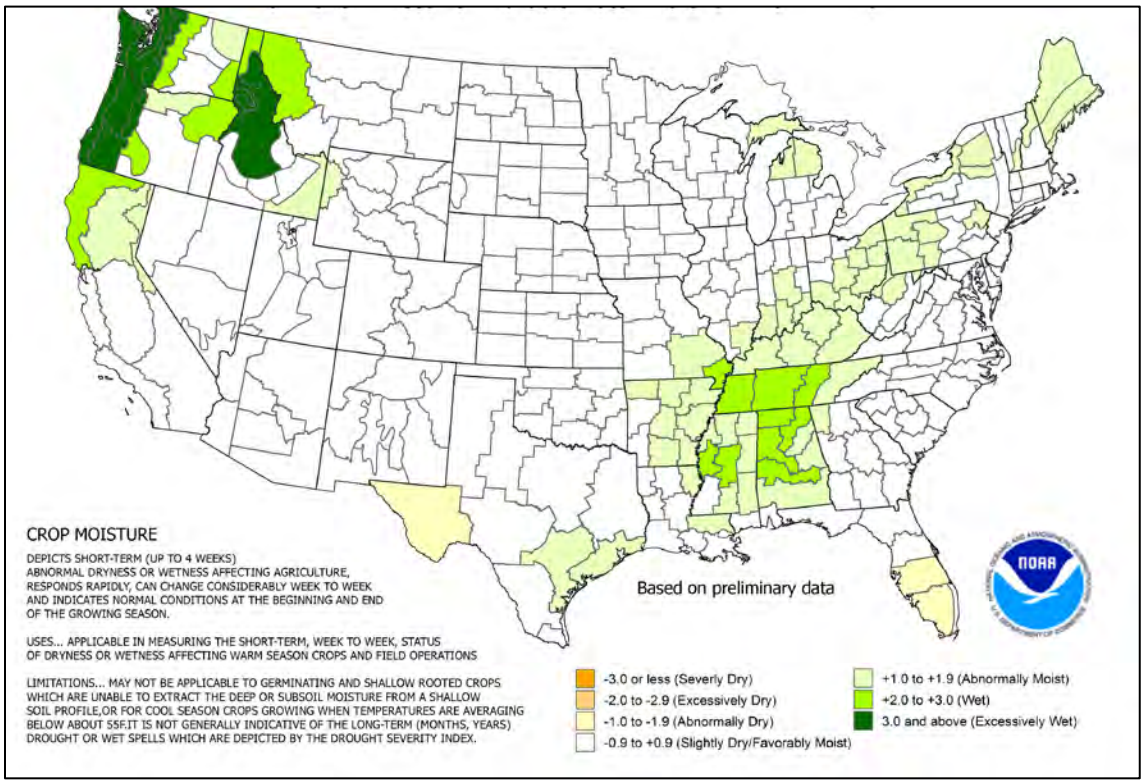


Figure 8-1. Palmer Crop Moisture Index for Week Ending March 11, 2017

Source: NOAA, NWS. 2017a

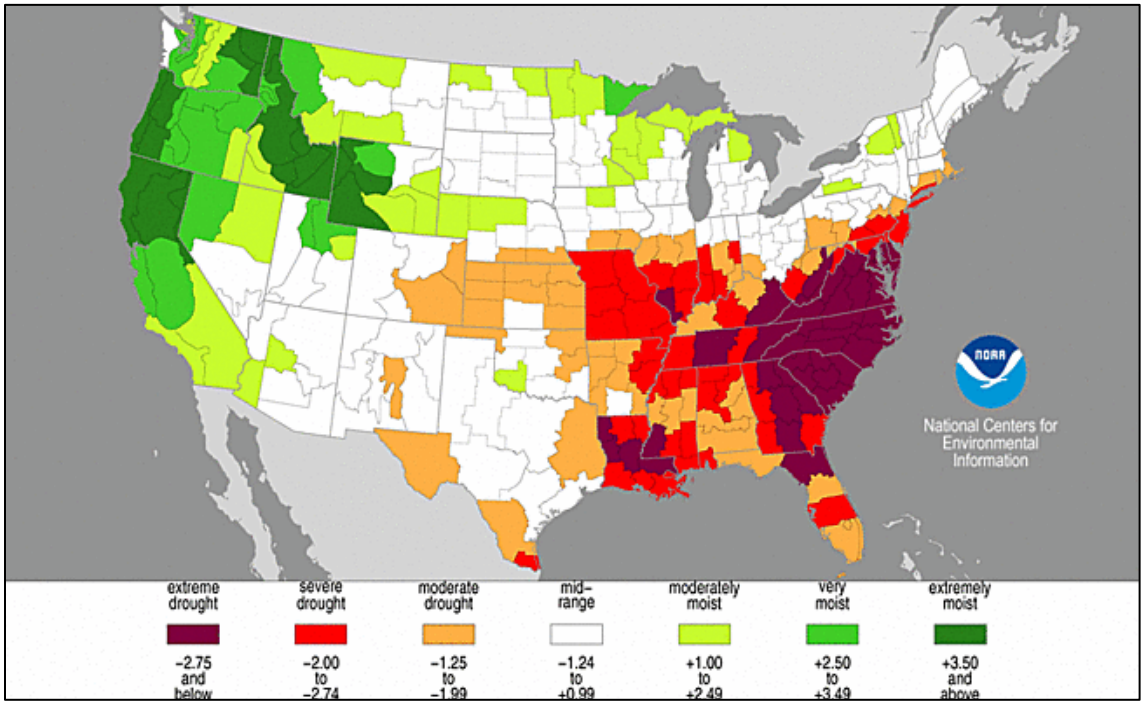


Figure 8-2. Palmer Z Index Short-Term Drought Conditions (February 2017)

Source: NOAA, NWS. 2017b

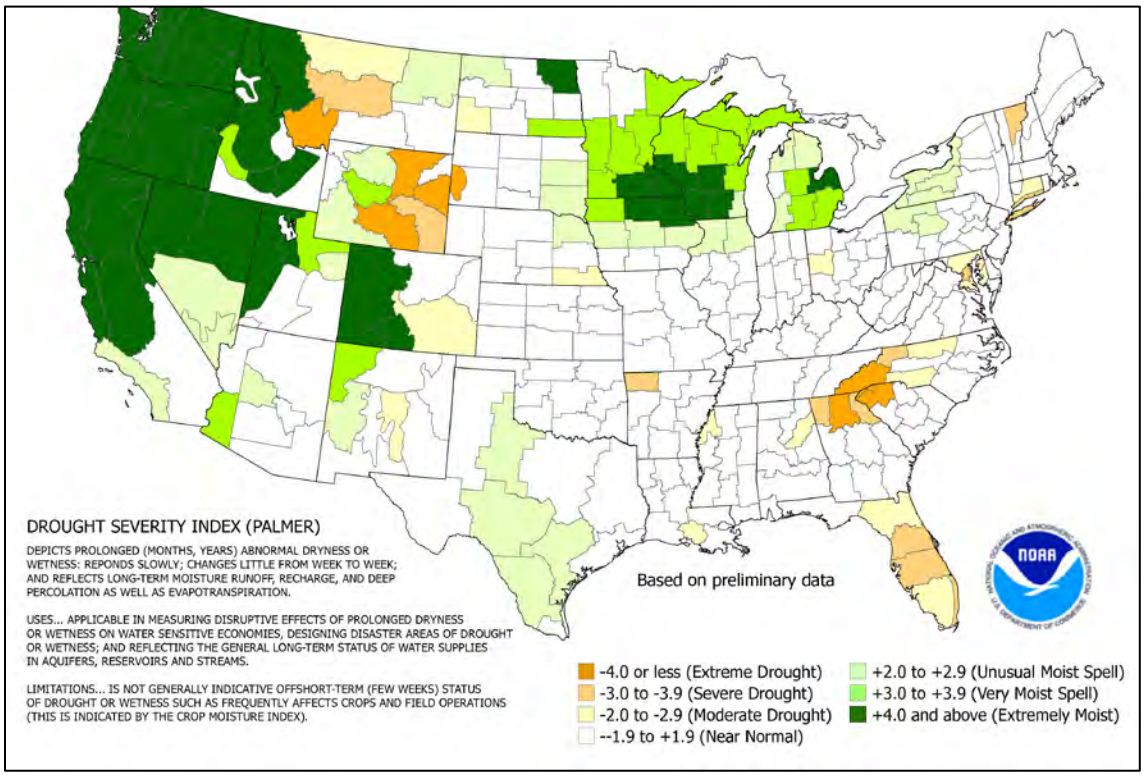


Figure 8-3. Palmer Drought Severity Index (March 11, 2017)

Source: NOAA, NWS. 2017c

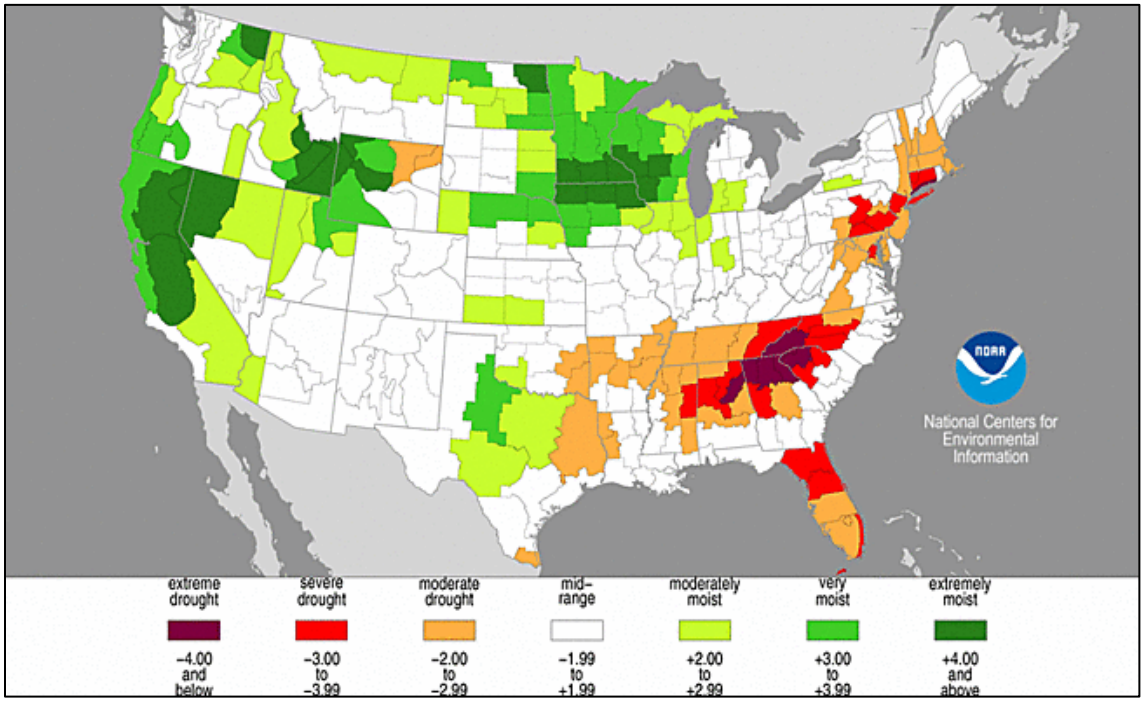


Figure 8-4. Palmer Hydrological Drought Index (February 2017)

Source: NOAA, NWS. 2017d

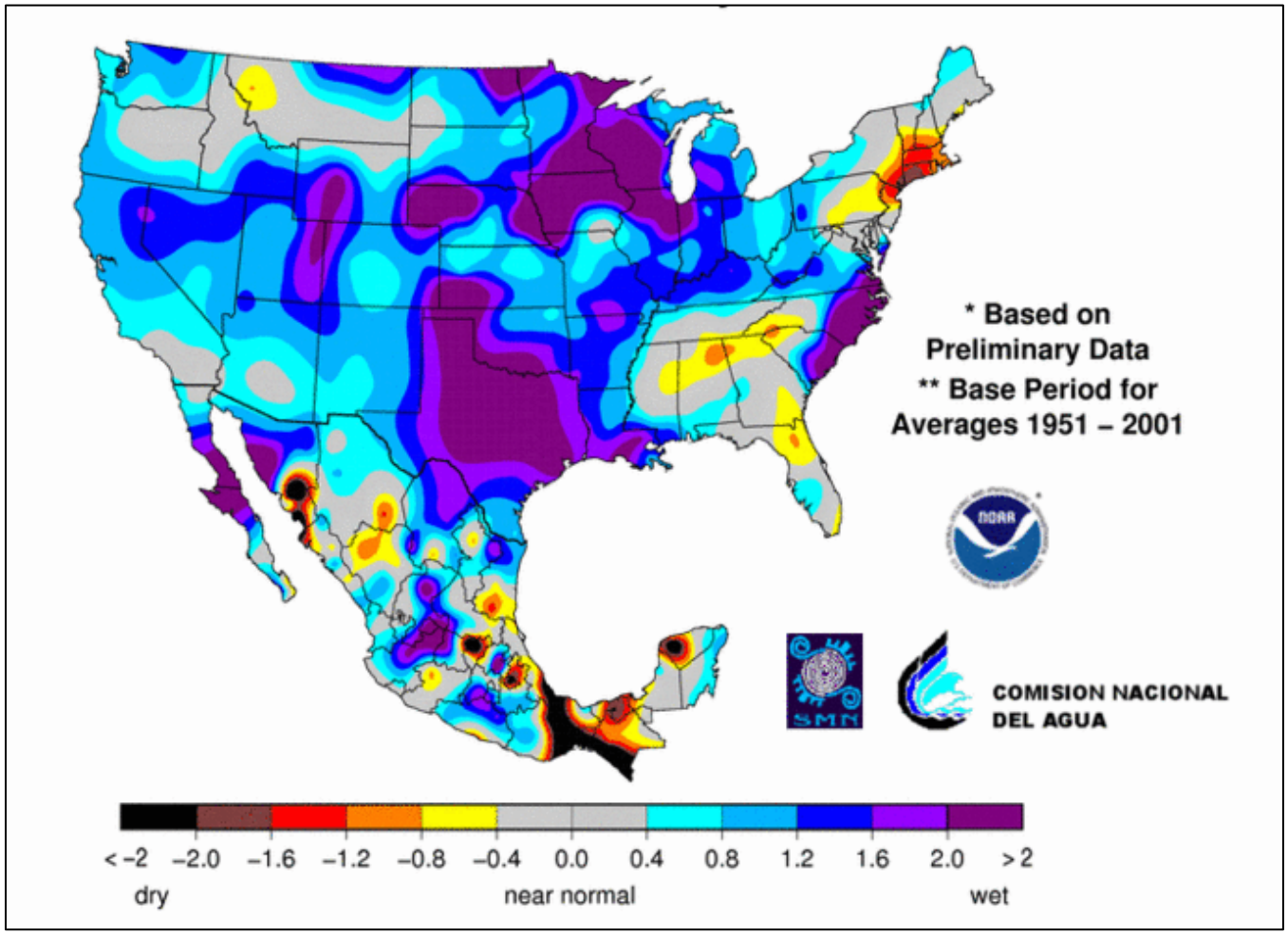


Figure 8-5. 24-Month Standardized Precipitation Index (March 2015 – February 2017)

8.1.2 Drought in California

Most of California's precipitation comes from storms moving across the Pacific Ocean. The path followed by the storms is determined by the position of an atmospheric high pressure belt that normally shifts southward during the winter, allowing low pressure systems to move into the state. On average, 75 percent of California's annual precipitation occurs between November and March, and 50 percent occurs between December and February. A persistent Pacific high pressure zone over California in mid-winter signals a tendency for a dry water year.

A typical water year produces about 100 inches of rainfall over the North Coast, 50 inches of precipitation (combination of rain and snow) over the Northern Sierra, 18 inches in the Sacramento area, and 12 to 14 inches in the planning area. In extremely dry years, these totals can fall to as little as a third of these amounts.

The Sierra Nevada snowpack serves as the primary agent for replenishing water in the City of Los Angeles and for much of the state. A reduction in spring snowpack runoff, due to drier winters or to increasing temperatures leading to more rain than snow, can increase risk of summer or fall water shortages throughout the region.

8.1.3 Local Water Supply

The Los Angeles Department of Water and Power (LADWP), which operates water and power for the City, reports the following sources of local water supply for 2011 through 2015 (see Figure 8-6):

- The Los Angeles Aqueduct from the eastern Sierra Nevada Mountains provided 29 percent of local water
- The City purchased 57 percent of its water from the Metropolitan Water District of Southern California:
  - 48 percent from the California aqueducts
  - 9 percent from the Colorado River Aqueduct
- 12 percent was from groundwater,
- 2 percent was from recycled water.

Source: Los Angeles Department of Water and Power, 2017

Figure 8-6. Primary Water Supply Sources for City of Los Angeles

In general, the District is trying to conserve as much of its water as possible from the California aqueducts, and more water is being imported from the Colorado River.

Customers in the City used an average of 113 gallons per day per capita in 2014-2015. Residential users accounted for about 68 percent, and commercial/industrial users accounted for 32 percent. (LADWP, 2017)

8.1.4 Defined Drought Stages

During critically dry years, the California State Water Resources Control Board can mandate water entitlements on water right holders to address statewide water shortages. Table 8-1 shows the state drought management program stages mandated to water right holders.

Table 8-1. State Drought Management Program

Drought Stage	State Mandated Customer Demand Reduction	Rate Impacts
Stage 0 or 1	<10%	Normal rates
Stage 2	10 to 15%	Normal rates; Drought surcharge
Stage 3	15 to 20%	Normal rates; Drought surcharge
Stage 4	>20%	Normal rates, Drought surcharge

LADWP defined Emergency Water Conservation Plan Ordinance restrictions by phases in *2015 Urban Water Management Plan* (Chapter 3, Water Conservation). It enacts the state's mandates by activating Phases I through VI, with water conservation, prohibited uses, and penalties for violation that steadily increase by phase.

8.2 HAZARD PROFILE

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is considered to be long-term. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

8.2.1 Past Events

Statewide Droughts

The California Department of Water Resources has state hydrologic data back to the early 1900s (CA DWR, 2017). The hydrologic data show multi-year droughts from 1912 to 1913, 1918 to 1920, 1922 to 1924 and 1928 to 1934. The following sections describe additional prolonged periods of drought in California since then, all of which impacted the City of Los Angeles to some degree.

1976 to 1977 Drought

California had one of its most severe droughts due to lack of rainfall during the winters of 1976 and 1977. 1977 was the driest period on record in California to that time, with the previous winter recorded as the fourth driest. The cumulative impact led to widespread water shortages and severe water conservation measures throughout the state. Only 37 percent of the average Sacramento Valley runoff was received, with just 6.6 million acre-feet recorded. A federal disaster declaration was declared, but it did not apply to Los Angeles County.

1987 to 1992 Drought

California received precipitation well below average levels for four consecutive years. While the Central Coast was most affected by the lack of rainfall and low runoff, the Sierra Nevada range in Northern California and City of Los Angeles was also affected. During this drought, only 56 percent of average runoff for the Sacramento Valley was received, totaling just 10 million acre-feet. By February 1991, all 58 counties in California were suffering from drought conditions. Urban areas as well as rural and agricultural areas were impacted. In 1988, the City adopted a plumbing retrofit ordinance to mandate the installation of conservation devices in all properties and require water-efficient landscaping in new construction. An amendment to the ordinance in 1999 required the installation of ultra-low-flush toilets in single-family and multifamily residences prior to resale.

2007 to 2009 Drought

The governor issued an Executive Order that proclaimed a statewide drought emergency on June 4, 2008 after spring 2008 was the driest spring on record and snowmelt runoff was low. On February 27, 2009, the governor proclaimed a state of emergency for the entire state as the severe drought conditions continued widespread impacts and the largest court-ordered water restriction in state history (at the time).

2012 to 2016 Drought

California's latest drought set several records:

- The period from 2012 to 2014 ranked as the driest three consecutive years for statewide precipitation.
- 2014 set new climate records for statewide average temperatures and for record-low water allocations in the State Water Project and federal Central Valley Project.
- 2013 set minimum annual precipitation records for many communities.

On January 17, 2014 the governor declared a state of emergency for drought throughout California. This declaration followed release of a report that stated that California had had the least amount of rainfall in its 163-year history. Californians were asked to voluntarily reduce their water consumption by 20 percent. Drought conditions worsened into 2015. On April 1, 2015, following the lowest snowpack ever recorded, the governor announced actions to save water, increase enforcement to prevent wasteful water use, streamline the state's drought response, and invest in new technologies to make California more drought-resilient. The governor directed the State Water Resources Control Board to implement mandatory water reductions in cities and towns across California to reduce water usage by 25 percent on average. The LADWP was assigned a 16-percent water conservation target by the State Water Resources Control Board.

Drought Impact Reporter

The National Drought Mitigation Center developed the Drought Impact Reporter in response to the need for a national drought impact database for the United States. Information comes from a variety of sources: on-line, drought-related news stories and scientific publications, members of the public who visit the website and submit a drought-related impact for their region, members of the media, and members of relevant government agencies. The Drought Impact Reporter contains information on 98 impacts from droughts that specifically affected the City of Los Angeles from 2006 through January 2017. The following are the categories and reported number of impacts (note that some impacts have been assigned to more than one category):

- Agriculture—6
- Business and Industry—13
- Energy—0
- Fire—3
- Plants and Wildlife—12

- Relief, Response, and Restrictions—58
- Society and Public Health—45
- Tourism and Recreation—4
- Water Supply and Quality—71.

8.2.2 Location

Drought is a regional phenomenon. A drought that affects the planning area would affect the entirety of the area simultaneously and has the potential to directly or indirectly impact every person in the county as well as adversely affect the local economy.

8.2.3 Frequency

Historical drought data for the planning area indicate there have been four significant multi-year droughts in the last 40 years (1976 to 2016). For approximately 12 of the last 40 years, the City has been included in various levels of drought. This equates to a drought every three years on average, or a 30 percent chance of a drought in any given year. As temperatures increase, the probability of future droughts will likely increase as well.

8.2.4 Severity

Drought can have a widespread impact on the environment and the economy, although it typically does not result in loss of life or damage to property, as do other natural disasters. Nationwide, the impacts of drought occur in the following categories: agriculture; business and industry; energy; fire; plants and wildfire; relief, response and restrictions; tourism and recreation; and water supply and quality sectors. The National Drought Mitigation Center uses three categories to describe likely drought impacts:

- **Economic Impacts**—These impacts of drought cost people or businesses money (i.e., farmers' crops are destroyed, water supply is too low and money must be spent on irrigation or to drill new wells; businesses that sell boats and fishing equipment are not able to sell their goods; water companies must spend money on new or additional water supplies)
- **Environmental Impacts**—Plants and animals depend on water, just like people. When a drought occurs, their food supply can shrink and their habitat can be damaged
- **Social Impacts**—These impacts affect people's health and safety. Social impacts include public safety, health, conflicts between people when there is not enough water to go around, and changes in lifestyle.

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts.

Drought generally does not affect groundwater sources as quickly as surface water supplies, but groundwater supplies generally take longer to recover. Reduced precipitation during a drought means that groundwater supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Reduced replenishment of groundwater affects streams. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when stream flows are lowest.

8.2.5 Warning Time

Droughts are climatic patterns that occur over long periods of time. Only generalized warning can take place due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions.

Empirical studies conducted over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature; these include global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation.

Scientists at this time do not know how to predict drought more than a month in advance for most locations. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. California is currently finishing a several-year-long drought, while other areas in the United States may undergo droughts as short as 1 or 2 months. How long they last depends on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale.

8.3 SECONDARY IMPACTS

The secondary impact most commonly associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. Millions of board feet of timber have been lost, and in many cases erosion occurred, which caused serious damage to aquatic life, irrigation, and power production by heavy silting of streams, reservoirs, and rivers.

Drought also is often accompanied by extreme heat, exposing people to the risk of sunstroke, heat cramps and heat exhaustion. Pets and livestock are also vulnerable to heat-related injuries. Crops can be vulnerable as well.

8.4 EXPOSURE

Drought can affect a wide range of economic, environmental, and social activities. Its impacts can span many sectors of the economy because water is integral to the ability to produce goods and provide services. The impacts can reach well beyond the area undergoing physical drought. Vulnerability of an activity to drought depends on its water demand and the water supplies available to meet the demand.

California's 2005 Water Plan and subsequent updates indicate that water demand in the state will increase through 2030. The Department of Water Resources predicts a modest decrease in agricultural water use, but an urban water use increase of 1.5 to 5.8 million acre-feet per year (DWR 2005). The 2013 update to the Water Plan explores measures, benchmarks, and successes in increasing agricultural and urban water use efficiency.

8.5 VULNERABILITY

8.5.1 Population

The City of Los Angeles is vulnerable to drought events. Drought can affect people's health and safety, including health problems related to low water flows, poor water quality, or dust. Drought can also lead to loss of human life (National Drought Mitigation Center, 2017). Other possible impacts include recreational risks; effects on air quality; diminished living conditions related to energy, air quality, and hygiene; compromised food and nutrition; and increased incidence of illness and disease (Centers for Disease Control and Prevention, 2012). Droughts can also lead to reduced local firefighting capabilities.

LADWP and other regional stakeholders have devoted considerable time and effort to protect life, safety, and health during times of consecutive dry years. Provisions and measures have been taken to analyze and account for anticipated water shortages. With coordination with residents in the planning area, the LADWP has the ability to minimize and reduce impacts on residents and water consumers in the City.

8.5.2 Property

No structures will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

8.5.3 Critical Facilities

Critical facilities as defined for this plan will continue to be operational during a drought. A benefit of water conservation in the City is delaying the need for sewer facility expansions by reducing wastewater discharge into the sewer collection and treatment system. Critical facility elements such as landscaping may not be maintained due to limited resources, but the risk to the planning area's critical facilities inventory will be largely aesthetic. For example, when water conservation measures are in place, landscaped areas will not be watered and may die. These aesthetic impacts are not considered significant.

8.5.4 Environment

Environmental losses are the result of damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary condition. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention on these effects.

8.5.5 Economic Impact

Economic impact will be largely associated with industries that use water or depend on water for their business. For example, landscaping businesses were affected in the droughts of the past as the demand for service significantly declined because landscaping was not watered. Agricultural industries will be impacted if water usage is restricted for irrigation.

A prolonged drought can affect a community's economy significantly. Increased demand for water and electricity may result in shortages and higher costs of these resources. Industries that rely on water for business may be impacted the most (e.g., landscaping businesses). Although most businesses will still be operational, they may be affected aesthetically—especially the recreation and tourism industry. Moreover, droughts within another area could affect food supply and price for City residents.

8.6 FUTURE TRENDS IN DEVELOPMENT

The City of Los Angeles has a General Plan that includes policies directing land use and dealing with issues of water supply and the protection of water resources. This plan provides the capability at the local level to protect future development from the impacts of drought. The City of Los Angeles reviewed its General Plan under the

capability assessment performed for this effort. Deficiencies identified by this review can be addressed by mitigation actions to increase the capability to deal with future trends in development.

8.7 SCENARIO

An extreme, multiyear drought associated with record-breaking rates of low precipitation and high temperatures—such as the most recent drought across the State of California——is the worst-case scenario. Combinations of low precipitation and high temperatures could occur over several consecutive years. Intensified by such conditions, extreme wildfires could break out throughout the planning area, increasing the need for water. Surrounding communities, also in drought conditions, could increase their demand for water supplies relied upon by the City of Los Angeles, causing social and political conflicts. If such conditions persisted for several years, the economy of the City of Los Angeles could experience setbacks, especially in water dependent industries.

8.8 ISSUES

The planning team has identified the following drought-related issues:

- Identification and development of alternative water supplies
- Large residential populations stressing the water supply
- Utilization of groundwater recharge techniques to stabilize the groundwater supply
- The probability of increased multi-year drought and durations due to climate change, and the associated need to consider long-term conservation measures
- Loss of much of the water transported from aqueducts to leaks and evaporation
- Recycled water opportunities
- The capture and storage of urban runoff.

9. EARTHQUAKE

9.1 GENERAL BACKGROUND

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Geologists have found that earthquakes tend to reoccur along faults, which are zones of weakness in the earth's crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur. In fact, relieving stress along one part of a fault may increase it in another part.

DEFINITIONS

Earthquake—The shaking of the ground caused by an abrupt shift of rock along a fracture in the earth or a contact zone between tectonic plates. Earthquakes are typically measured in both magnitude and intensity.

Epicenter—The point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

Fault—A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other.

Hypocenter—The region underground where an earthquake's energy originates

Liquefaction— Loosely packed, water-logged sediments losing their strength in response to strong shaking, causing major damage during earthquakes.

California is seismically active because of movement of the North American Plate, on which everything east of the San Andreas Fault sits, and the Pacific Plate, which includes coast communities west of the fault. The planning area is on the Pacific Plate, which is constantly moving northwest past the North American Plate, at a relative rate of movement of about 2 inches per year.

Active faults have experienced displacement in historical time. However, inactive faults, where no such displacements have been recorded, also have the potential to reactivate or experience displacement along a branch sometime in the future. An example of a fault zone that has been reactivated is the Foothills Fault Zone. The zone was considered inactive until evidence of an earthquake (approximately 1.6 million years ago) was found near Spenceville, California. Then, in 1975, an earthquake occurred on another branch of the zone near Oroville, California (now known as the Cleveland Hills Fault). The State Division of Mines and Geology indicates that increased earthquake activity throughout California may cause movement along currently inactive fault systems.

9.1.1 Earthquake Classifications

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as magnitude; or by the impact on people and structures, measured as intensity.

Magnitude

An earthquake's magnitude is a measure of the energy released at the source of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments. It is commonly expressed by ratings on the Richter

scale and the moment magnitude (M_w) scale. The Richter scale magnitude is based on the amplitude of the largest energy wave released by the earthquake. Richter scale readings are suitable for smaller earthquakes; however, because it is a logarithmic scale, the scale does not distinguish clearly the magnitude of large earthquakes above a certain level. Table 9-1 summarizes Richter scale magnitudes and corresponding earthquake effects.

Table 9-1. Richter Magnitude Scale

Richter Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph
2.5 to 5.4	Often felt, but causes only minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can totally destroy communities near the epicenter

The moment magnitude (M_w) scale was introduced in 1979 to address shortcomings of the Richter scale while maintaining consistency. It is based on the seismic moment of the earthquake. For medium-sized earthquakes, moment magnitude values are similar to Richter values—a magnitude 5.0 earthquake is about 5.0 on both scales. Unlike other scales, the moment magnitude scale does not saturate at the upper end; there is no upper limit to the magnitude it can measure. However, this has the side-effect that the scales diverge for smaller earthquakes (Hanks and Hiroo, 1979). The M_w scale, described in Table 9-2, is currently the most commonly used magnitude scale.

Table 9-2. Moment Magnitude Class

Magnitude Class	Magnitude Range (M_W=magnitude)
Great	$M_W \geq 8$
Major	$M_W = 7.0 – 7.9$
Strong	$M_W = 6.0 – 6.9$
Moderate	$M_W = 5.0 – 5.9$
Light	$M_W = 4.0 – 4.9$
Minor	$M_W = 3.0 – 3.9$
Micro	$M_W < 3$

Intensity

The intensity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and varies with location. The intensity of earthquake shaking lessens with distance from the earthquake epicenter. The Modified Mercalli Intensity (MMI) scale expresses intensity of an earthquake and describes how strong a shock was felt at a particular location in values. The MMI is currently the most commonly used intensity scale (see Table 9-3).

9.1.2 Ground Motion

During an earthquake when the ground is shaking, it also experience acceleration. The peak acceleration is the largest increase in velocity recorded by a particular station during an earthquake. Earthquake hazard assessment based on expected ground motion involves determining the annual probability that certain ground motion accelerations will be exceeded, then summing the annual probabilities over a time period of interest.

Table 9-3. Modified Mercalli Intensity Scale

Mercalli Intensity	Shaking	Description
I	Not Felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing cars may rock slightly. Vibrations similar to the passing of a truck.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very Strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

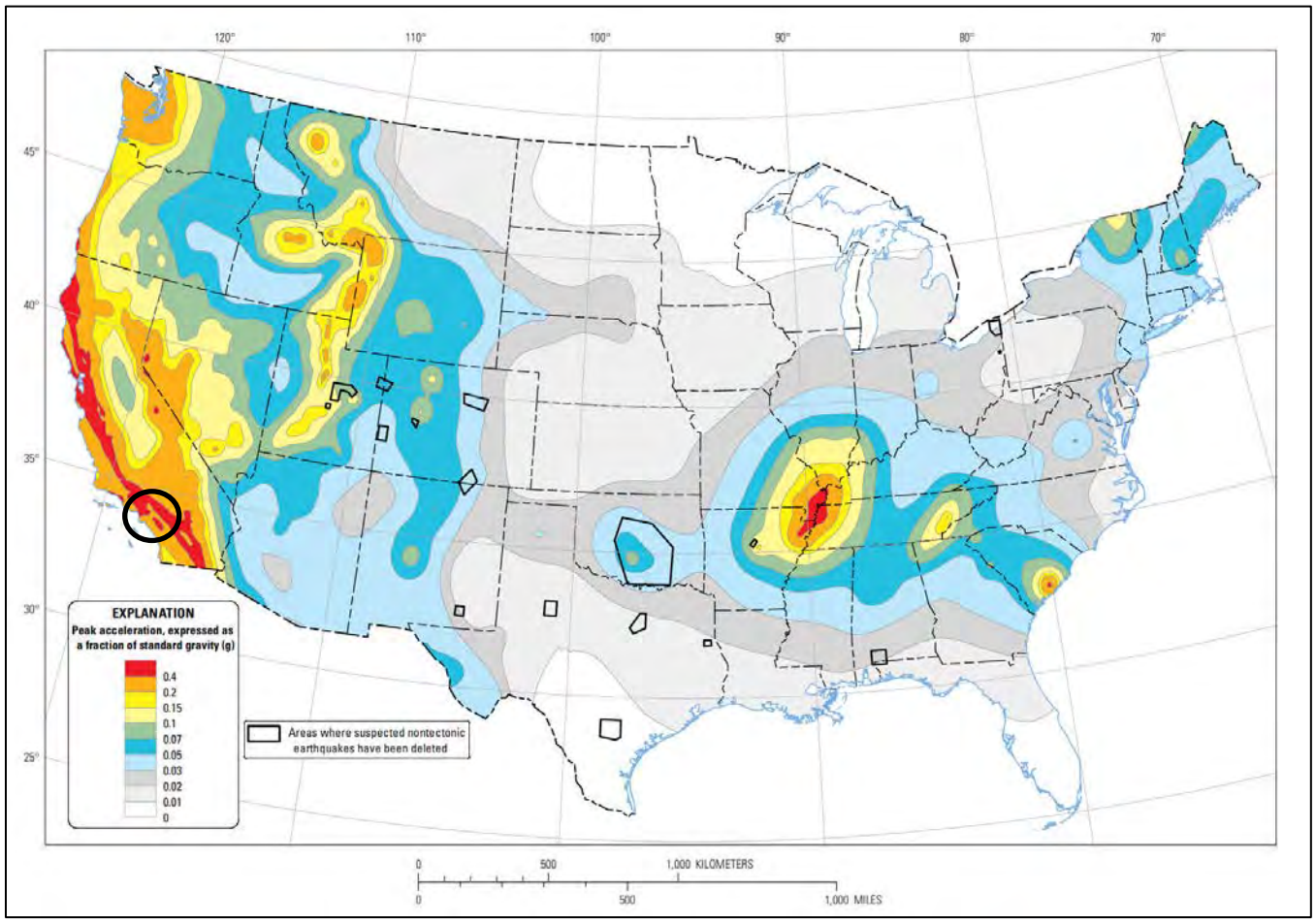
Source: USGS 2014

The most commonly mapped ground motion parameters are the horizontal and vertical peak ground accelerations (PGA) for a given soil or rock type. PGA expresses the severity of an earthquake and is a measure of how hard the earth shakes, or accelerates, in a given geographic area. Instruments called accelerographs record levels of ground motion due to earthquakes at stations throughout a region. PGA is measured in g (the acceleration due to gravity) or expressed as a percent acceleration force of gravity (%g). These readings are recorded by state and federal agencies that monitor and predict seismic activity.

National maps of earthquake shaking hazards have been produced since 1948. They provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities and land use planning used in the U.S. Scientists frequently revise these maps to reflect new information and knowledge. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (Brown et al., 2001).The USGS updated the National Seismic Hazard Maps in 2014, superseding the 2008 maps. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps. The 2014 map (see Figure 9-1) represents the best available data as determined by the USGS.

Maps of PGA values form the basis of seismic zone maps that are included in building codes such as the International Building Code. Buildings, bridges, highways and utilities built to meet modern seismic design requirements are typically able to withstand earthquakes better, with less damages and disruption. Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. PGA values are directly related to these lateral forces that could damage “short period structures” (e.g. single-family dwellings). Longer period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table 9-4 lists damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

Source: USGS 2014



Black circle indicates the approximate location of the City of Los Angeles

Figure 9-1. Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years

Table 9-4. Mercalli Scale and Peak Ground Acceleration Comparison

Modified Mercalli Scale	Perceived Shaking	Potential Structure Damage		Estimated PGA[a] (%g)
		Resistant Buildings	Vulnerable Buildings	
I	Not Felt	None	None	<0.17%
II-III	Weak	None	None	0.17% – 1.4%
IV	Light	None	None	1.4% – 3.9%
V	Moderate	Very Light	Light	3.9% – 9.2%
VI	Strong	Light	Moderate	9.2% – 18%
VII	Very Strong	Moderate	Moderate/Heavy	18% – 34%
VIII	Severe	Moderate/Heavy	Heavy	34% – 65%
IX	Violent	Heavy	Very Heavy	65% – 124%
X – XII	Extreme	Very Heavy	Very Heavy	>124%

a. PGA measured in percent of g, where g is the acceleration of gravity

Sources: USGS, 2008; USGS, 2010

9.1.3 Effect of Soil Types

The impact of an earthquake on structures and infrastructure is largely a function of ground shaking, distance from the source of the quake, and liquefaction, a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. Liquefaction generally occurs in soft, unconsolidated sedimentary soils.

A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 9-5 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are most affected by ground shaking have NEHRP Soils D, E and F. In general, these areas are most susceptible to liquefaction.

Table 9-5. NEHRP Soil Classification System

NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	Depends on soil type

The USGS has created a soil-type map for the Los Angeles area that provides rough estimates of site effects based on surface geology. NEHRP soil types were assigned to a geologic unit based on the average velocity of that unit, and USGS notes that this approach can lead to some inaccuracy. For instance, a widespread unit consisting of Quaternary sand, gravel, silt, and mud has been assigned as Class C soil types; however, some of the slower soil types in this unit fall under Class D. USGS does not have any way of differentiating units for slower-velocity soils in its digital geologic dataset (USGS, 2016e).

9.2 HAZARD PROFILE

9.2.1 Past Events

Los Angeles has been included in three FEMA declarations for earthquakes: the 1994 Northridge Earthquake (DR-1008), the 1987 earthquakes (DR-799), and the 1971 San Fernando Earthquake (DR-299). Table 9-6 lists earthquakes of magnitude 5.0 or greater within a 100-mile radius of the planning area.

The 1994 Northridge Earthquake was the most recent earthquake to greatly affect the city. It was the most costly seismic event in California since the 1906 San Francisco Earthquake. The infrastructure of the metropolitan area was severely disrupted. Freeways collapsed, power systems for the city and linked communities as far away as Oregon were temporarily blacked out, and communications were disrupted. Table 9-7 lists estimated damage.

Officially lasting approximately 30 seconds, and with a magnitude of M6.7, this earthquake caused significant damage to buildings in every area of the city. Of 57 fatalities attributed to this quake, 16 were a result of the collapse of a single structure—the Northridge Meadows apartment building. The ground motion was measured throughout Southern California, including intensity readings of 1.82 g near the Ventura Freeway in the Tarzana area. Ground motions as strong as 1.21 g were measured as far away as Inglewood (approximately 25 miles from Northridge). One “g” of ground motion is enough to make unsecured buildings literally hop off their foundations.

Table 9-6. Earthquakes Magnitude 5.0 or Larger Within 100-mile Radius of the Planning Area

Date	Magnitude	Epicenter Location	Fault Line
03/29/2014 Brea Earthquake	5.1	Near Brea, CA	Puente Hills fault
07/29/2008	5.44	Near Chino Hills, CA	Whittier fault
01/17/1994 Northridge Earthquake	6.7	20 miles west-northwest of LA	Northridge Thrust
06/28/1991 Sierra Madre Earthquake	5.8	12 miles northeast of Pasadena, CA	Clamshell-Sawpit Canyon fault
02/28/1990 Upland Earthquake	7.9	30 miles east of LA	San Jose fault
01/18/1989 Malibu Earthquake	5.0	20 miles south of Malibu, CA	N/A
12/03/1988 Pasadena Earthquake	5.0	Below City of Pasadena, CA	Raymond fault
06/26/1988 Upland Earthquake	7.9	30 miles east of LA	San Jose fault
06/10/1988 Tejon Ranch Earthquake	6.8	Northeast of Frazier Park, CA	N/A
10/01/1987 Whittier Narrows Earthquake	5.9	Southeast of Pasadena	Puente Hills fault
01/01/1979 Malibu Earthquake	5.2	South of Malibu, CA	N/A
08/13/1978 Santa Barbara Earthquake	5.1	Southeast of Santa Barbara, CA	unknown
02/21/1973 Point Mugu Earthquake	5.3	Near Oxnard, 45 miles west of LA	San Fernando fault
02/09/1971 San Fernando Earthquake	6.5	Near Sylmar, CA	San Fernando fault
12/4/1948 Desert Hot Springs Earthquake	6.0	Near Desert Hot Springs, 100 miles east of LA	S. Branch San Andreas fault
6/30/1941 Santa Barbara Earthquake	5.5	6 miles ESE of Santa Barbara, CA	N/A
3/10/1933 Long Beach Earthquake	6.4	3 miles south of Huntington Beach, CA	Newport-Inglewood fault

Source: Southern California Earthquake Data Center, 2017

Table 9-7. Northridge Earthquake Estimated Damages

	Number	Estimated Losses
Residential	86,457	$1,150,939,340
Commercial	6,236	$459,955,246
Mix Use	224	$7,568,900
Total	92,917	$1,618,463,486

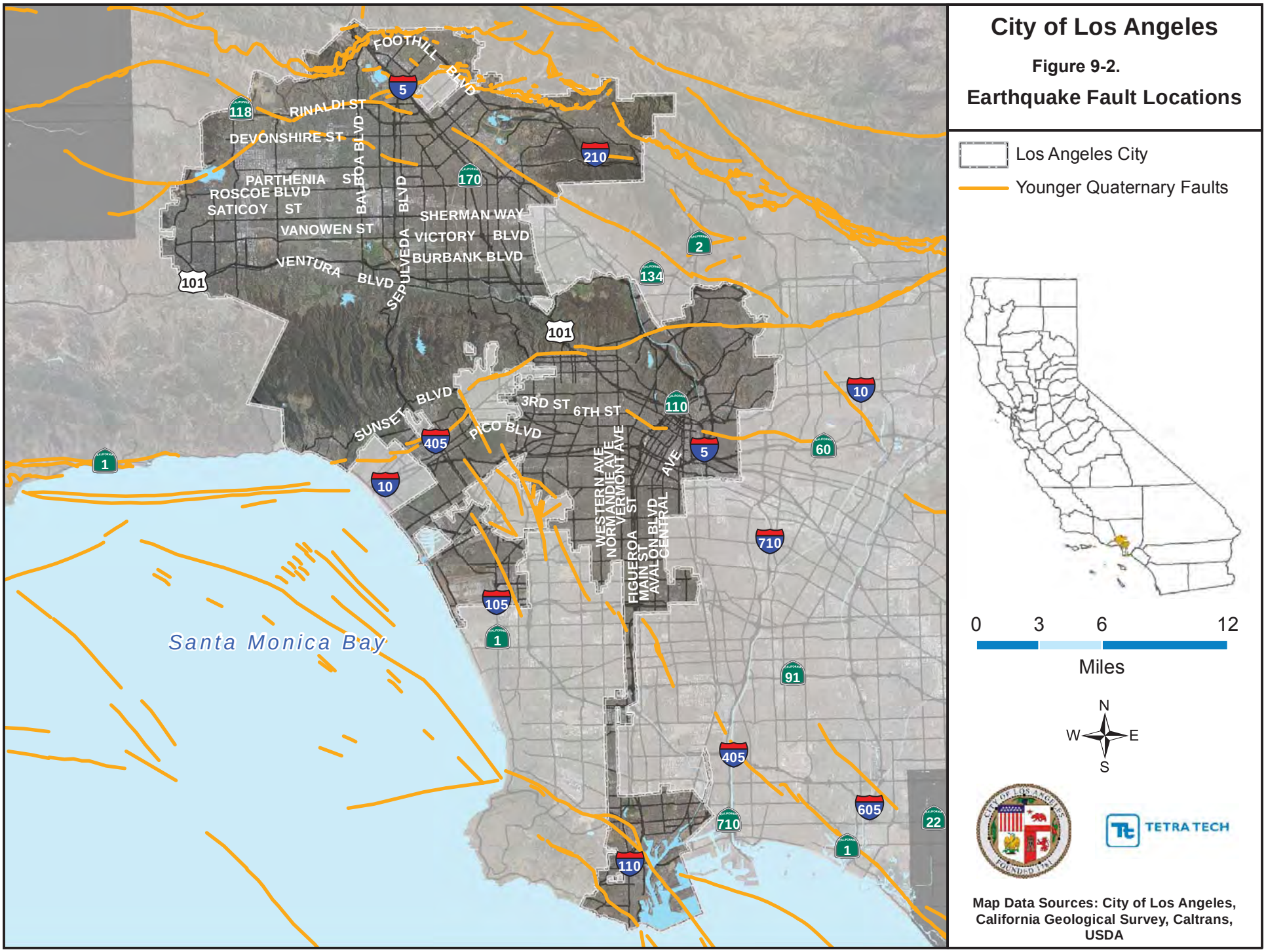
Source: City of Los Angeles, 2011

According to the scientists of the U.S. Geological Survey (USGS) and the Southern California Earthquake Center, the Northridge Earthquake raised nearby mountains by as much as 70 centimeters. The fault, which was previously unknown, appears to be truncated by the fault that broke in the similarly sized 1971 San Fernando Earthquake, the two faults abutting at a depth of 5 miles. The Northridge Earthquake caused many times more damage than the 1971 event, primarily because its fault is directly under the densely populated valley, whereas the 1971 fault lies under the mountains.

9.2.2 Location

Major Faults

The City of Los Angeles is located in a region of high seismicity with numerous local faults, as shown on Figure 9-2. The primary seismic hazard for the City is potential ground shaking from these major known faults, especially the Newport-Inglewood, Palos Verde, Puente Hills, San Andreas, and Santa Monica faults, which are further described in the sections below.



City of Los Angeles

Figure 9-2.

Earthquake Fault Locations

Los Angeles City

Younger Quaternary Faults

0 3 6 12

Miles

N

W E

S

TETRA TECH

Map Data Sources: City of Los Angeles, California Geological Survey, Caltrans, USDA

Newport-Inglewood

The Newport-Inglewood fault is a right-lateral strike-slip fault that extends for 47 miles from Culver City southeast through Inglewood and other coastal communities to Newport Beach, at which point the fault extends east-southeast into the Pacific Ocean where it is known as the Rose Canyon Fault. The fault can be inferred on the Earth's surface as passing along and through a line of hills extending from Signal Hill to Culver City. This is the second most active fault in California and is capable of producing an earthquake with a magnitude of 6.3 to 7.5.

Palos Verde

The Palos Verde fault extends from the Pacific Ocean and comes ashore near the southwest point of the Redondo Beach-Torrance border. The fault then curves around the base of the Palos Verdes Peninsula roughly midway between the Pacific Coast Highway and the peninsula. It continues this southerly course until it runs into the Los Angeles Harbor.

Puente Hills

The Puente Hills fault, also known as the Puente Hills thrust system, is an active geological fault that runs about 25 miles in three discrete sections from the Puente Hills region in the southeast to just south of Griffith Park in the northwest. The fault is known as a blind thrust fault due to the lack of surface features normally associated with thrust faults. This fault is capable of producing an earthquake with a magnitude between 7.0 and 7.5.

San Andreas

The San Andreas fault is a continental transform fault that extends roughly 800 miles through California. It forms the tectonic boundary between the Pacific Plate and the North American Plate, and its motion is right-lateral strike-slip (horizontal). The fault divides into three segments, each with different characteristics and a different degree of earthquake risk, the most significant being the southern segment, which passes within about 35 miles of Los Angeles.

Santa Monica

The Santa Monica fault is one of several northeast-southwest-trending, north-dipping, reverse faults that extend through the Los Angeles metropolitan area for approximately 50 miles. This fault is capable of producing an earthquake with a magnitude of 6.0 to 7.0.

Mapping of Earthquake Impact

The impact of an earthquake is largely a function of the following components:

- Ground shaking (ground motion accelerations)
- Liquefaction (soil instability)
- Distance from the source (both horizontally and vertically).

Mapping that shows the impacts of these components was used to assess the risk of earthquakes within the planning area. While the impacts of these components can build upon each other during an earthquake, the mapping looks at each component individually.

Shake Maps

A shake map is a representation of ground shaking produced by an earthquake. The information it presents is different from the earthquake magnitude and epicenter that are released after an earthquake because shake maps focus on the ground shaking resulting from the earthquake, rather than the parameters describing the earthquake source. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at

sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A shake map shows the extent and variation of ground shaking in a region immediately following significant earthquakes.

Ground motion and intensity maps are derived from peak ground motion amplitudes recorded on seismic sensors (accelerometers), with interpolation based on estimated amplitudes where data are lacking, and site amplification corrections. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. Earthquake scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. The following scenarios were assessed for this plan:

- Newport-Inglewood Fault Scenario—A Magnitude 7.2 event with a depth of 7.5 miles and epicenter 32 miles southeast of downtown Los Angeles. See Figure 9-3.
- Palos Verde Fault Scenario—A Magnitude 7.3 event with a depth of 7.0 miles and epicenter 55 miles south-southeast of downtown Los Angeles. See Figure 9-4.
- Puente Hills Fault Scenario—A Magnitude 7.0 event with a depth of 7.6 miles and epicenter 11.5 miles northeast of downtown Los Angeles. See Figure 9-5.
- San Andreas Fault Scenario—A Magnitude 7.8 event with a depth of 4.7 miles and epicenter 150 miles east-southeast of downtown Los Angeles. See Figure 9-6.
- Santa Monica Fault Scenario—A Magnitude 6.8 event with a depth of 5.7 miles and epicenter 9.5 miles northwest of downtown Los Angeles. See Figure 9-7.

NEHRP Soil Maps

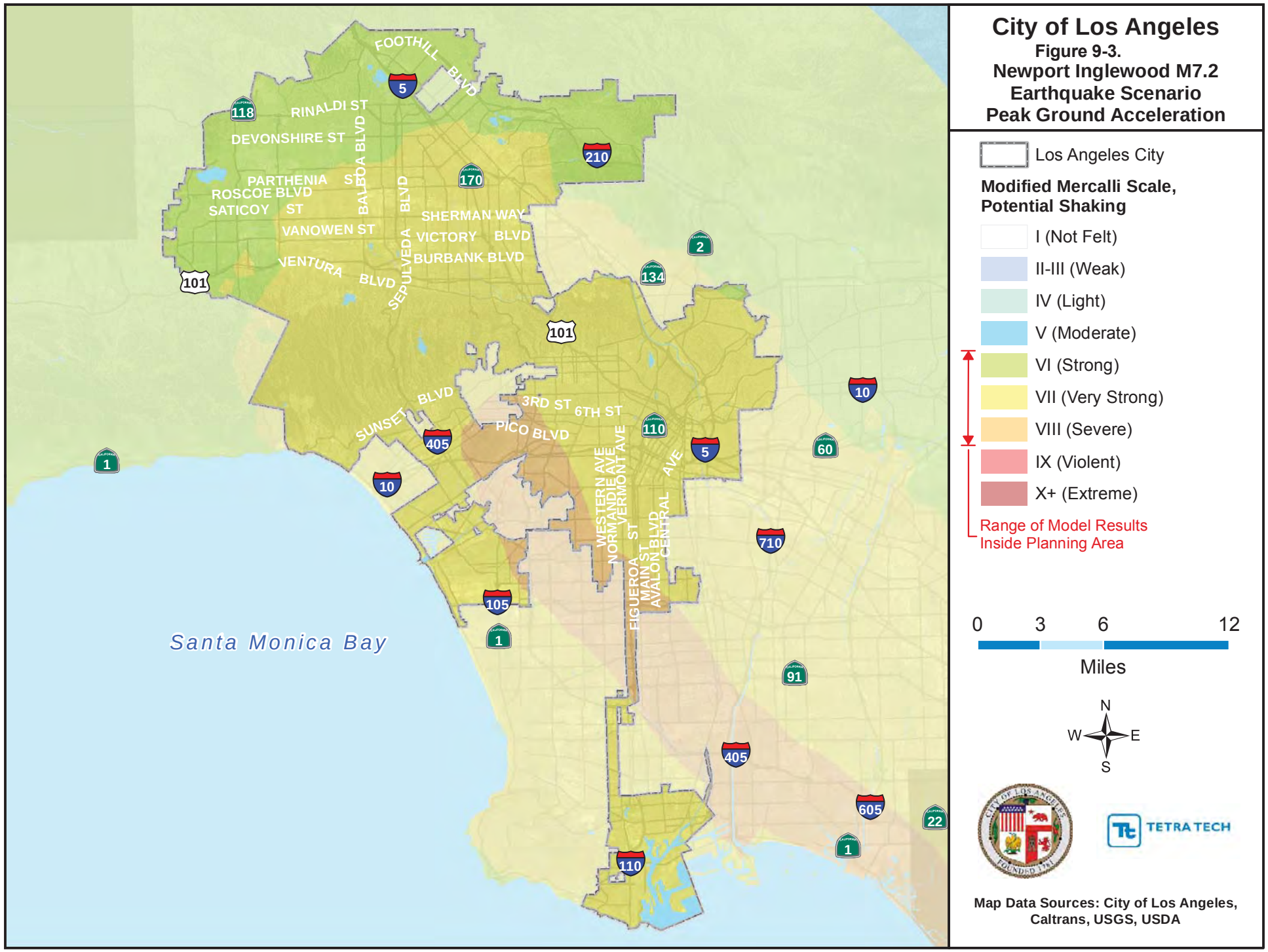
NEHRP soil types define the locations that will be significantly impacted by an earthquake. NEHRP Soils B and C typically can sustain low-magnitude ground shaking without much effect. The areas that are most commonly affected by ground shaking have NEHRP Soils D, E and F. NEHRP soil classifications in each APC are shown in Figure 9-8 through Figure 9-14.

Liquefaction Maps

When the ground liquefies, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. In general, areas with NEHRP Soils D, E and F are susceptible to liquefaction. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it, creating sand boils. Liquefaction susceptibility in each APC is shown in Figure 9-15 through Figure 9-21.

9.2.3 Frequency

California experiences hundreds of earthquakes each year, most with minimal damage and magnitudes below 3.0 on the Richter Scale. Earthquakes that cause moderate damage to structures occur several times a year. According to the USGS, a strong earthquake measuring greater than 5.0 on the Richter Scale occurs every two to three years and major earthquakes of more than 7.0 on the Richter Scale occur once a decade. The San Andreas Fault has the potential for experiencing major to great events. The State Hazard Mitigation Plan indicates that in the next 30 years in California there is over a 99-percent probability of a magnitude 6.7 earthquake and a 94-percent probability of a magnitude 7.0 earthquake.



City of Los Angeles

Figure 9-3.
Newport Inglewood M7.2 Earthquake Scenario Peak Ground Acceleration

Los Angeles City

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

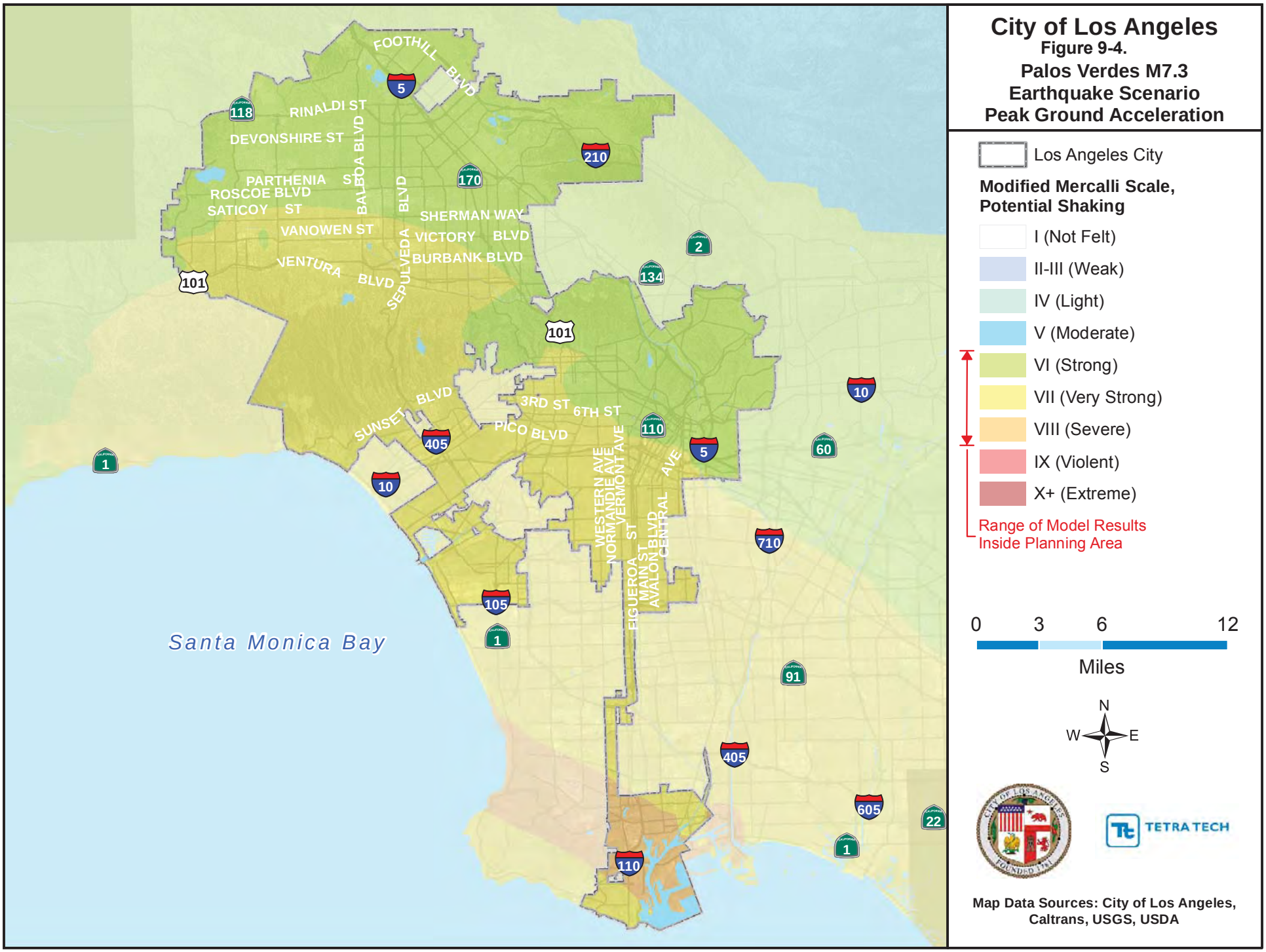
0 3 6 12

Miles

N W E S

TETRA TECH

Map Data Sources: City of Los Angeles, Caltrans, USGS, USDA



City of Los Angeles

Figure 9-4.

Palos Verdes M7.3 Earthquake Scenario Peak Ground Acceleration

Los Angeles City

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

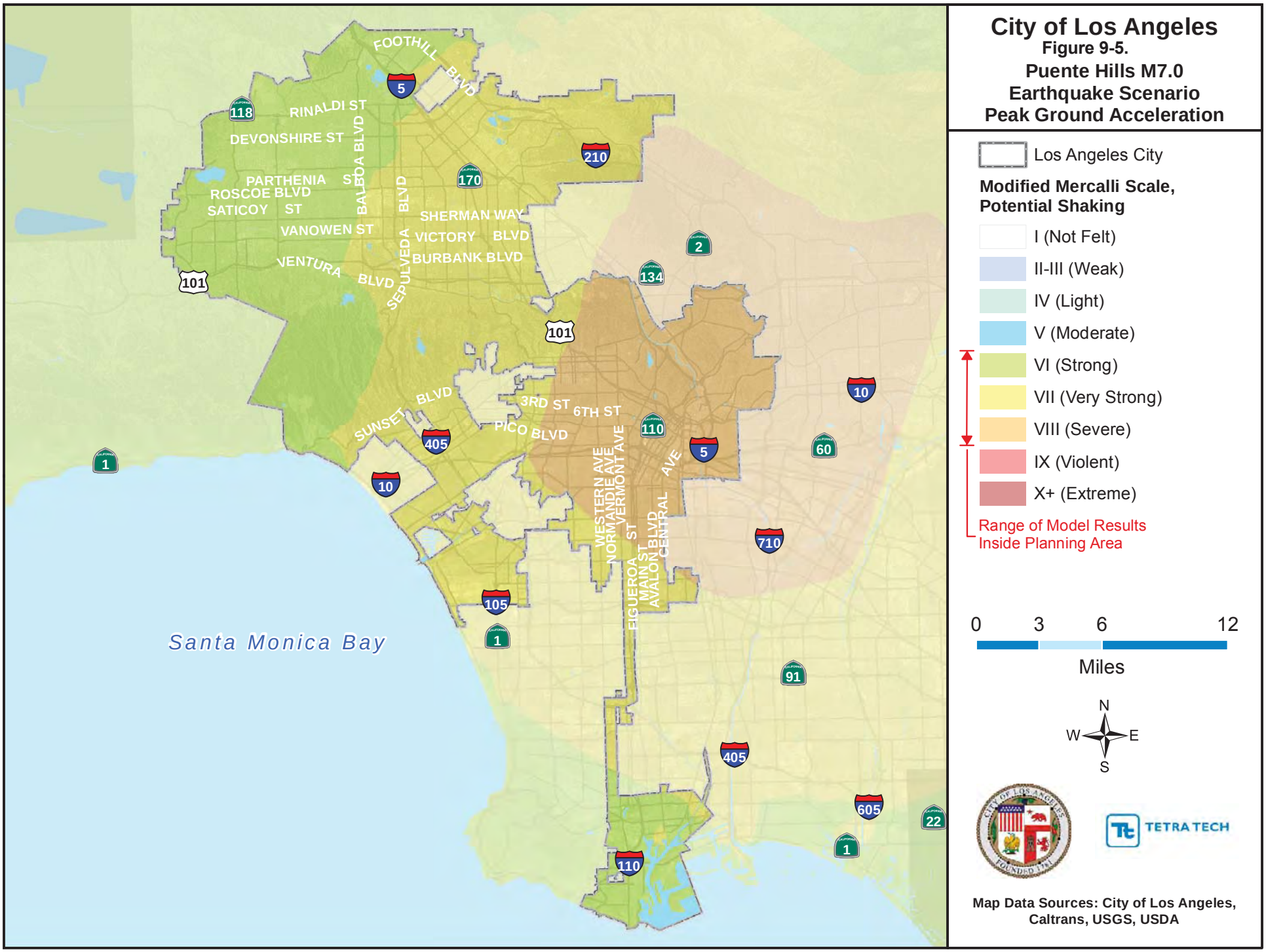
0 3 6 12

Miles

N W E S

TETRA TECH

Map Data Sources: City of Los Angeles, Caltrans, USGS, USDA



City of Los Angeles

Figure 9-5.

Puente Hills M7.0 Earthquake Scenario Peak Ground Acceleration

Los Angeles City

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

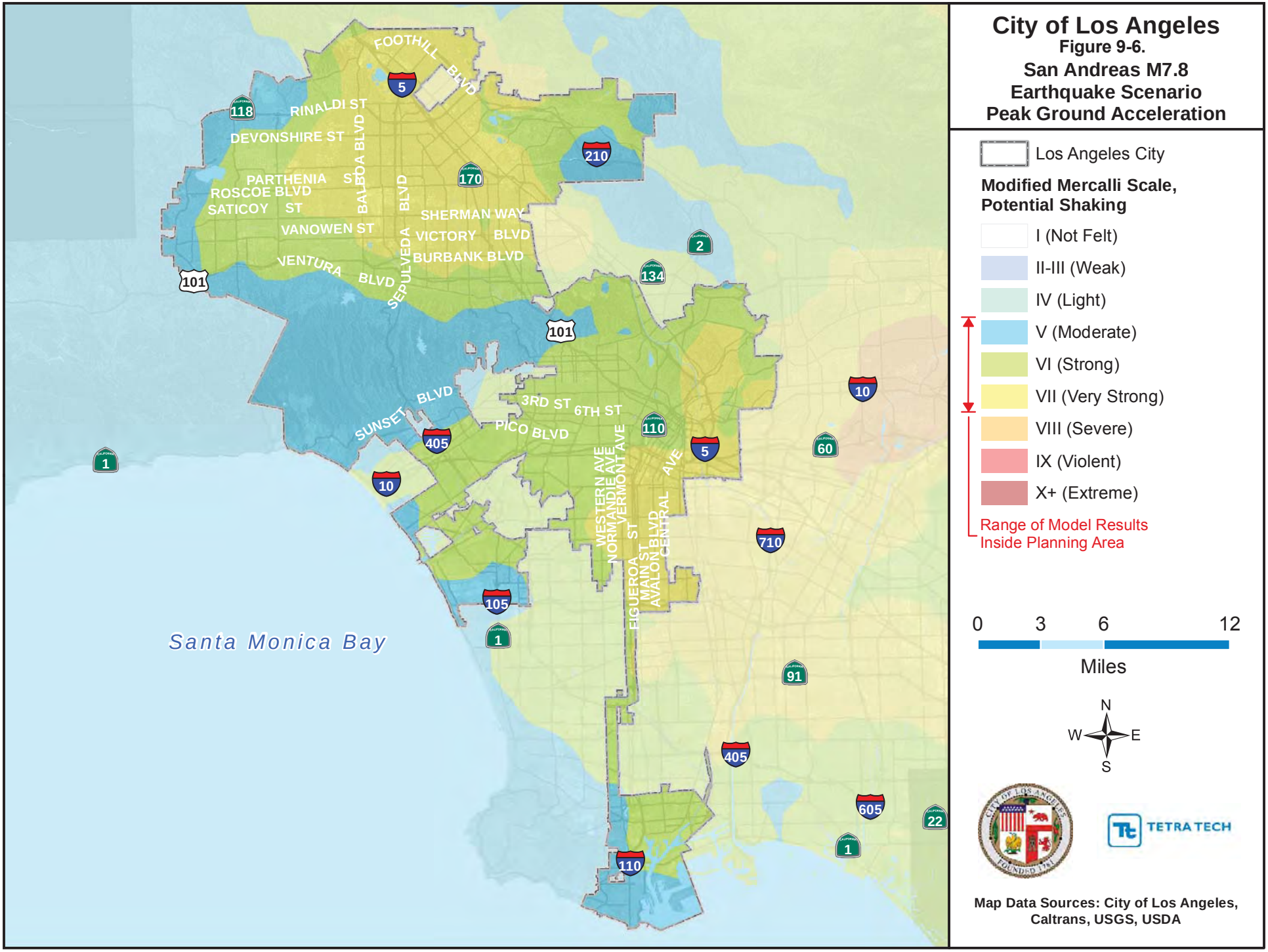
0 3 6 12

Miles

N W E S

TETRA TECH

Map Data Sources: City of Los Angeles, Caltrans, USGS, USDA



City of Los Angeles

Figure 9-6.

San Andreas M7.8 Earthquake Scenario Peak Ground Acceleration

Los Angeles City

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

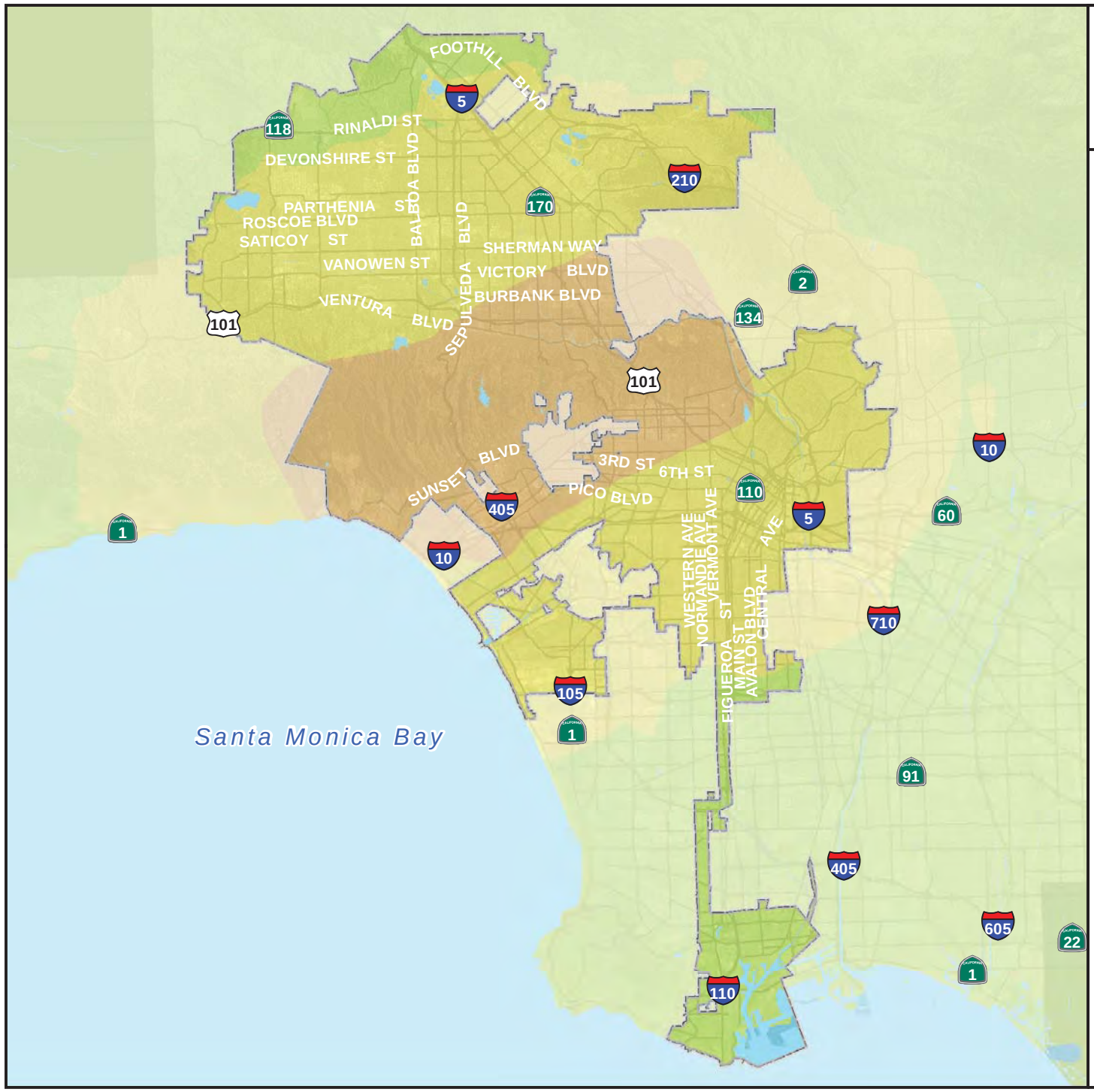
0 3 6 12

Miles

N W E S

TETRA TECH

Map Data Sources: City of Los Angeles, Caltrans, USGS, USDA



City of Los Angeles

Figure 9-7.
Santa Monica M6.8 Earthquake Scenario Peak Ground Acceleration

Los Angeles City

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

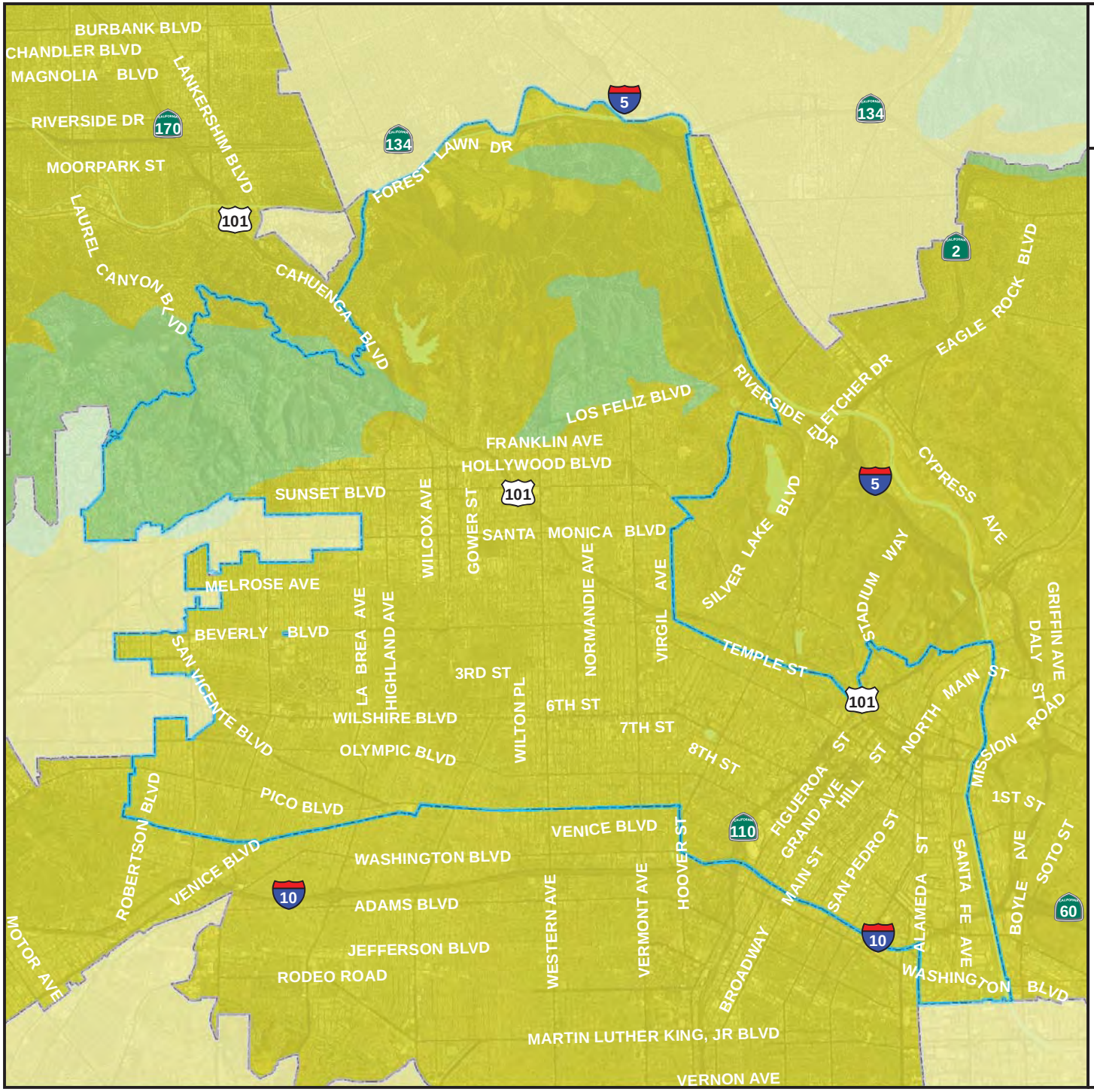
0 3 6 12

Miles

N W E S

TETRA TECH

Map Data Sources: City of Los Angeles, Caltrans, USGS, USDA



Central APC

Figure 9-8.
National Earthquake Hazards Reduction Program (NEHRP) Soils

APC Boundary

Los Angeles City

NEHRP Site Class / Soil Profile

C / Very Dense Soil - Soft Rock

D / Stiff Soil

E / Soft Soil

No Soil Data Available

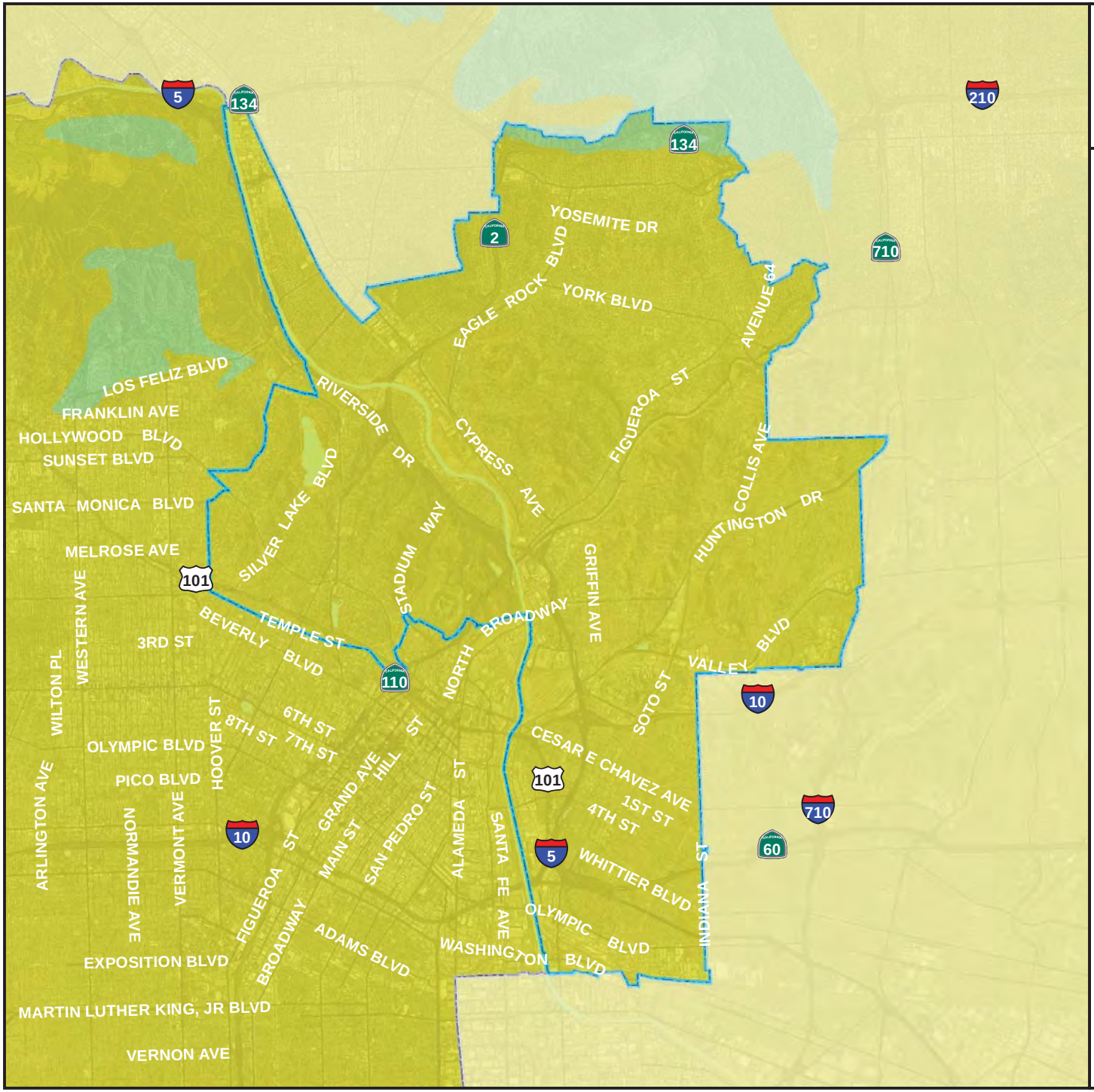
Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen, M., D. Beeby, W. Bryant, T. Cao, C. Cramer, J. Davis, M. Reichle, G. Saucedo, S. Tan G., Taylor, T. Toppozada, J. Treiman, and C. Wills (1999) Seismic Shaking Hazard Maps of California: California Division of Mines and Geology Map Sheet 48).

0 0.75 1.5 3

Miles

N W E S

Map Data Sources: City of Los Angeles, Caltrans, California Department of Conservation, USDA



East Los Angeles APC

Figure 9-9.

National Earthquake Hazards Reduction Program (NEHRP) Soils

APC Boundary

Los Angeles City

NEHRP Site Class / Soil Profile

C / Very Dense Soil - Soft Rock

D / Stiff Soil

E / Soft Soil

No Soil Data Available

Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen, M., D. Beeby, W. Bryant, T. Cao, C. Cramer, J. Davis, M. Reichle, G. Saucedo, S. Tan G., Taylor, T. Toppozada, J. Treiman, and C. Wills (1999) Seismic Shaking Hazard Maps of California: California Division of Mines and Geology Map Sheet 48).

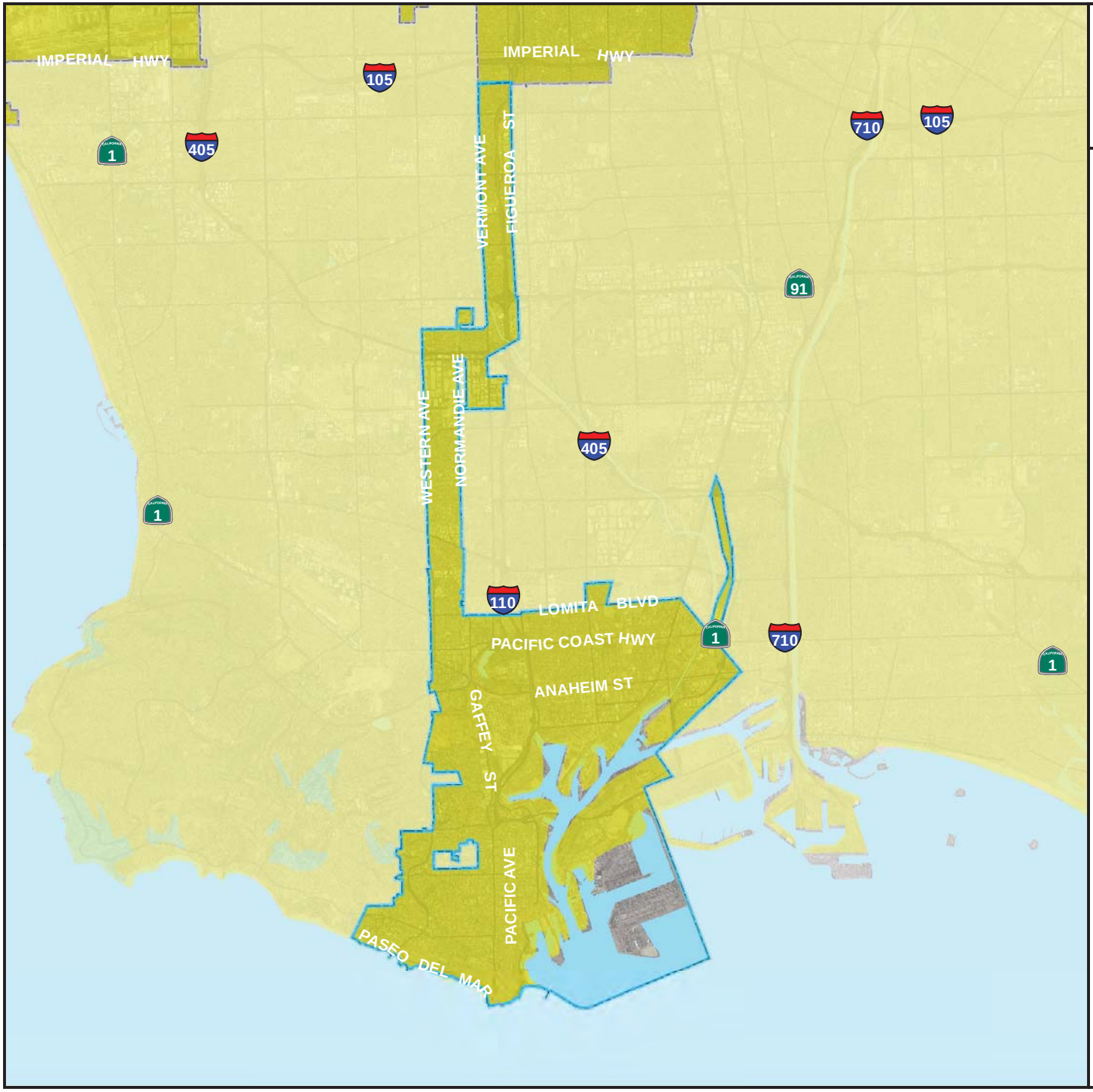
0 0.75 1.5 3

Miles

N W E S

TETRA TECH

Map Data Sources: City of Los Angeles, Caltrans, California Department of Conservation, USDA



Harbor APC

Figure 9-10.

National Earthquake Hazards Reduction Program (NEHRP) Soils

APC Boundary

Los Angeles City

NEHRP Site Class / Soil Profile

C / Very Dense Soil - Soft Rock

D / Stiff Soil

E / Soft Soil

No Soil Data Available

Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen, M., D. Beeby, W. Bryant, T. Cao, C. Cramer, J. Davis, M. Reichle, G. Saucedo, S. Tan G., Taylor, T. Toppozada, J. Treiman, and C. Wills (1999) Seismic Shaking Hazard Maps of California: California Division of Mines and Geology Map Sheet 48).

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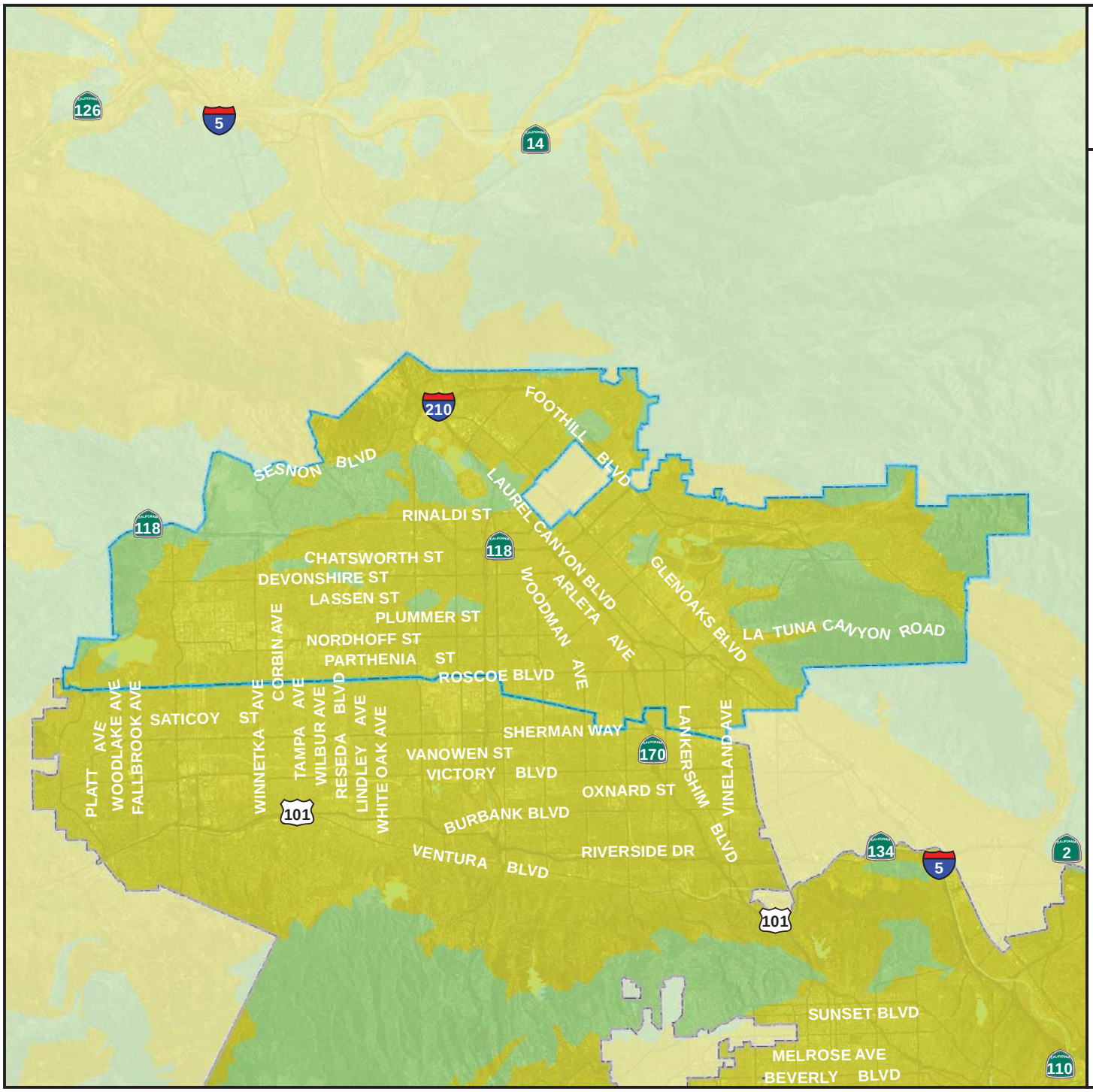
Map Data Sources: City of Los Angeles, Caltrans, California Department of Conservation, USDA



North Valley APC

Figure 9-11.

National Earthquake Hazards Reduction Program (NEHRP) Soils

APC Boundary

Los Angeles City

NEHRP Site Class / Soil Profile

C / Very Dense Soil - Soft Rock

D / Stiff Soil

E / Soft Soil

No Soil Data Available

Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen, M., D. Beeby, W. Bryant, T. Cao, C. Cramer, J. Davis, M. Reichle, G. Saucedo, S. Tan G., Taylor, T. Toppozada, J. Treiman, and C. Wills (1999) Seismic Shaking Hazard Maps of California: California Division of Mines and Geology Map Sheet 48).

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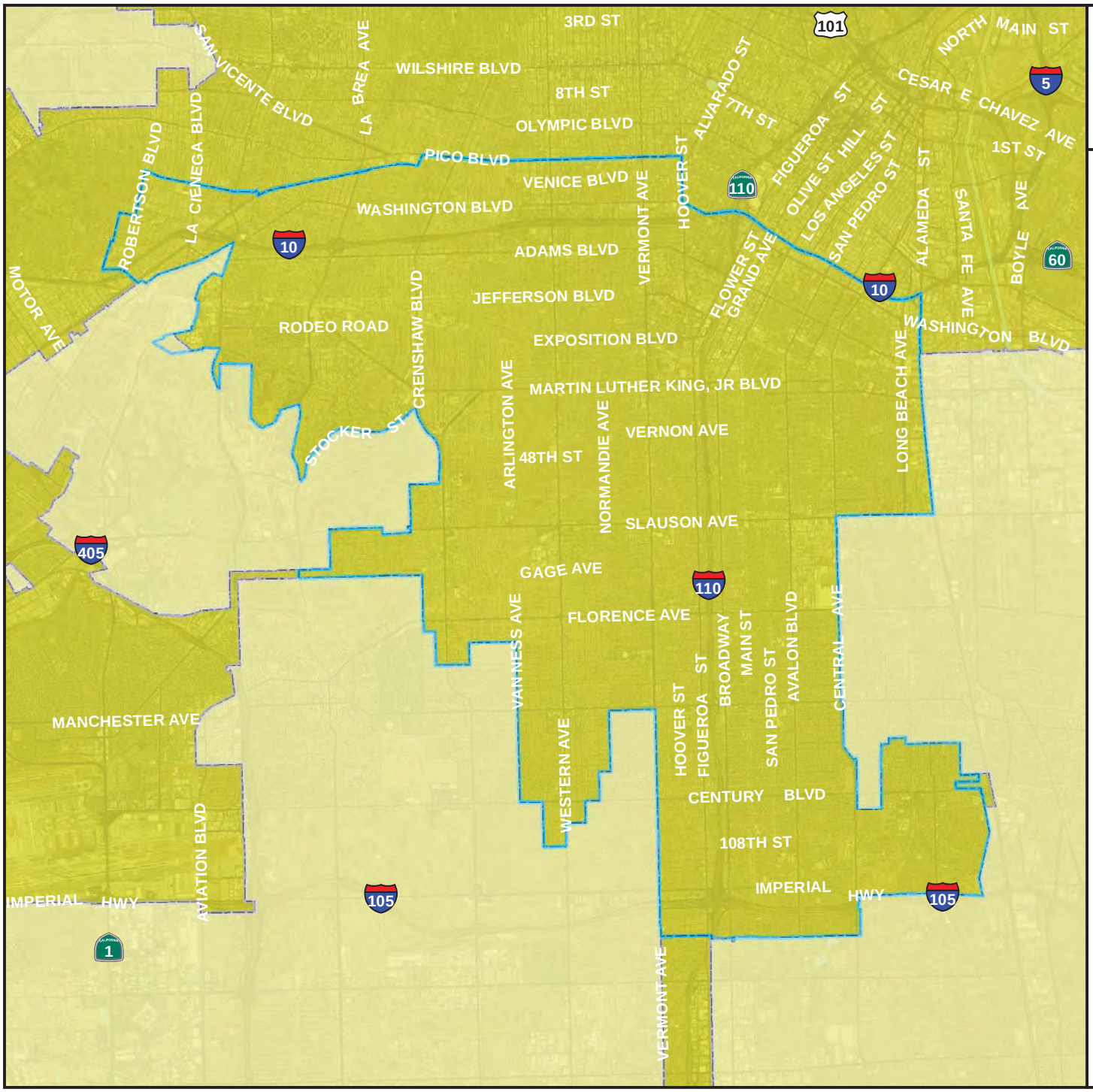
Map Data Sources: City of Los Angeles, Caltrans, California Department of Conservation, USDA



South Los Angeles APC

Figure 9-12.
National Earthquake Hazards Reduction Program (NEHRP) Soils

APC Boundary

Los Angeles City

NEHRP Site Class / Soil Profile

- C / Very Dense Soil - Soft Rock
- D / Stiff Soil
- E / Soft Soil
- No Soil Data Available

Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen, M., D. Beeby, W. Bryant, T. Cao, C. Cramer, J. Davis, M. Reichle, G. Saucedo, S. Tan G., Taylor, T. Toppozada, J. Treiman, and C. Wills (1999) Seismic Shaking Hazard Maps of California: California Division of Mines and Geology Map Sheet 48).

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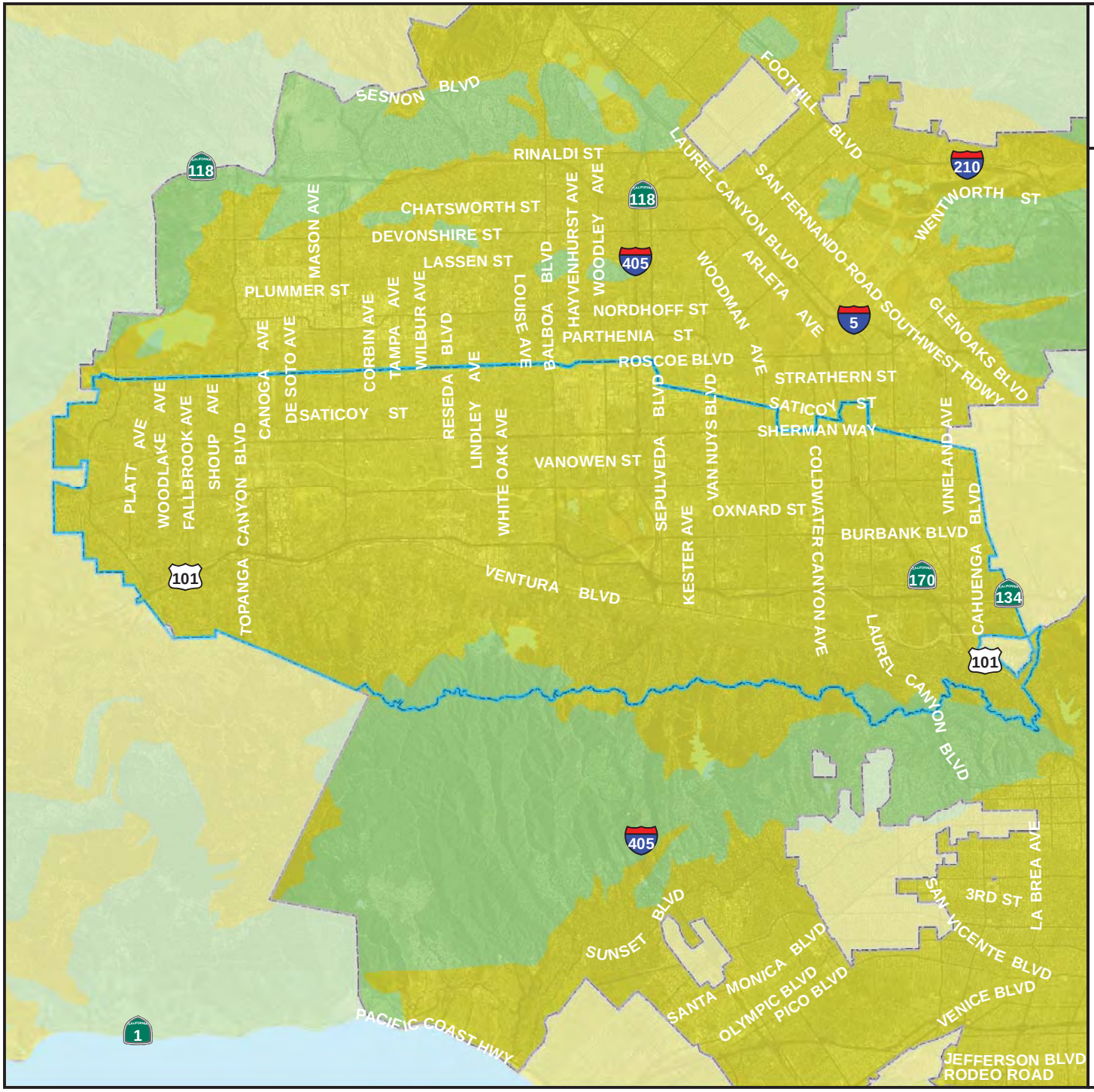
Map Data Sources: City of Los Angeles, Caltrans, California Department of Conservation, USDA



South Valley APC

Figure 9-13.
National Earthquake Hazards Reduction Program (NEHRP) Soils

APC Boundary

Los Angeles City

NEHRP Site Class / Soil Profile

- C / Very Dense Soil - Soft Rock
- D / Stiff Soil
- E / Soft Soil
- No Soil Data Available

Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen, M., D. Beeby, W. Bryant, T. Cao, C. Cramer, J. Davis, M. Reichle, G. Saucedo, S. Tan G., Taylor, T. Toppozada, J. Treiman, and C. Wills (1999) Seismic Shaking Hazard Maps of California: California Division of Mines and Geology Map Sheet 48).

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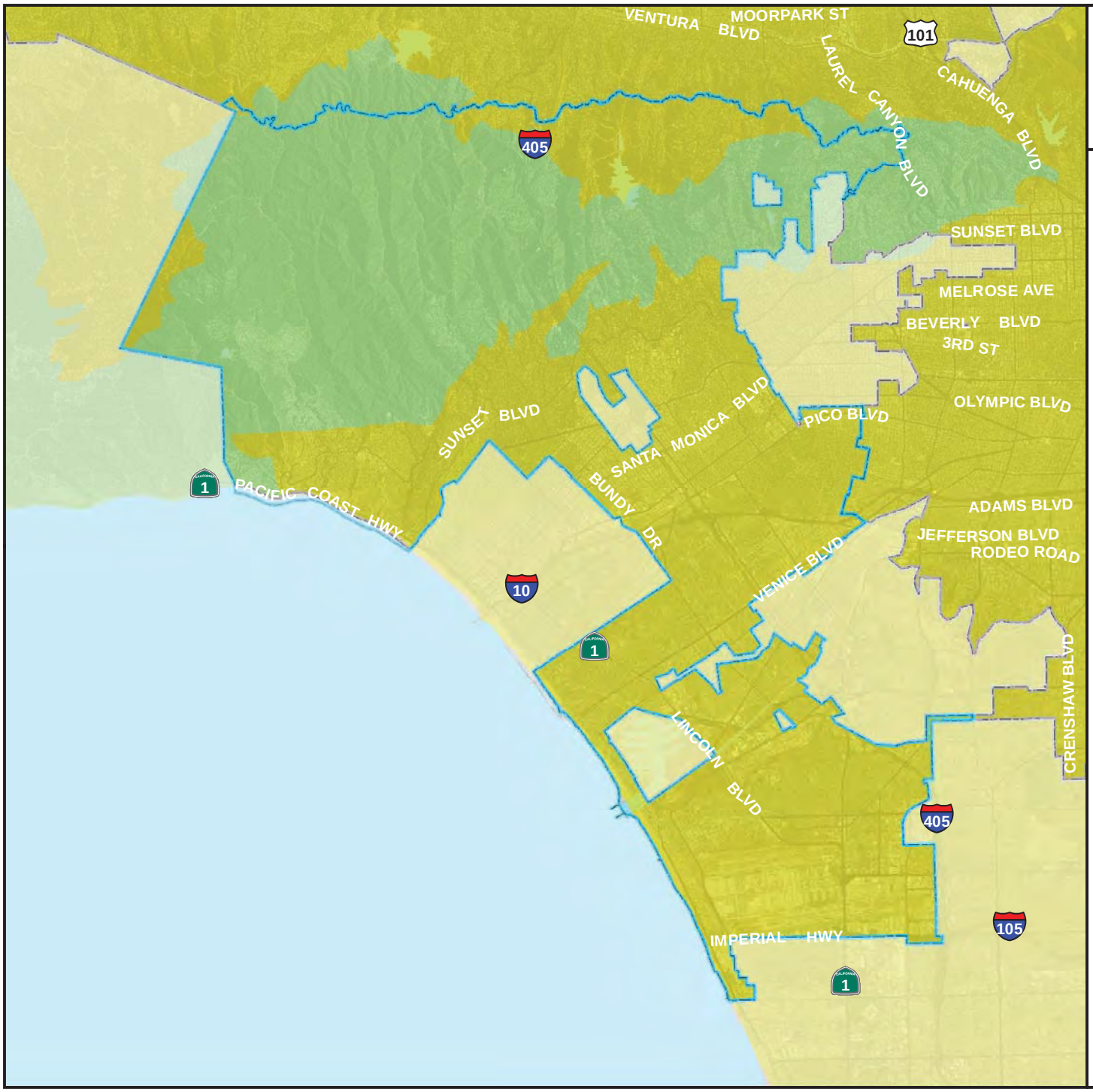
Map Data Sources: City of Los Angeles, Caltrans, California Department of Conservation, USDA



West Los Angeles APC

Figure 9-14.
National Earthquake Hazards Reduction Program (NEHRP) Soils

APC Boundary

Los Angeles City

NEHRP Site Class / Soil Profile

- C / Very Dense Soil - Soft Rock
- D / Stiff Soil
- E / Soft Soil
- No Soil Data Available

Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen, M., D. Beeby, W. Bryant, T. Cao, C. Cramer, J. Davis, M. Reichle, G. Saucedo, S. Tan G., Taylor, T. Toppozada, J. Treiman, and C. Wills (1999) Seismic Shaking Hazard Maps of California: California Division of Mines and Geology Map Sheet 48).

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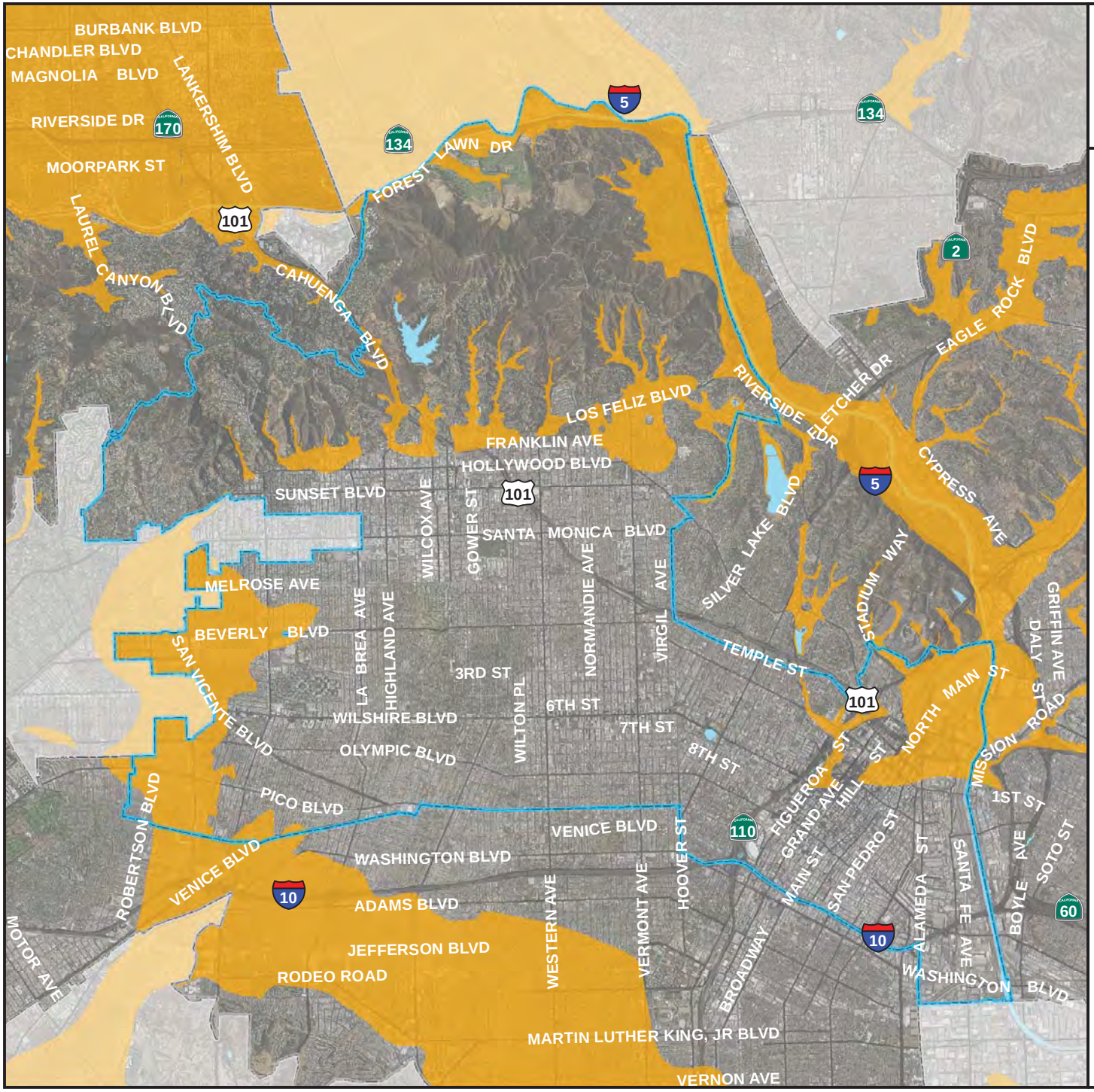
Map Data Sources: City of Los Angeles, Caltrans, California Department of Conservation, USDA



Central APC

Figure 9-15.

Liquefaction Zones

- APC Boundary
- Los Angeles City
- Liquefaction Zones

Liquefaction zones identify where the stability of foundation soils must be investigated, and countermeasures undertaken in the design and construction of buildings for human occupancy. Statutes require that cities and counties use these zones as part of their construction permitting process. Areas of liquefaction may become instable during an earthquake and cause potential damage to foundations and infrastructure.

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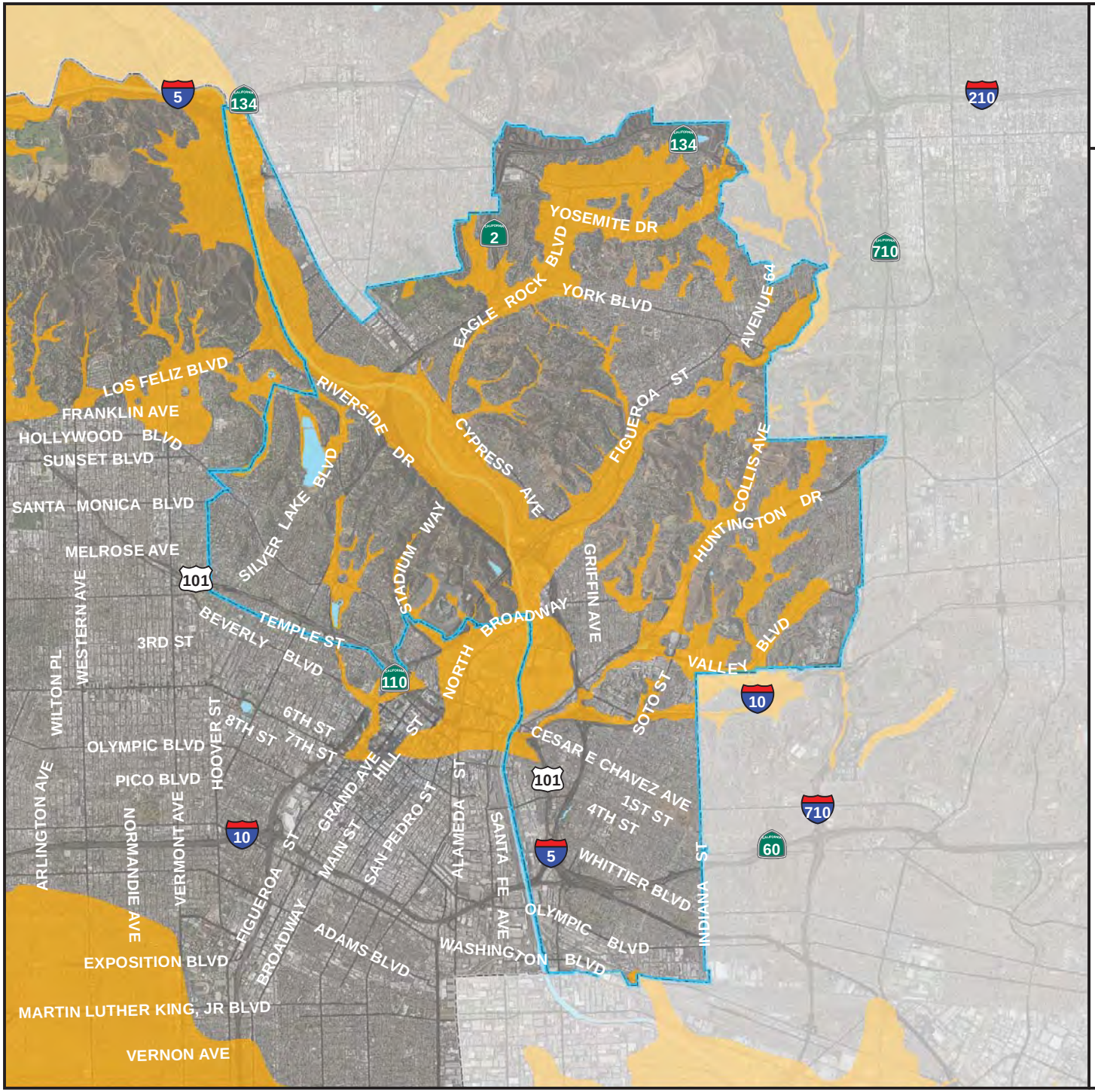
Map Data Sources: City of Los Angeles, Caltrans, USDA



East Los Angeles APC

Figure 9-16.

Liquefaction Zones

APC Boundary

Los Angeles City

Liquefaction Zones

Liquefaction zones identify where the stability of foundation soils must be investigated, and countermeasures undertaken in the design and construction of buildings for human occupancy. Statutes require that cities and counties use these zones as part of their construction permitting process. Areas of liquefaction may become instable during an earthquake and cause potential damage to foundations and infrastructure.

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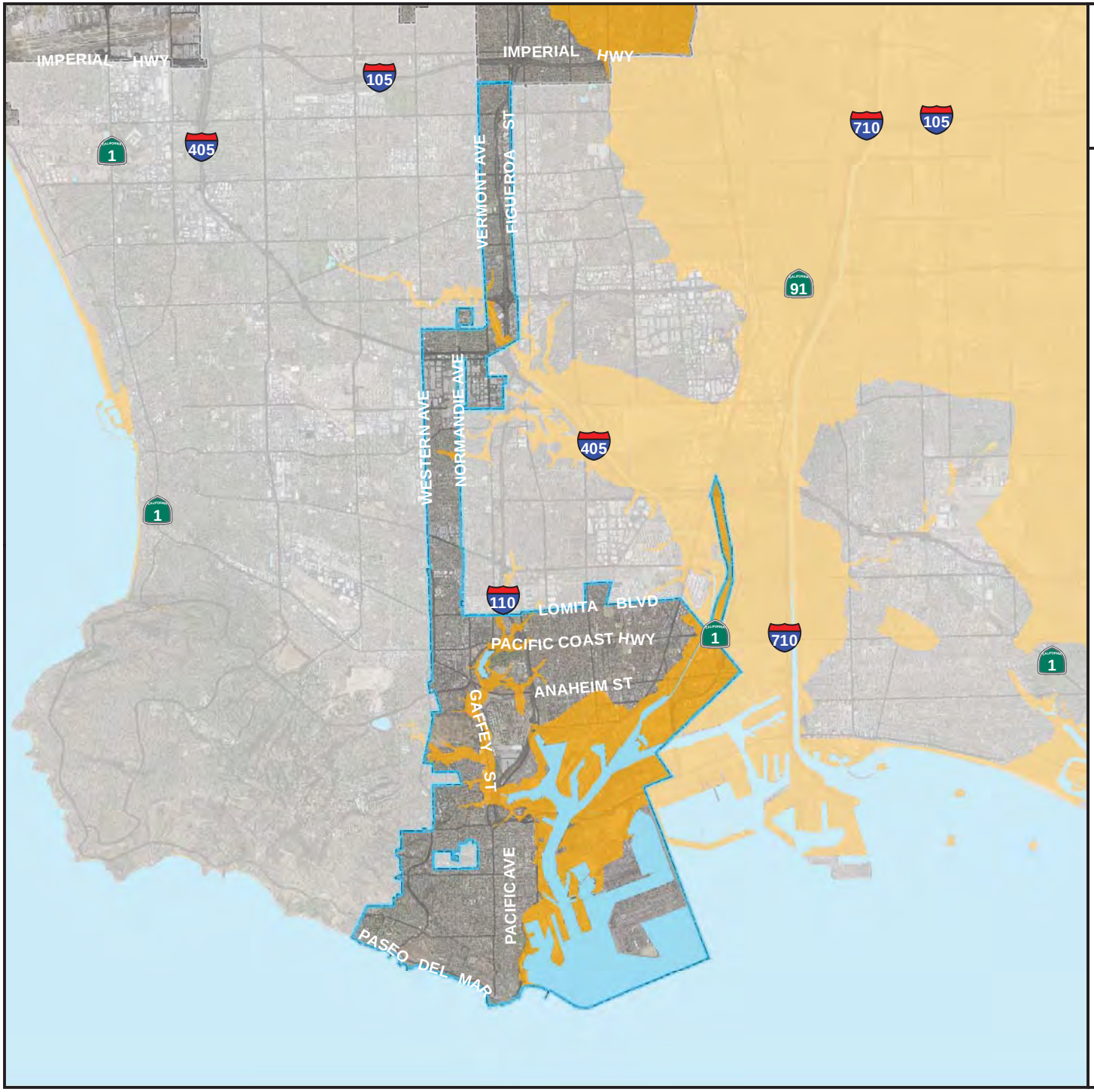
Map Data Sources: City of Los Angeles, Caltrans, USDA



Harbor APC

Figure 9-17.

Liquefaction Zones

APC Boundary

Los Angeles City

Liquefaction Zones

Liquefaction zones identify where the stability of foundation soils must be investigated, and countermeasures undertaken in the design and construction of buildings for human occupancy. Statutes require that cities and counties use these zones as part of their construction permitting process. Areas of liquefaction may become instable during an earthquake and cause potential damage to foundations and infrastructure.

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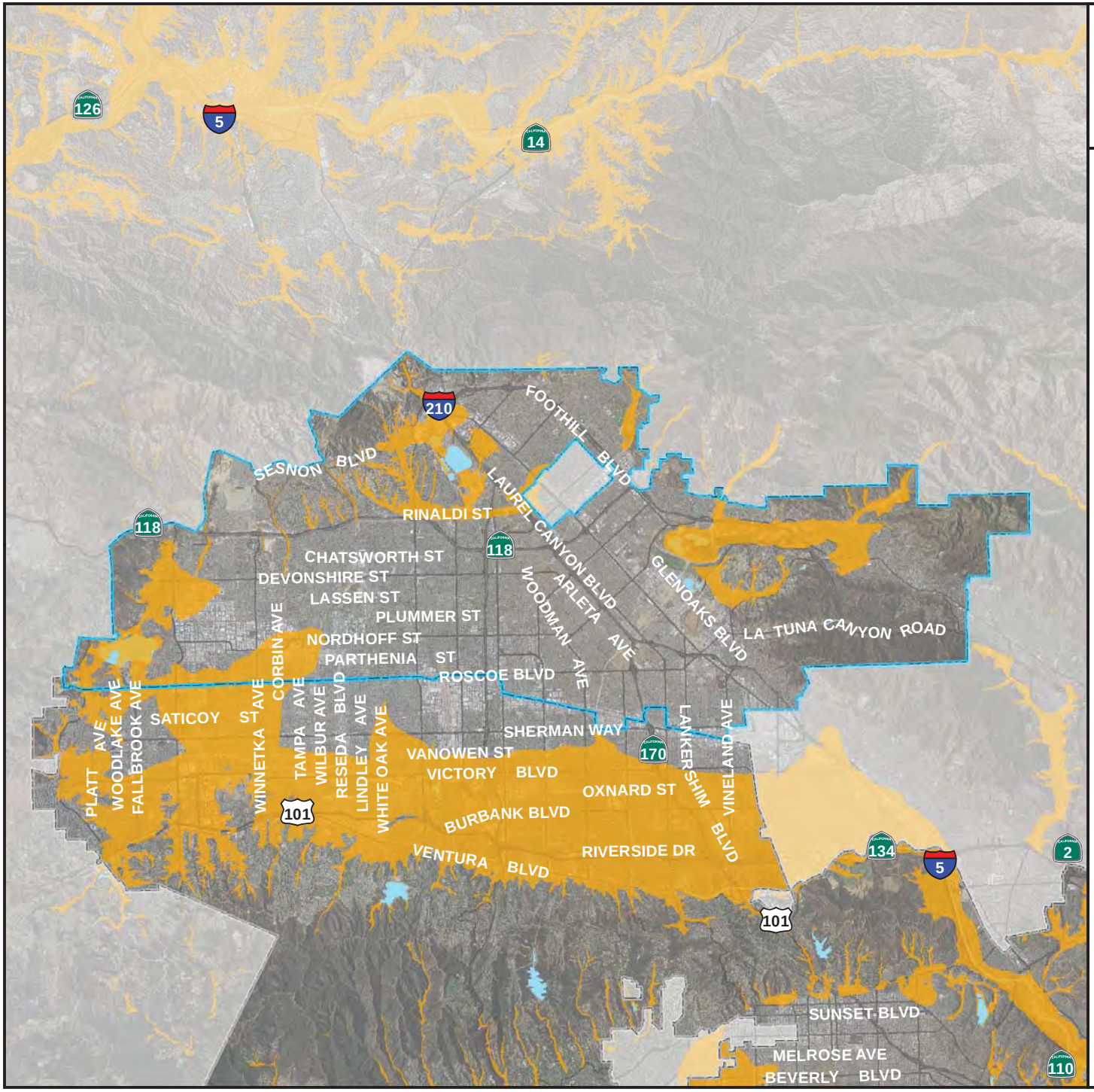
Map Data Sources: City of Los Angeles, Caltrans, USDA



North Valley APC

Figure 9-18.

Liquefaction Zones

APC Boundary

Los Angeles City

Liquefaction Zones

Liquefaction zones identify where the stability of foundation soils must be investigated, and countermeasures undertaken in the design and construction of buildings for human occupancy. Statutes require that cities and counties use these zones as part of their construction permitting process. Areas of liquefaction may become instable during an earthquake and cause potential damage to foundations and infrastructure.

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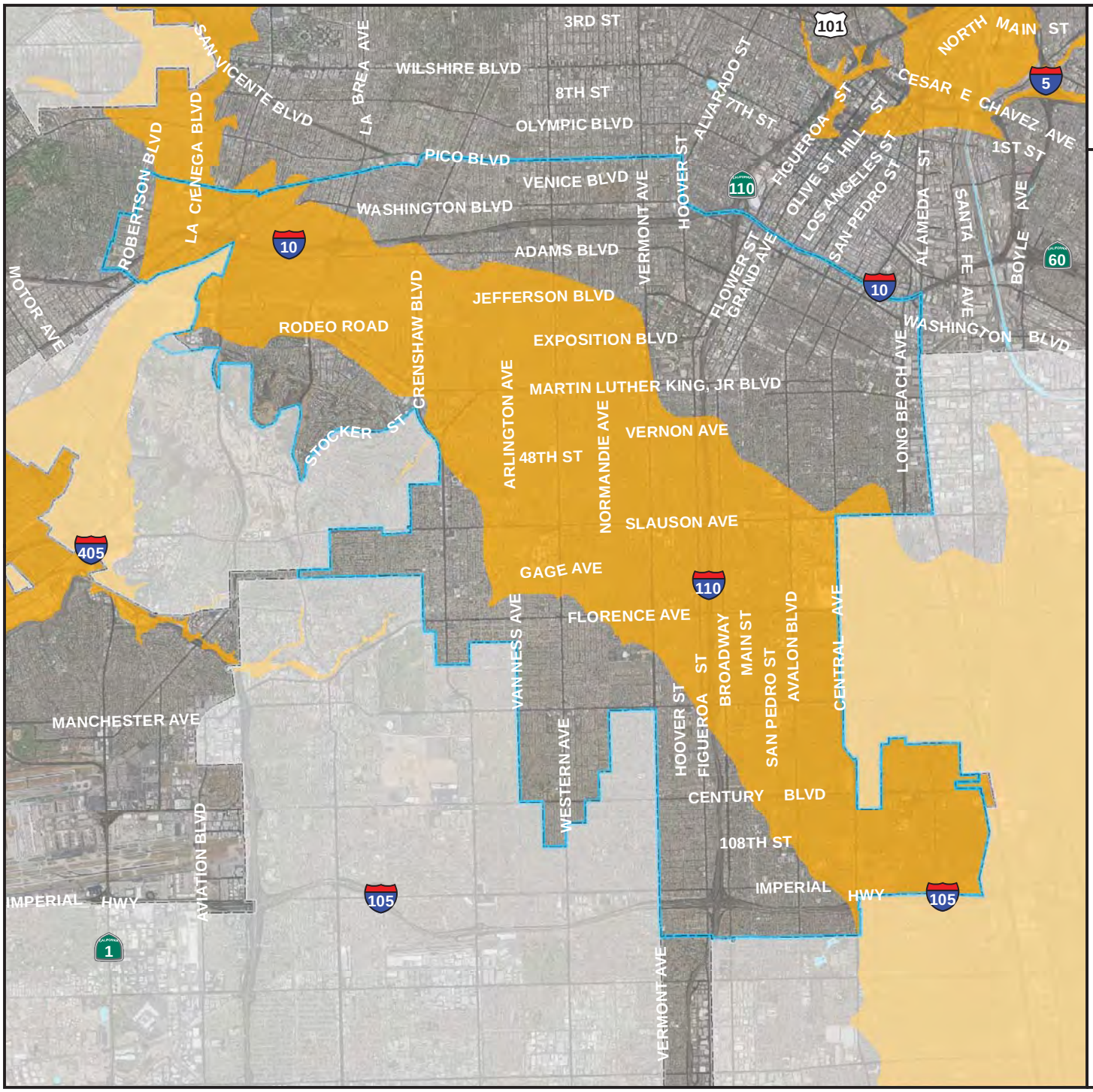
Map Data Sources: City of Los Angeles, Caltrans, USDA



South Los Angeles APC

Figure 9-19.

Liquefaction Zones

APC Boundary

Los Angeles City

Liquefaction Zones

Liquefaction zones identify where the stability of foundation soils must be investigated, and countermeasures undertaken in the design and construction of buildings for human occupancy. Statutes require that cities and counties use these zones as part of their construction permitting process. Areas of liquefaction may become instable during an earthquake and cause potential damage to foundations and infrastructure.

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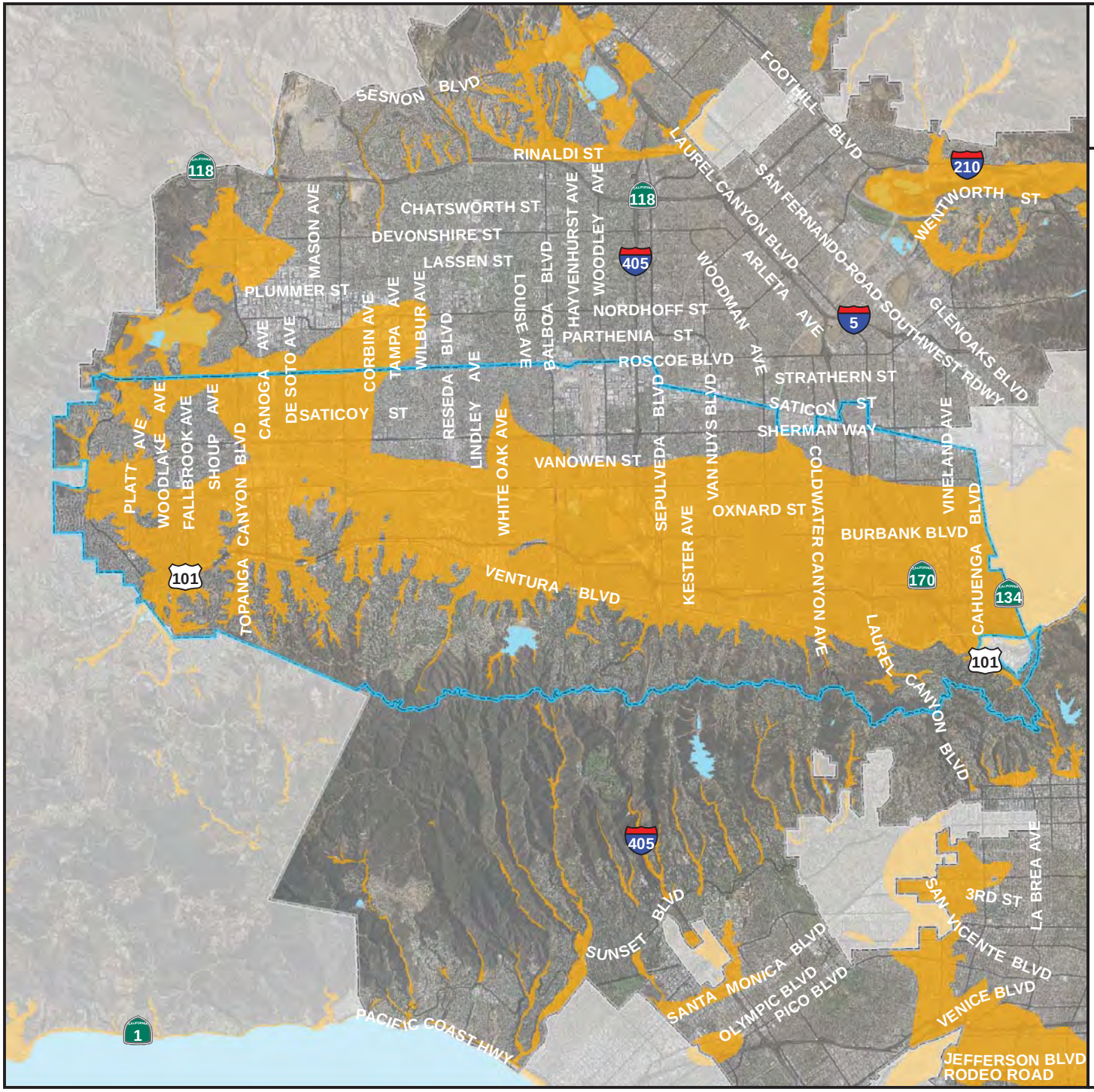
Map Data Sources: City of Los Angeles, Caltrans, USDA



South Valley APC

Figure 9-20.

Liquefaction Zones

APC Boundary

Los Angeles City

Liquefaction Zones

Liquefaction zones identify where the stability of foundation soils must be investigated, and countermeasures undertaken in the design and construction of buildings for human occupancy. Statutes require that cities and counties use these zones as part of their construction permitting process. Areas of liquefaction may become instable during an earthquake and cause potential damage to foundations and infrastructure.

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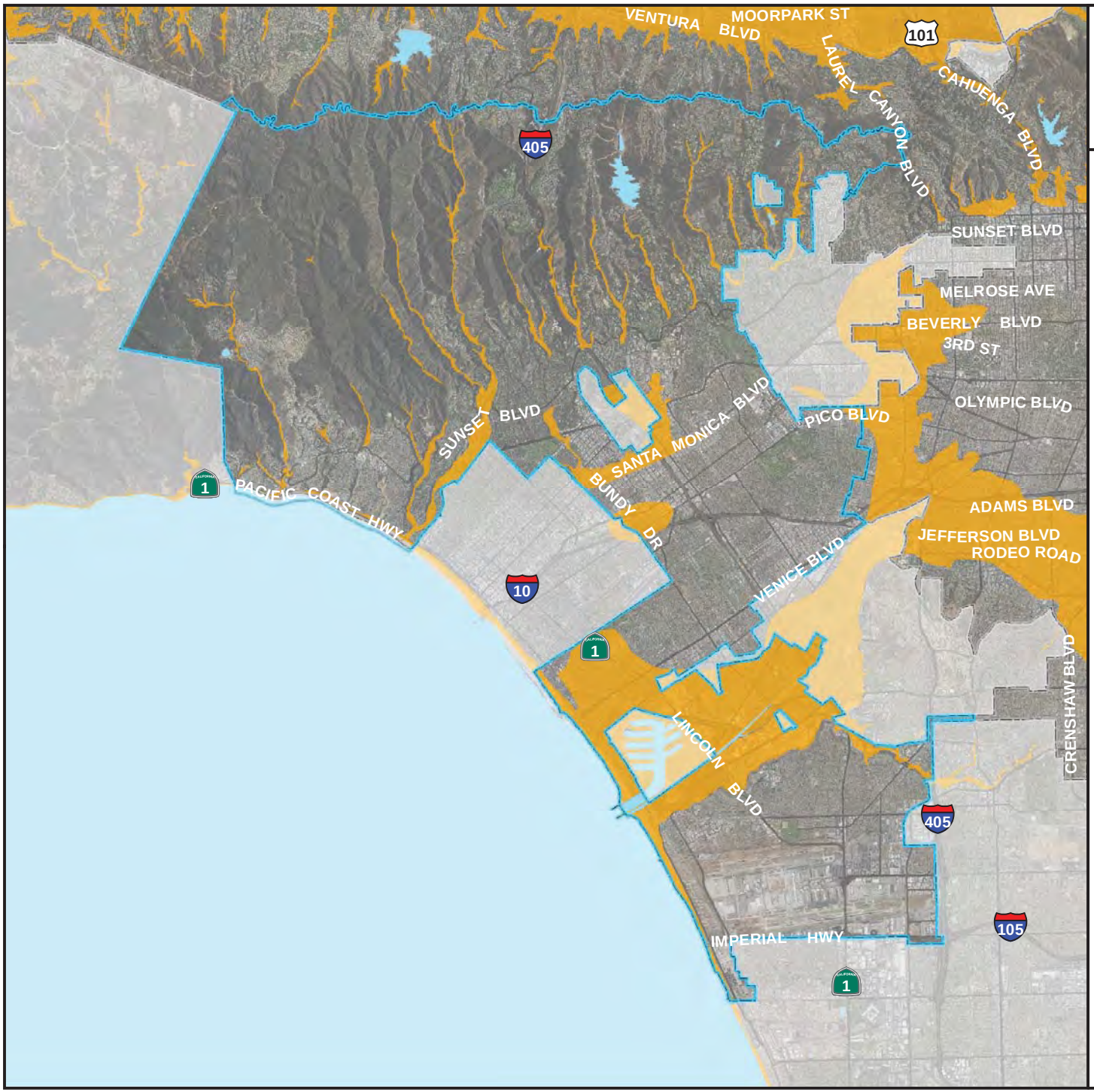
Map Data Sources: City of Los Angeles, Caltrans, USDA



West Los Angeles APC

Figure 9-21.

Liquefaction Zones

APC Boundary

Los Angeles City

Liquefaction Zones

Liquefaction zones identify where the stability of foundation soils must be investigated, and countermeasures undertaken in the design and construction of buildings for human occupancy. Statutes require that cities and counties use these zones as part of their construction permitting process. Areas of liquefaction may become instable during an earthquake and cause potential damage to foundations and infrastructure.

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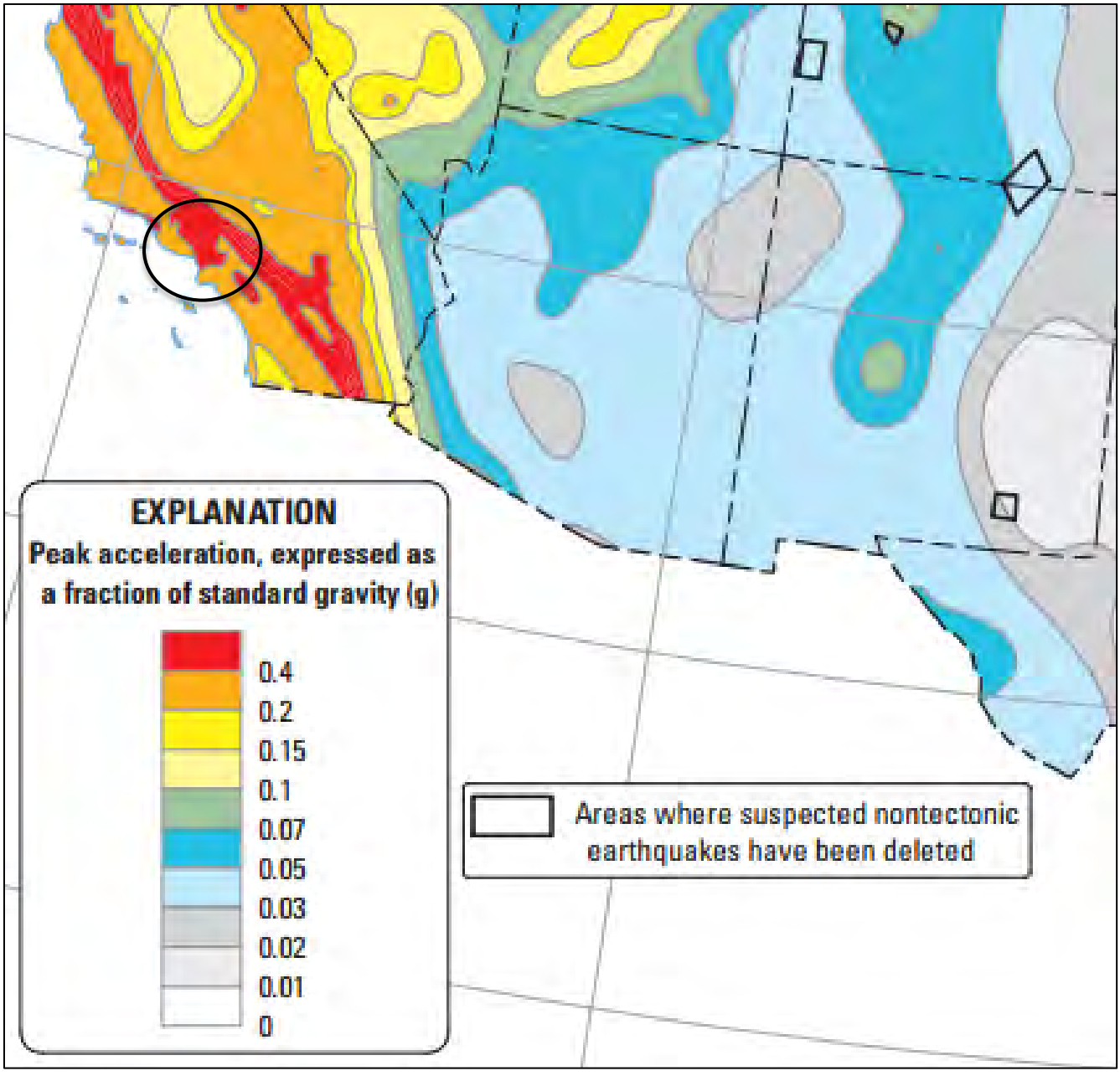
Map Data Sources: City of Los Angeles, Caltrans, USDA

9.2.4 Severity

The USGS has created ground motion maps based on current information about fault zones. These maps show the PGA that has a certain probability (2 percent or 10 percent) of being exceeded in a 50-year period. The maps were most recently updated in 2014 with new seismic, geologic, and geodetic information on earthquake rates and ground shaking, representing the best currently available data. The 2014 map for California shows that for City of Los Angeles, the PGA with a 10-percent probability of exceedance in 50 years is 0.4g and 0.2g (see Figure 9-22).



Oval is approximate location of City of Los Angeles

Figure 9-22. PGA with 2-Percent Probability of Exceedance in 50 Years

9.2.5 Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system.

9.3 SECONDARY IMPACTS

Earthquakes can cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes.

Earthquakes can also trigger tsunamis. Tsunamis significantly damage many locations beyond where the earthquake struck. Coastal communities near the earthquake epicenter that are also vulnerable to tsunamis could experience devastating impacts. Additionally, fires can result from gas lines or power lines that are broken or downed during the earthquake. It may be difficult to control a fire, particularly if the water lines feeding fire hydrants are also broken.

9.4 EXPOSURE

9.4.1 Population

The entire population of the planning area is potentially exposed to direct and indirect impacts from earthquakes. Whether directly impacted or indirectly impacted, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

9.4.2 Property

According to assessor records, there are 746,352 buildings in the planning area, with a total replacement value of $767.9 billion. Since all structures in the planning area are susceptible to earthquake impacts to varying degrees, this total represents the property exposure to seismic events. Table 9-8 shows the exposure value breakdown by Area Planning Commission.

9.4.3 Critical Facilities and Infrastructure

All critical facilities in the planning area are exposed to the earthquake hazard. Table 4-5 lists the number of each type of facility in the planning area. Facilities holding hazardous materials are of particular concern because of possible isolation of neighborhoods surrounding them. Hazardous materials releases can occur during an earthquake from fixed facilities or transportation-related incidents. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment. Transportation corridors can be disrupted during an earthquake, leading to the release of materials to the surrounding environment.

Table 9-8. Earthquake Exposure by Area Planning Commission

Area Planning Commission	Total # of Buildings	Total Building Value—Structure and Contents
Central	84,429	$191,217,052,041
East Los Angeles	72,052	$66,257,497,608
Harbor	39,749	$40,999,775,796
North Valley	151,060	$115,609,300,175
South Los Angeles	112,787	$98,455,728,673
South Valley	173,423	$145,505,548,380
West Los Angeles	112,852	$109,858,703,574
Total	746,352	$767,903,606,246

9.4.4 Environment

Secondary hazards associated with earthquakes will likely have damaging effects on the environment. Earthquake-induced landslides can significantly impact surrounding habitat. It is also possible for streams to be rerouted after an earthquake. This can change the water quality, possibly damaging habitat and feeding areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology.

9.5 VULNERABILITY

Earthquake vulnerability data was generated using a Level 2 Hazus analysis. Once the location and size of a hypothetical earthquake are identified, Hazus estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up.

9.5.1 Population

The degree of vulnerability of people exposed to the earthquake hazard is dependent on many factors, including the age and construction type of the structures they live in, the soil type their homes are constructed on, their proximity to fault location, etc. There are estimated to be 1,189,384 people in over 428,992 households living on soils with liquefaction potential in the planning area. This is about 77 percent of the total population. Three population groups are particularly vulnerable to earthquake hazards:

- **Population Below Poverty Level**—An estimated 209,133 households in areas with liquefaction potential soils have household incomes less than $50,000 per year. This is about 49 percent of all households located on liquefaction potential soils. These households may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Economically disadvantaged residents are also less likely to have insurance to compensate for losses in earthquakes.
- **Population Over 65 Years Old**—An estimated 123,376 residents in areas with liquefaction potential soils are over 65 years old. This is about 10 percent of all residents in these areas. This population group is vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations.
- **Linguistically Isolated Populations**——Problems arise when there is an urgent need to inform non-English speaking residents of an earthquake event. They are vulnerable because of difficulties in understanding hazard-related information from predominantly English-speaking media and government agencies. No estimates have been developed of the number of linguistically isolated persons living in areas with liquefaction potential soils.

Impacts on persons and households in the planning area were estimated for the five scenario events through the Level 2 Hazus analysis. Table 9-9 summarizes the results.

Table 9-9. Estimated Earthquake Impact on Persons and Households

Earthquake Scenario	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
Newport-Inglewood	50,064	34,315
Palos Verde	13,015	9,193
Puente Hills	116,329	92,303
San Andreas	71,428	57,776
Santa Monica	93,572	55,283

9.5.2 Property

Building Age

Table 9-10 identifies significant milestones in building and seismic code requirements that directly affect the structural integrity of development. Using these time periods, the planning team used Hazus to identify the number of structures in the planning area by date of construction.

Table 9-10. Age of Structures in Planning Area

Time Period	Number of Current Planning Area Structures Built in Period	Significance of Time Frame
Pre-1933	120,497	Before 1933, there were no explicit earthquake requirements in building codes. State law did not require local governments to have building officials or issue building permits.
1933-1940	42,566	In 1940, the first strong motion recording was made.
1941-1960	250,943	In 1960, the Structural Engineers Association of California published guidelines on recommended earthquake provisions.
1961-1975	145,368	In 1975, significant improvements were made to lateral force requirements.
1976-1994	127,211	In 1994, the Uniform Building Code was amended to include provisions for seismic safety.
1994 – present	59,773	Seismic code is currently enforced.
Total	746,358	

The number of structures does not reflect the number of total housing units, as many multi-family units and attached housing units are reported as one structure. Approximately 8 percent of the planning area's structures were constructed after the Uniform Building Code was amended in 1994 to include seismic safety provisions. Approximately 16 percent were built before 1933 when there were no building permits, inspections, or seismic standards.

Loss Potential

Property losses were estimated through the Level 2 Hazus analysis for the five earthquake fault scenarios. Table 9-11 through Table 9-15 shows the results for damage to structures and damage to building contents.

Table 9-11. Loss Estimates for Newport-Inglewood Fault Scenario

Area Planning Commission	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Central	$8,241,730,263	$1,920,045,166	$10,161,775,428	5.3%
East Los Angeles	$1,305,221,209	$445,761,452	$1,750,982,661	2.6%
Harbor	$1,749,599,309	$531,934,262	$2,281,533,571	5.6%
North Valley	$867,454,730	$348,651,514	$1,216,106,244	1.1%
South Los Angeles	$7,569,043,634	$1,863,552,074	$9,432,595,708	9.6%
South Valley	$1,999,692,385	$636,853,477	$2,636,545,861	1.8%
West Los Angeles	$6,648,152,056	$1,651,233,193	$8,299,385,249	7.6%
Total	$28,380,893,585	$7,398,031,139	$35,778,924,723	4.7%

Table 9-12. Loss Estimates for Palos Verde Fault Scenario

Area Planning Commission	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Central	$1,964,015,648	$697,062,972	$2,661,078,620	1.4%
East Los Angeles	$500,900,960	$213,829,877	$714,730,836	1.1%
Harbor	$3,135,433,765	$960,807,399	$4,096,241,164	10.0%
North Valley	$571,011,942	$249,616,280	$820,628,222	0.7%
South Los Angeles	$1,290,293,580	$408,926,868	$1,699,220,448	1.7%
South Valley	$1,177,185,021	$439,600,127	$1,616,785,148	1.1%
West Los Angeles	$2,849,929,987	$779,747,585	$3,629,677,572	3.3%
Total	$11,488,770,903	$3,749,591,107	$15,238,362,010	2.0%

Table 9-13. Loss Estimates for Puente Hills Fault Scenario

Area Planning Commission	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Central	$30,232,804,494	$7,858,974,294	$38,091,778,788	19.9%
East Los Angeles	$10,319,509,533	$3,332,567,416	$13,652,076,949	20.6%
Harbor	$399,610,119	$139,106,363	$538,716,483	1.3%
North Valley	$1,503,231,885	$500,450,267	$2,003,682,153	1.7%
South Los Angeles	$13,651,437,366	$3,934,772,239	$17,586,209,605	17.9%
South Valley	$2,326,598,180	$675,458,539	$3,002,056,719	2.1%
West Los Angeles	$3,041,456,855	$784,733,477	$3,826,190,332	3.5%
Total	$61,474,648,432	$17,226,062,595	$78,700,711,027	10.2%

Table 9-14. Loss Estimates for San Andreas Fault Scenario

Area Planning Commission	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Central	$9,333,230,996	$1,900,962,563	$11,234,193,560	5.9%
East Los Angeles	$3,737,577,115	$1,029,274,178	$4,766,851,293	7.2%
Harbor	$556,079,154	$158,953,374	$715,032,528	1.7%
North Valley	$9,511,961,668	$3,300,449,662	$12,812,411,330	11.1%
South Los Angeles	$8,315,518,426	$2,268,565,184	$10,584,083,611	10.8%
South Valley	$7,524,900,766	$2,045,858,489	$9,570,759,256	6.6%
West Los Angeles	$1,420,912,516	$257,007,998	$1,677,920,514	1.5%
Total	$40,400,180,642	$10,961,071,449	$51,361,252,091	6.7%

Table 9-15. Loss Estimates for Santa Monica Fault Scenario

Area Planning Commission	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Central	$13,967,469,958	$3,164,742,973	$17,132,212,930	9.0%
East Los Angeles	$2,660,404,526	$812,956,065	$3,473,360,591	5.2%
Harbor	$128,768,156	$63,755,338	$192,523,494	0.5%
North Valley	$2,419,071,907	$784,598,527	$3,203,670,434	2.8%
South Los Angeles	$2,728,171,717	$659,059,936	$3,387,231,653	3.4%
South Valley	$8,674,190,206	$2,303,452,116	$10,977,642,322	7.5%
West Los Angeles	$8,811,852,451	$2,234,256,872	$11,046,109,324	10.1%
Total	$39,389,928,921	$10,022,821,827	$49,412,750,748	6.4%

A summary of the property-related loss results is as follows:

- For the Newport-Inglewood Fault Scenario, the estimated damage potential is $35.8 billion, or 4.66 percent of the total replacement value for the planning area.
- For the Palos Verde Fault Scenario, the estimated damage potential is $15.3 billion, or 1.98 percent of the total replacement value for the planning area.
- For the Puente Hills Fault Scenario, the estimated damage potential is $78.7 billion, or 10.25 percent of the total replacement value for the planning area.
- For the San Andreas Fault Scenario, the estimated damage potential is $51.4 billion, or 6.69 percent of the total replacement value for the planning area.
- For the Santa Monica Fault Scenario, the estimated damage potential is $49.4 billion, or 6.43 percent of the total replacement value for the planning area.

The Hazus analysis also estimated the amount of earthquake-caused debris in the planning area for the five scenario events, as summarized in Table 9-16.

Table 9-16. Estimated Earthquake-Caused Debris

	Debris to Be Removed (tons)
Newport-Inglewood	12,233
Palos Verde	3,941
Puente Hills	28,158
San Andreas	21,037
Santa Monica	16,181

9.5.3 Critical Facilities and Infrastructure

Level of Damage

Hazus classifies the vulnerability of critical facilities to earthquake as no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a category to each critical facility in the planning area for the five earthquake fault scenarios. Table 9-17 through Table 9-21 summarize the results.

Time to Return to Functionality

Hazus estimates the time to restore critical facilities to fully functional use. Results are presented as probability of being functional at specified time increments: 1, 3, 7, 14, 30 and 90 days after the event. For example, Hazus may estimate that a facility has 5 percent chance of being fully functional at Day 3, and a 95-percent chance of being fully functional at Day 90. The analysis of critical facilities in the planning area was performed for the five scenario events assessed. Table 9-22 and Table 9-26 summarize the results.

9.5.4 Environment

The environment vulnerable to earthquake hazard is the same as the environment exposed to the hazard.

Table 9-17. Estimated Number of Critical Facilities Damaged, by Damage Level—Newport/Inglewood Scenario

Category	# of Critical Facilities	Number of Buildings with 50% or Greater Probability of Achieving Damage Level				
		None	Slight	Moderate	Extensive	Complete
Critical Operating Facilities	20	3	11	6	0	0
Critical Response Facilities						
Evacuation Centers / Debris Removal	9	3	4	1	1	0
Fire	73	18	28	15	12	0
Medical	33	29	4	0	0	0
Police	17	3	6	4	4	0
Schools	847	447	97	190	113	0
Critical Infrastructure—Transportation						
Airports	2	2	0	0	0	0
Bridges	841	841	0	0	0	0
Bus Systems	19	5	8	6	0	0
Light Rail	29	4	21	4	0	0
Port / Harbor	20	6	13	1	0	0
Railroads	7	6	1	0	0	0
Critical Infrastructure—Utilities						
Communications	28	1	1	19	5	2
Electric Power	9	2	4	3	0	0
Hazardous Materials	294	77	124	61	32	0
Petroleum & Natural Gas	58	7	19	22	10	0
Potable Water	31	11	7	9	4	0
Waste Water	85	7	48	22	8	0
Overall	2,422	1,472	396	363	189	2

Table 9-18. Estimated Number of Critical Facilities Damaged, by Damage Level—Palos Verdes Scenario

Category	# of Critical Facilities	Number of Buildings with 50% or Greater Probability of Achieving Damage Level				
		None	Slight	Moderate	Extensive	Complete
Critical Operating Facilities	20	12	7	1	0	0
Critical Response Facilities						
Evacuation Centers / Debris Removal	9	3	4	1	1	0
Fire	73	55	11	2	5	0
Medical	33	33	0	0	0	0
Police	17	15	2	0	0	0
Schools	847	748	49	25	25	0
Critical Infrastructure—Transportation						
Airports	2	2	0	0	0	0
Bridges	841	841	0	0	0	0
Bus Systems	19	17	2	0	0	0
Light Rail	29	24	0	5	0	0
Port / Harbor	20	0	0	20	0	0
Railroads	7	7	0	0	0	0
Critical Infrastructure—Utilities						
Communications	28	8	10	7	3	0
Electric Power	9	5	0	1	2	1
Hazardous Materials	294	220	38	25	11	0
Petroleum & Natural Gas	58	16	2	11	28	1
Potable Water	31	17	6	5	3	0
Waste Water	85	18	12	36	19	0
Overall	2,422	2041	143	139	97	2

Table 9-19. Estimated Number of Critical Facilities Damaged, by Damage Level—Puente Hills Scenario

Category	# of Critical Facilities	Number of Buildings with 50% or Greater Probability of Achieving Damage Level				
		None	Slight	Moderate	Extensive	Complete
Critical Operating Facilities	20	4	3	6	7	0
Critical Response Facilities						
Evacuation Centers / Debris Removal	9	2	3	3	1	0
Fire	73	16	13	13	27	4
Medical	33	15	12	6	0	0
Police	17	2	2	3	9	1
Schools	847	311	88	113	334	1
Critical Infrastructure—Transportation						
Airports	2	1	1	0	0	0
Bridges	841	841	0	0	0	0
Bus Systems	19	3	8	6	2	0
Light Rail	29	5	3	15	6	0
Port / Harbor	20	19	1	0	0	0
Railroads	7	3	2	1	1	0
Critical Infrastructure—Utilities						
Communications	28	1	2	9	4	12
Electric Power	9	1	6	1	0	1
Hazardous Materials	294	79	69	33	113	0
Petroleum & Natural Gas	58	25	24	1	8	0
Potable Water	31	11	7	5	8	0
Waste Water	85	32	40	5	8	0
Overall	2,422	1371	284	220	528	19

Table 9-20. Estimated Number of Critical Facilities Damaged, by Damage Level—San Andreas Scenario

Category	# of Critical Facilities	Number of Buildings with 50% or Greater Probability of Achieving Damage Level				
		None	Slight	Moderate	Extensive	Complete
Critical Operating Facilities	20	6	6	7	1	0
Critical Response Facilities						
Evacuation Centers / Debris Removal	9	4	1	2	2	0
Fire	73	22	14	23	5	9
Medical	33	33	0	0	0	0
Police	17	2	3	8	3	1
Schools	847	363	142	166	153	23
Critical Infrastructure—Transportation						
Airports	2	1	1	0	0	0
Bridges	841	841	0	0	0	0
Bus Systems	19	1	8	8	2	0
Light Rail	29	8	9	12	0	0
Port / Harbor	20	19	1	0	0	0
Railroads	7	0	4	2	1	0
Critical Infrastructure—Utilities						
Communications	28	3	1	2	20	2
Electric Power	9	1	3	1	3	1
Hazardous Materials	294	1	2	86	174	31
Petroleum & Natural Gas	58	37	11	6	3	1
Potable Water	31	14	3	9	3	2
Waste Water	85	57	10	15	3	0
Overall	2,422	1413	219	347	373	70

Table 9-21. Estimated Number of Critical Facilities Damaged, by Damage Level—Santa Monica Scenario

Category	# of Critical Facilities	Number of Buildings with 50% or Greater Probability of Achieving Damage Level				
		None	Slight	Moderate	Extensive	Complete
Critical Operating Facilities	20	4	5	11	0	0
Critical Response Facilities						
Evacuation Centers / Debris Removal	9	3	3	3	0	0
Fire	73	10	22	13	28	0
Medical	33	19	14	0	0	0
Police	17	1	5	6	5	0
Schools	847	257	205	209	176	0
Critical Infrastructure—Transportation						
Airports	2	0	1	1	0	0
Bridges	841	841	0	0	0	0
Bus Systems	19	4	9	6	0	0
Light Rail	29	8	13	8	0	0
Port / Harbor	20	20	0	0	0	0
Railroads	7	3	4	0	0	0
Critical Infrastructure—Utilities						
Communications	28	4	0	15	6	3
Electric Power	9	3	1	3	2	0
Hazardous Materials	294	68	113	69	44	0
Petroleum & Natural Gas	58	32	11	11	4	0
Potable Water	31	11	7	3	9	1
Waste Water	85	21	15	15	28	6
Overall	2,422	1309	428	373	302	10

Table 9-22. Functionality of Critical Facilities—Newport/Inglewood Scenario

Category	Probability of Being Fully Functional (%)					
	at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Critical Operating Facilities	32.9	33.7	66.5	67.4	94.8	95.9
Critical Response Facilities						
Evacuation Centers / Debris Removal	36.0	37.5	66.5	66.6	87.6	96.2
Fire	32.5	32.9	51.8	52.3	80.7	88.4
Medical	71.0	71.5	93.4	94.0	98.0	98.2
Police	28.3	28.8	47.4	47.9	78.3	87.0
Schools	47.0	47.4	62.0	62.4	84.0	90.2
Critical Infrastructure—Transportation						
Airports	79.7	81.8	82.7	83.1	84.1	88.6
Bridges	94.3	96.1	97.3	97.5	97.7	98.6
Bus Systems	76.4	87.8	91.8	92.1	92.8	95.7
Light Rail	80.9	92.1	95.9	96.1	96.4	97.8
Port / Harbor	86.4	92.6	94.8	94.9	95.2	96.4
Railroads	96.2	98.1	98.8	98.8	98.8	99.2
Critical Infrastructure—Utilities						
Communications	50.4	71.7	78.4	87.6	93.2	98.7
Electric Power	44.9	69.6	89.9	96.1	97.8	99.9
Hazardous Materials	32.5	33.5	54.3	54.4	85.3	96.2
Petroleum & Natural Gas	42.7	54.8	64.5	77.8	88.4	98.2
Potable Water	56.2	74.7	83.0	85.6	89.8	97.5
Waste Water	40.7	66.8	81.5	83.4	89.0	98.4
Overall	57.2	65.1	77.8	79.9	90.7	95.6

Table 9-23. Functionality of Critical Facilities—Palos Verdes Scenario

Category	Probability of Being Fully Functional (%)					
	at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Critical Operating Facilities	58.5	59.1	85.6	86.3	97.0	98.1
Critical Response Facilities						
Evacuation Centers / Debris Removal	65.6	66.7	87.7	87.8	97.7	98.7
Fire	61.9	62.3	79.4	79.9	93.2	95.6
Medical	90.9	91.1	98.8	98.9	99.2	99.2
Police	68.4	68.8	87.2	87.7	98.5	98.9
Schools	76.5	76.8	88.0	88.3	95.9	97.3
Critical Infrastructure—Transportation						
Airports	88.4	89.0	89.3	89.5	89.9	92.1
Bridges	98.8	99.3	99.5	99.6	99.6	99.7
Bus Systems	96.2	97.6	98.2	98.2	98.3	98.7
Light Rail	89.2	94.7	96.5	96.7	96.9	98.1
Port / Harbor	45.4	73.1	82.6	83.2	84.7	91.0
Railroads	99.4	99.7	99.8	99.8	99.8	99.8
Critical Infrastructure—Utilities						
Communications	71.5	87.4	90.7	94.9	97.4	99.5
Electric Power	50.8	64.5	79.5	89.4	94.0	99.9
Hazardous Materials	57.5	58.5	78.4	78.4	95.0	98.7
Petroleum & Natural Gas	39.0	46.7	54.4	65.5	77.5	95.7
Potable Water	68.7	82.0	88.1	90.3	93.6	98.3
Waste Water	31.5	55.4	71.9	75.0	84.4	97.8
Overall	69.9	76.2	86.4	88.3	94.0	97.6

Table 9-24. Functionality of Critical Facilities—Puente Hills Scenario

Category	Probability of Being Fully Functional (%)					
	at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Critical Operating Facilities	21.5	21.8	34.5	34.9	67.6	79.4
Critical Response Facilities						
Evacuation Centers / Debris Removal	22.4	23.7	50.5	50.6	83.7	94.2
Fire	22.4	22.7	35.2	35.5	56.6	69.3
Medical	42.2	42.9	74.3	75.1	95.6	96.2
Police	13.4	13.6	22.2	22.4	40.6	57.4
Schools	33.5	33.8	44.9	45.2	64.3	76.5
Critical Infrastructure—Transportation						
Airports	75.8	81.1	83.0	83.3	84.2	88.3
Bridges	86.6	89.3	90.8	91.1	91.5	94.0
Bus Systems	62.8	78.5	84.0	84.6	86.3	93.2
Light Rail	47.1	67.6	74.9	76.0	78.8	90.5
Port / Harbor	98.8	99.4	99.6	99.6	99.6	99.7
Railroads	76.5	84.6	87.5	87.9	89.1	93.9
Critical Infrastructure—Utilities						
Communications	37.9	51.6	59.1	70.4	79.7	96.4
Electric Power	48.8	72.6	89.1	93.8	96.5	99.9
Hazardous Materials	26.7	27.5	42.4	42.5	63.3	84.6
Petroleum & Natural Gas	64.1	75.2	80.3	86.7	91.8	97.8
Potable Water	48.9	64.6	73.6	76.8	81.7	92.6
Waste Water	54.2	75.1	84.8	86.1	90.3	98.6
Overall	49.1	57.0	67.3	69.0	80.1	89.0

Table 9-25. Functionality of Critical Facilities—San Andreas Scenario

Category	Probability of Being Fully Functional (%)					
	at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Critical Operating Facilities	34.4	35.0	59.1	59.8	89.5	93.7
Critical Response Facilities						
Evacuation Centers / Debris Removal	33.0	34.0	53.8	53.8	73.3	93.4
Fire	28.7	29.1	43.8	44.2	71.1	80.7
Medical	80.4	80.9	98.3	98.7	99.8	99.8
Police	16.6	16.9	33.2	33.7	67.8	79.7
Schools	39.5	39.8	54.6	55.0	78.5	86.0
Critical Infrastructure—Transportation						
Airports	88.6	96.8	99.6	99.6	99.6	99.8
Bridges	92.2	94.4	95.5	95.7	95.9	97.4
Bus Systems	62.8	81.0	87.3	87.8	89.2	94.8
Light Rail	75.2	89.6	94.5	94.8	95.4	97.9
Port / Harbor	98.0	99.4	99.9	99.9	99.9	99.9
Railroads	59.7	78.0	84.4	85.1	86.8	93.9
Critical Infrastructure—Utilities						
Communications	40.4	55.8	65.8	80.9	89.9	98.2
Electric Power	36.1	54.0	75.8	89.8	94.4	99.9
Hazardous Materials	1.8	2.0	6.0	6.1	32.7	76.2
Petroleum & Natural Gas	68.2	78.5	83.4	90.0	94.9	99.3
Potable Water	53.3	69.5	78.9	82.9	88.8	96.7
Waste Water	62.0	79.6	89.0	90.6	95.3	99.5
Overall	53.9	61.9	72.4	74.9	85.7	93.7

Table 9-26. Functionality of Critical Facilities—Santa Monica Scenario

Category	Probability of Being Fully Functional (%)					
	at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Critical Operating Facilities	23.7	24.3	50.8	51.5	89.7	93.0
Critical Response Facilities						
Evacuation Centers / Debris Removal	34.2	35.2	55.8	55.9	87.4	96.5
Fire	21.8	22.1	36.2	36.6	63.6	76.4
Medical	52.7	53.6	88.2	89.1	96.6	96.8
Police	16.3	16.7	33.0	33.4	67.6	79.7
Schools	33.6	34.0	49.6	50.0	76.4	85.2
Critical Infrastructure—Transportation						
Airports	54.6	69.8	75.1	75.6	76.7	82.1
Bridges	92.2	93.9	94.7	94.8	95.0	96.3
Bus Systems	70.6	84.9	89.9	90.2	91.1	94.8
Light Rail	75.7	89.8	94.6	94.8	95.4	97.7
Port / Harbor	99.9	99.9	99.9	99.9	99.9	99.9
Railroads	84.0	94.2	97.6	97.6	97.8	98.4
Critical Infrastructure—Utilities						
Communications	43.8	61.8	70.2	82.6	90.2	98.2
Electric Power	48.2	67.5	87.3	96.2	98.0	99.9
Hazardous Materials	31.8	32.8	51.7	51.8	82.9	96.0
Petroleum & Natural Gas	70.8	79.2	84.0	90.2	95.2	99.3
Potable Water	51.7	68.3	76.7	80.9	87.9	96.6
Waste Water	37.1	53.8	66.4	70.1	81.9	97.7
Overall	52.4	60.1	72.3	74.5	87.4	93.6

9.6 FUTURE TRENDS IN DEVELOPMENT

The City of Los Angeles will strictly enforce all seismic building codes and design standards to prevent loss of life and property from earthquakes. Public education, cooperation with the development community, and individual preparedness are essential.

The City has a General Plan with policies directing land use and dealing with issues of geologic and seismic safety. This plan provides the capability to protect future development from the impacts of earthquakes. Deficiencies identified by development reviews can be identified as mitigation actions to increase the capability to deal with future trends in development.

Since all of the planning area is located within earthquake hazard zones, all future development will, to some extent, be exposed to the earthquake hazard.

9.7 SCENARIO

With the abundance of fault exposure in southern California, the potential scenarios for earthquake activity are many. An earthquake does not have to occur within the planning area to have a significant impact on the people, property and economy of the planning area.

Any seismic activity of 6.0 or greater on faults within the planning area would have significant impacts throughout the planning area. Potential warning systems could give approximately 40 seconds notice that a major

earthquake is about to occur. This would not provide adequate time for preparation. Earthquakes of this magnitude or higher would lead to massive structural failure of property on NEHRP C, D, E, and F soils. Levees and revetments built on these poor soils would likely fail, representing a loss of critical infrastructure. These events could cause secondary impacts, including landslides and mudslides that would further damage structures. River valley hydraulic-fill sediment areas are also vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction would occur in water-saturated sands, silts or gravelly soils.

9.8 ISSUES

Important issues associated with an earthquake include the following:

- More than 74 percent of the planning area's building stock was built prior to 1975, when seismic provisions became uniformly applied through building code applications.
- Based on the modeling of critical facility performance performed for this plan, a high number of facilities in the planning area are expected to have complete or extensive damage from scenario events. These facilities are prime targets for structural retrofits.
- Critical facility owner should be encouraged to create or enhance continuity of operations plans using the information on risk and vulnerability contained in this plan.
- Geotechnical standards should be established that take into account the probable impacts from earthquakes in the design and construction of new or enhanced facilities.
- There are a large number of earthen dams within the planning area. Dam failure warning and evacuation plans and procedures should be reviewed and updated to reflect the dams' risk potential associated with earthquake activity in the region.
- Earthquakes could trigger other natural hazard events such as dam failures and landslides, which could severely impact the planning area.
- A worst-case scenario would be the occurrence of a large seismic event during a flood or high-water event. Levee failures would happen at multiple locations, increasing the impacts of the individual events.