3.7 Geologic, Seismic, and Soil Hazards

This section describes the existing regulatory setting, the geologic, seismic, and soil hazards in the PWIMP Planning Area(s), and evaluates how construction and operation of the components of the PWIMP would result in potential adverse impacts related to existing soil conditions or seismicity. Background information specific to the PWIMP Planning Area's soil conditions is addressed in Section 3.2 - Agricultural and Soil Resources. Mineral resource issues are discussed in 3.11 - Mineral Resources.

3.7.1 Introduction

This evaluation of geologic and seismic hazard conditions was based on information from the City of Oxnard's 2030 General Plan and was completed using information collected from the United States Geological Survey and the California Department of Conservation – Division of Mines and Geology (CDMG).

Key Terms and concepts include the following:

- **Alquist-Priolo Fault Zone.** The Alquist-Priolo Earthquake Fault Zoning Act, passed in 1972, requires the State Geologist to identify zones of special study around active faults.
- **Fault.** A fault is a fracture in the Earth's crust that is accompanied by displacement between the two sides of the fault. An active fault is defined as a fault that has moved in the last 10,000 to 12,000 years (Holocene time). A potentially active fault is one that has been active in the past 1.6 million years (Quaternary period). A sufficiently active fault is one that shows evidence that Holocene displacement occurred on one or more of its segments or branches (Hart, 1997).
- **Landslide.** Downslope movement of soil and/or rock, which typically occurs during an earthquake or following heavy rainfall.
- **Liquefaction.** Liquefaction in soils and sediments occurs during some earthquake events, when material is transformed from a solid state into a liquid state because of increases in pressure in the pores (the spaces between soil particles). Earthquake-induced liquefaction most often occurs in low-lying areas with soils or sediments composed of unconsolidated, saturated, clay-free sands and silts, but it can also occur in dry, granular soils or saturated soils with some clay content.
- **Magnitude.** Earthquake magnitude is measured by the Richter scale, indicated as a series of Arabic numbers with no theoretical maximum magnitude. The greater the energy released from the fault rupture, the higher the magnitude of the earthquake. Magnitude increases logarithmically in the Richter scale; thus, an earthquake of magnitude 7.0 is thirty times stronger than one of magnitude 6.0. Earthquake energy is most intense at the point of fault slippage, which is called the epicenter because the energy radiates from that point in a circular wave pattern; the farther an area is from an earthquake's epicenter, the less likely that area is to be affected by groundshaking.

3.7.2 Regulatory Context

Relevant federal, state, and local guidelines specific to geologic and seismic hazards are discussed in this section.

3.7.2.1 Federal Regulations

There are no current federal regulations relevant to geologic and seismicity issues in the state.

3.7.2.2 State Regulations

The relevant state regulations are discussed below.

Alquist-Priolo Earthquake Fault Zoning Act. The Alquist-Priolo Earthquake Fault Zoning Act (formerly the Alquist-Priolo Special Studies Zone Act), signed into law December 1972, requires the delineation of zones along active faults in California. The purpose of the Alquist-Priolo Act is to regulate development on or near active fault traces to reduce the hazards associated with fault rupture and to prohibit the location of most structures for human occupancy across these traces. Cities and counties must regulate certain development projects within these zones, which include withholding development permits until geologic investigations demonstrate that development sites are not threatened by future surface displacement (Hart, 1997). Surface fault rupture is not necessarily restricted to the area within an Alquist-Priolo Zone.

Seismic Hazards Mapping Act. The Seismic Hazards Mapping Act was developed to protect the public from the effects of strong groundshaking, liquefaction, landslides, or other ground failure, and from other hazards caused by earthquakes. This act requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site has to be conducted and appropriate mitigation measures incorporated into the project design.

California Building Code. The California Building Code is another name for the body of regulations known as the California Code of Regulations (C.C.R.), Title 24, Part 2, which is a portion of the California Building Standards Code. Title 24 is assigned to the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. Under State law, all building standards must be centralized in Title 24 or they are not enforceable (Bolt, 1988). Published by the International Conference of Building Officials, the Uniform Building Code is a widely adopted model building code in the United States. The California Building Code incorporates by reference the Uniform Building Code with necessary California amendments. About one-third of the text within the California Building Code has been tailored for California earthquake conditions.

California Department of Transportation – Highway Design Manual. The California Department of Transportation (Caltrans) has developed roadway design standards including those for seismic safety. Consideration of earthquake hazards in roadway design is detailed in the Highway Design Manual published by Caltrans (1995). Modifications to local highways and roads would be required to adhere to Caltrans engineering standards.

3.7.2.3 Local Regulations

The relevant local regulations are discussed below.

City of Oxnard - Oxnard 2030 General Plan. The Safety Element of the City's existing General Plan contains an objective and several policies pertinent to geologic and seismic hazard conditions.

3.7.3 Environmental Setting

The PWIMP Study Area is situated on the Oxnard Plain, which is located near the western edge of the Transverse Range Province. The Coastal Mountains and the Sierra Nevada Range are located to the north and the peninsular ranges to the south. Local geologic conditions of the Study Area consist of coastal lowland areas that range in elevation from sea level to about 115-feet above sea level. These areas are comprised of alluvial deposits of silt, sands and gravel, which extend to a depth of approximately 500- feet beneath the Study Area. The history of alluviation is related to the Santa Clara River and its flood patterns. Beneath the alluvium lies the San Pedro formation (approximately 4,000- feet thick beneath the City), which consists of moderately indurated sandstones and conglomerates.

Seismic Activity. The potential earthquake-induced hazards that may affect the City of Oxnard consist of fault rupture and strong ground motions, and the secondary effects of ground motion, such as liquefaction and tsunamis. Each of these is discussed below.

Seismicity and Regional Faults. The Study Area is located within Seismic Risk Zone 4. Earthquakes occurring in Seismic Risk Zone 4 have the potential to create the greatest impacts compared to the other risk zones. Areas within Seismic Zone 4, have a one in ten chance that an earthquake with an active peak acceleration level of 0.04g (4/10 the acceleration of gravity) will occur within the next 50 years.

The CDMG has determined the probability of earthquake occurrences and their associated peak ground accelerations throughout the State of California. According to the CDMG's probabilistic seismic hazard map for California, peak ground accelerations in the Study Area could range from 0.50 g to 0.80 g (California Geological Survey, 1998).

The City will probably experience ground shaking from earthquake activity that is most likely associated with the historically active faults in the surrounding area (see Figure 3.7-1). The resultant ground shaking could be severe with an earthquake of maximum credible or probable magnitude in one of the nearby faults. The estimated maximum (moment) magnitudes (Mw) represent characteristic earthquakes on particular faults. The maximum credible earthquake for a particular fault is the largest magnitude event that appears capable of occurring under the presently known tectonic framework. The maximum probable earthquake is the maximum earthquake likely to occur during a 100-year interval. It is regarded as a probable occurrence, not as an assured event that will occur at a specific time. Table 3.7-1 provides a listing of faults in the proximity of the Study Area and the maximum magnitude of some of these nearby faults that may cause future ground shaking activity. As shown in Figure 3.7-1, several active and/or potentially active faults are located in the vicinity of the Study Area. The most regionally active faults are the Oak Ridge, Pitas Point-Ventura, Red Mountain, Acacapa, and Malibu Coast faults, all within 5- to 10-miles of the PWIMP Study Area. Although the

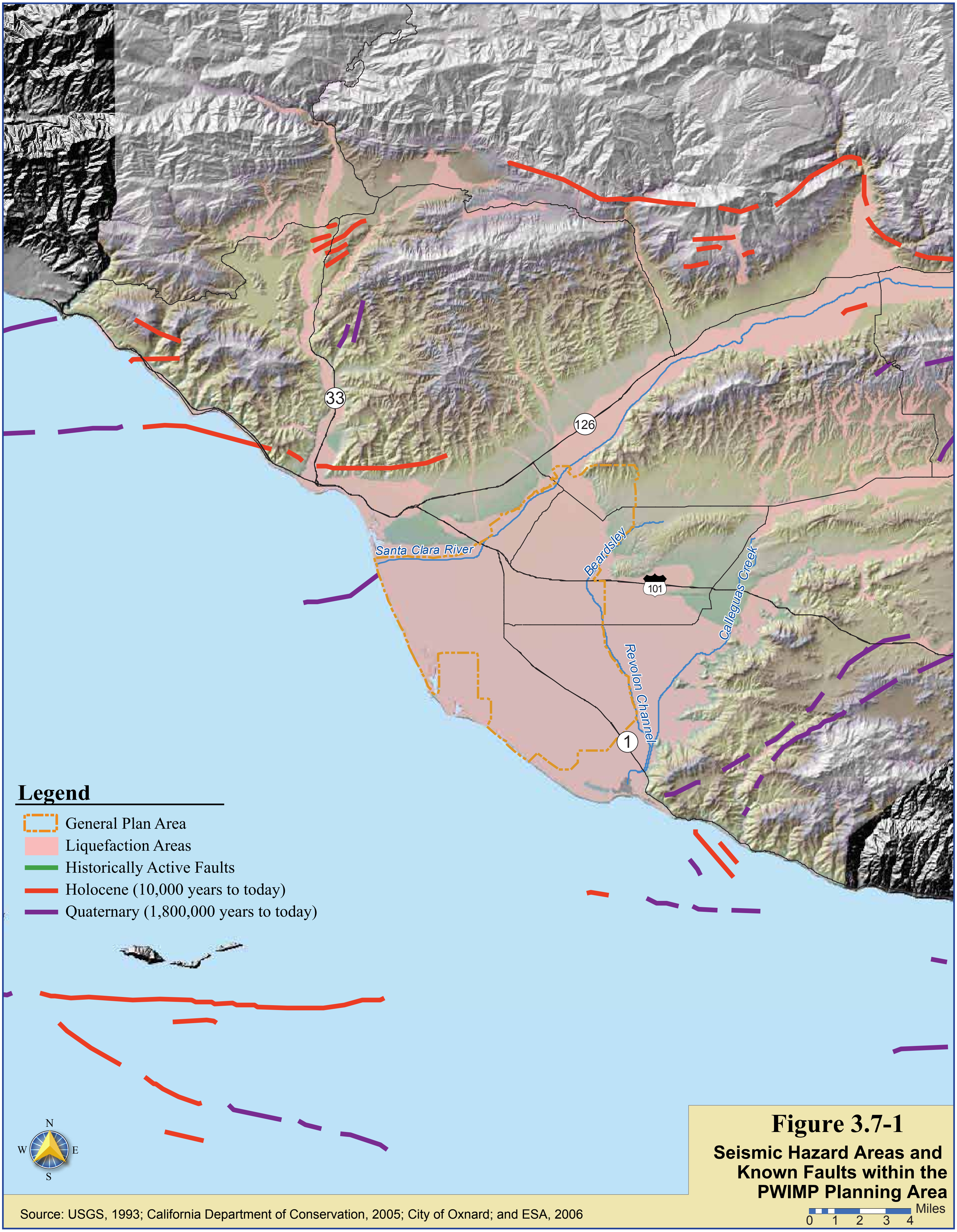

Figure 3.7-1

Seismic Hazard Areas and Known Faults within the PWIMP Planning Area

Source: USGS, 1993; California Department of Conservation, 2005; City of Oxnard; and ESA, 2006

Study Area is not located within an Alquist-Priolo zone or no large-magnitude earthquakes greater than 6.0 have occurred historically along other major regional faults, the Study Area is situated within a seismically active region and is susceptible to several types of earthquake-related risks, including surface rupture, ground shaking, liquefaction and tsunamis.

Table 3.7-1
Fault Systems in the Vicinity of the Oxnard Planning Area

Fault Zone	Location Relative to Oxnard	Historical Seismicity and Recency of Faulting	Slip Rate (mm/Year)	Maximum Credible Magnitude	Maximum Probable Magnitude
Oak Ridge	1 mile northwest	Holocene, in part; mainly Late Quaternary	3.5 to 6.0	7.5	6.7
Springville	1.5 miles northeast	N/A	N/A	N/A	N/A
Camarillo	3.5 miles northeast	N/A	N/A	N/A	N/A
Pitas Point-Ventura	6 miles northwest	Holocene, probably within the last 1500 years	0.5 to 1.5	6.1	6.6
Simi	7 miles northwest	Holocene	N/A	6.6	6.6
Red Mountain	10 miles northwest	Holocene to Late Quaternary	0.4 to 1.5	N/A	6.6
Anacapa	12 miles south	N/A	N/A	N/A	6.7
Orcutt Canyon	14 miles north	N/A	N/A	N/A	N/A
Javon	14 miles northwest	N/A	1.1	N/A	N/A
Carpenteria	14 miles northwest	N/A	N/A	N/A	N/A
Lion Canyon	14 miles north	Late Quaternary	N/A	N/A	N/A
Oakview	14 miles north	Late Quaternary	N/A	N/A	N/A
San Cayetano	15 miles north	Less than 5,000 years ago	1.3 to 9.0	6.75	6.7
Malibu Coast	15 miles southeast	Holocene, in part; otherwise Late Quaternary	0.3	7.5	6.6
Mission Ridge Arroyo Parida	16 miles northwest	30,000 years ago	about 0.37	N/A	6.6
Stepard Mesa-Rincon Creek	18 miles northwest	Late Quaternary	about 0.3	N/A	N/A
Santa Ynez	20 miles north	Late Quaternary; except for a short	0.1 to 0.7	7.5	6.7

Table 3.7-1 Fault Systems in the Vicinity of the Oxnard Planning Area					
Fault Zone	**Location Relative to Oxnard**	**Historical Seismicity and Recency of Faulting**	**Slip Rate (mm/Year)**	**Maximum Credible Magnitude**	**Maximum Probable Magnitude**
		segment near the intersection with the Baseline fault, which is Holocene in age			
Santa Susana	24 miles northeast	Late Quaternary Short segment ruptured during the 1971 San Fernando earthquake	5.0 to 7.0	6.6	6.6
Santa Cruz Island	24 miles southwest	Holocene, offshore; Late Quaternary on Santa Cruz Island	0.9	N/A	6.7
San Pedro Basin	24 miles southeast	N/A	N/A	N/A	6.6
Holser	25 miles northeast	Late Quaternary	0.4	N/A	6.0
Palos Verdes Hills	29 miles southeast	Holocene, offshore; Late Quaternary on shore.	0.1 to 3.0	7	6.6
Northridge	32 miles northeast	Late Quaternary; 1994 Northridge Earthquake.	N/A	6.5	6.2
San Jose	33 miles northwest	Late Quaternary Last significant quake: 2/28/90; No surface rupture found.	0.2 to 2.0	N/A	6.4
San Gabriel	34 miles northeast	Late Quaternary west of intersection with the Sierra Madre fault zone; Quaternary east of that intersection; Holocene only between Saugus and Castaic.	1.0 to 5.0	N/A	6.7
More Ranch	34 miles northwest	N/A	N/A	7.25	6.6
Santa Monica	35 miles southeast	Late Quaternary	0.27 to 0.39	7.5	6.6

Table 3.7-1
Fault Systems in the Vicinity of the Oxnard Planning Area

Fault Zone	Location Relative to Oxnard	Historical Seismicity and Recency of Faulting	Slip Rate (mm/Year)	Maximum Credible Magnitude	Maximum Probable Magnitude
San Fernando	38 miles northeast	Last occurrence: February 9, 1971	5	6.5	6.4
San Andreas	42 miles northeast	January 9, 1857 (Mojave Segment); April 18, 1906 (Northern Segment)	20 to 35	8.25	8.1

Source: *Hart, Fault Rupture Hazard Zones in California, 1997*

Other Geologic Hazards in the Study Area. Detailed below are other geologic hazards in the PWIMP Study Area.

- **Surface Fault Rupture.** A surface rupture is a break in the ground's surface and the associated deformation resulting from the movement of a fault. Fault activity is classified as active or potentially active. An active fault is one that has had surface displacement within the last 10,000 to 12,000 years (Holocene time) and a potentially active fault is one that has experienced surface displacement during the last 1.6 million years (Quaternary period).

  Fault systems in the immediate vicinity of the Study Area are identified in Figure 3.7-1. Information specific to these local faults along with other regional faults not identified in the figure is provided in Table 3.7-1. As shown in Figure 3.7-1, no known active faults are present within the City's Study Area. However, active and/or potentially active faults are present in the surrounding region, and some of these may extend into the subsurface beneath the Study Area.
- **Liquefaction.** Liquefaction is an unstable ground condition in which water-saturated soils change from a solid to semi-liquid state because of a sudden shock or strain. Liquefaction may occur in water-saturated sediment during moderate to great earthquakes. As shown in Figure 3.7-1, the potential for liquefaction occurs throughout most of the Study Area. Liquefaction conditions occur within the Study Area for several reasons, including underlying sections of thick alluvial deposits, high groundwater levels (0 feet near the coastline to approximately 40 feet at the northeastern corner of the City), and the potential for strong regional ground shaking. The combination of these factors constitutes a significant seismic hazard in the southern California region, including the Study Area.
- **Subsidence and Uplift.** Subsidence may be defined as the downward movement of a relatively large amount of land caused by the withdrawal of subsurface water and/or petroleum. Conversely, uplift is the upward movement of a relatively large amount of land caused by the injection of water or petroleum and/or by tectonic forces.

  Portions of the City are subject to subsidence. Historic records show that the amount of much of this subsidence is at least one foot. In the area near Hueneme Road and

Rice Avenue, which is adjacent to the southeast corner of the Study Area, the amount of subsidence has been up to 12- feet.

- **Landslides (Slope Failure).** Landslides (or slope failure) refer to the dislodging and falling of a mass of soil or rocks along a sloped surface. Although the potential for small-scale slope failure may exist locally, particularly along stream banks, margins of drainage channels, and similar settings where steep banks or slopes occur, the relatively flat terrain of the Study Area minimizes this potential geologic hazard.
- **Tsunamis.** A tsunami is an ocean wave produced by offshore seismic activity. As a coastal city, there is always the potential for tsunami damage; development along the coast-line has increased the risk. While most coasts along the Pacific Basin have a long history of tsunami damage, such damage to California has been relatively slight in recent historical times. The most recent tsunami to cause appreciable damage to California occurred with the great Alaskan earthquake on March 27, 1964.

3.7.4 Impact Analyses

This section includes a discussion of the relevant significance criteria, the approach and methodology to the analyses, and any identified impacts and mitigation measures.

3.7.4.1 Significance Criteria

Significance thresholds below are based on Appendix G (Environmental Checklist Form) of the *CEQA Guidelines* and modified from the City's *May 2017 CEQA Guidelines*, which indicates that a potentially significant impact on cultural and tribal resources would occur if the PWIMP would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist or based on other substantial evidence of a known fault;
  - Strong seismic groundshaking that cannot be addressed through compliance with standard Code requirements.
- Be located on a geologic unit or soil that is unstable or that could become unstable as a result of the project and potentially result in an on-site or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse that cannot be addressed through compliance with standard Code requirements;
- Be located on expansive soil, creating substantial risks to life or property that cannot be addressed through compliance with standard Code requirements;
- Expose people or structures to inundation by seiche or tsunami;
- Rely on dredging or other maintenance activity by another agency that is not guaranteed to continue.

3.7.4.2 Approach and Methodology

As described in Chapter 2, Project Description, the City's PWIMP is comprised of improvements to the City's Water Supply System, Recycled Water System, Wastewater System, and Stormwater System through build-out of the City's 2030 General Plan. However, the design details, final options, and the timing of construction phases are not precisely known, despite the best estimates provided in the schedules in Chapter 2. Further, it is not practical or prudent to try to provide project-level or detailed quantitative analysis at this time as many of the details are not known and the timing will likely change and/or the requirements for project-level analysis could change and be different in the future. As such, the environmental impact analysis for this section has been prepared at a programmatic level of detail and it addresses the full range of potential environmental effects associated with implementation of the PWIMP, but the analysis is more qualitative and general. Specifically, the analysis focuses on providing a discussion on potential significant impacts and provides broad mitigation measures that can and should be implemented at the project-level. This approach is consistent with the State CEQA Guidelines provisions for a Program EIR, as described in Section 15168, which suggests that the level of detail is dictated by "ripeness"; detailed analysis should be reserved for issues that are ripe for consideration.

Due to the nature of the PWIMP and individual project facilities and actions, geologic, seismic, and soil discussions will vary negligibly between project components as well as between construction and operations. The potential for an earthquake would be the same for all PWIMP project elements and would consist of fault rupture and strong ground motions, and the secondary effects of ground motion, including, liquefaction, and tsunamis. In most cases, the impact of geologic, seismic, and soil hazards would be reduced to acceptable levels by implementing appropriate design and construction techniques based on site-specific geotechnical investigations; and further mitigation would not be required. As a result, this impact assessment addresses all geologic, seismic, and soils hazards under one impact statement and includes both construction and operations.

3.7.4.3 Impacts and Mitigation Measures

Based on the significance criteria and approach and methodology described above, the potential impacts to agricultural resources are discussed below.

Impact 3.7-1: Implementation of the PWIMP and/or identified components/facilities could expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving earthquakes, landslides, liquefaction, and/or subsidence. The potential impacts due to temporary construction and long-term operations are discussed below.

Temporary Construction and Long-Term Operational Impacts

As described above in the Environmental Setting, the potential exists for a large magnitude earthquake to result in high intensity ground shaking, landslides, liquefaction, and subsidence. The intensity of such an event would depend on the causative fault and the distance to the epicenter, the moment magnitude, and the duration of shaking. Intense ground shaking and high ground accelerations would affect the entire area around the proposed facilities and associated pipelines. The primary and secondary effects of ground shaking could damage structural foundations, distort pipelines and other water conveyance structures, and cause failure of concrete. Damage to these features would cause temporary service disruption and possibly loss of water due to leakage and pipe rupture. Pumps could be rendered inoperable. In comparison to above-ground structures, underground pipelines and buried structures are generally less susceptible to damage from strong ground shaking because they are imbedded in compacted backfill that can tolerate more seismic wave motion. Broken pipelines could result in soil washout and sinkholes.

Locating and repairing damaged pipelines and the pumps could require a temporary cessation of operation of the facilities for a significant period of time. The 1989 Loma Prieta earthquake reportedly caused more than 60 water pipeline breaks in Santa Cruz, the nearest urbanized area to the epicenter (CDMG, 1990). However, modern standard engineering and construction practices include design criteria to mitigate potential damage from an earthquake, and any potential interruption of service would likely be temporary in nature. While these practices would not completely eliminate the potential for damage to the facilities, they would ensure that the resultant improvements will have the structural fortitude to withstand anticipated groundshaking without significant damage. With implementation of **Mitigation Measure 3.7-1a**, this impact would be reduced to a less-than-significant level.

Temporary Construction and Long-Term Operational Mitigation Measure

Mitigation Measure 3.7-1a: Conduct Appropriate Geotechnical Engineering Studies. A California licensed geotechnical engineer or engineering geologist will conduct geotechnical investigations of all PWIMP facilities prior to the final design and prepare recommendations applicable to foundation design, earthwork, backfill and site preparation prior to or during the project design phase. The investigations will specify seismic and geologic hazards including potential ground movements and co-seismic effects (including liquefaction). The recommendations of the geotechnical engineer will be incorporated into the design and specifications in accordance with California Geological Survey Special Publication 117 and shall be implemented by the construction contractor. The construction manager will conduct inspections and certify that all design criteria have been met in accordance with the California Building Code as well as applicable City and County ordinances.

All PWIMP elements and pipeline facilities will comply with applicable policies and appropriate engineering investigation practices necessary to reduce the potential detrimental effects of expansive soils, and corrosivity. Appropriate geotechnical studies will be conducted by California licensed geotechnical engineers or engineering geologists using generally accepted and appropriate engineering techniques for determining the susceptibility of the sites to unstable, weak or corrosive soils in accordance with the most recent version of the California Building Code. A licensed geotechnical engineer or engineering geologist will prepare recommendations applicable to foundation design, earthwork, and site preparation prior to or during the project design phase. Recommendations will address mitigation of site-specific, adverse soil and bedrock conditions that could hinder development. Project engineers will implement the recommendations and incorporate them into project specifications. Geotechnical design and design criteria will comply with the most recent version of the California Building Code and applicable local construction and grading ordinances. Once appropriately designed and subsequently constructed, in accordance with local and state building code requirements, the resultant improvements will have the structural fortitude to withstand the potential hazards of expansive soils or corrosivity without significant damage.

During the design phase for all PWIMP components that require ground-breaking activities, the project applicant will perform site-specific design- level geotechnical evaluations which will include slope stability conditions and provide recommendations to reduce and eliminate any potential slope hazards, if any, in the final design and if necessary, throughout construction. For all pipelines located in landslide hazard areas, appropriate piping material with the ability to deform without rupture (e.g. ductile steel) will be used. For all other facilities, a geotechnical evaluation will be conducted and the geotechnical evaluations will include detailed slope stability evaluations, which could include a review of aerial photographs, field reconnaissance, soil testing, and slope stability modeling. Facilities design and construction will incorporate the slope stability recommendations contained in the geotechnical analysis conducted by California licensed geotechnical engineers or engineering geologists. Final slope stabilization measures, determined by the licensed geotechnical engineer or engineering geologist in accordance with California Building Code requirements, may include, without limitation, one or more of the following:

- Appropriate slope inclination (not steeper than 2 horizontal to 1 vertical)
- Slope terracing
- Fill compaction
- Soil reinforcement
- Surface and subsurface drainage facilities
- Engineered retaining walls
- Buttresses
- Erosion control measures

Mitigation measures included in the geotechnical report will be incorporated into the project construction specifications and become part of the project.

Significance After Mitigation: Less-than-Significant Impact

3.7.5 Cumulative Effects

Due to the nature of the PWIMP and individual project facilities and actions, geologic, seismic, and soil discussions will vary negligibly between project components as well as between construction and operations. The potential for an earthquake would be the same for all PWIMP project elements and would consist of fault rupture and strong ground motions, and the secondary effects of ground motion, including, liquefaction, and tsunamis. In most cases, the impact of geologic, seismic, and soil hazards would be reduced to acceptable levels by implementing appropriate design and construction techniques based on site-specific geotechnical investigations; and further mitigation would not be required. The PWIMP would not have any cumulative impacts to geology, seismicity, and soils hazards and no further mitigation is required.