4.22 Earth/Geology (CEQA)

4.22.1 Introduction

The earth/geology analysis addresses the potential for the Master Plan alternatives to increase the consequences of adverse geologic conditions and hazards including earthquake-induced ground shaking, earthquake fault surface rupture, earthquake-induced liquefaction and settlement, non-seismic settlement, expansive soils, slope stability, oil field gases, and construction. Information pertaining to other hazards, including tsunami, oil field subsidence, and subsidence due to groundwater withdrawal, is provided in Technical Report 12, *Earth/Geology Technical Report*. Technical Report 12, *Earth/Geology Technical Report,* also includes additional information on the affected environment relative to earth/geology and details about the methodologies used to assess baseline conditions and project impacts. Conclusions regarding the significance of impacts provided in this section are strictly for the purposes of CEQA.

Potential impacts of stormwater drainage are discussed in Section 4.7, *Hydrology and Water Quality*; of contaminated earth and groundwater in Section 4.23, *Hazardous Materials*; and of oil and mineral resources in Section 4.17.2, *Natural Resources*.

4.22.2 General Approach and Methodology

This analysis characterizes baseline earth/geologic conditions, processes, hazards, and landforms within the study area and compares them with those for the No Action/No Project Alternative and the four build alternatives. The study area comprises the Master Plan boundaries, as defined in the introduction to this chapter.

Reports prepared by the California Department of Conservation, Division of Mines and Geology (CDMG), the United States Geological Survey (USGS), and others, dated 1954 through 1999, were reviewed to obtain current information regarding geology and faults and earthquake (seismic) hazards in the LAX and Los Angeles region. The *City of Los Angeles General Plan, Safety Element*, was also reviewed. The *Safety Element* identifies critical facilities and lifeline systems that may be vulnerable to damage from a variety of hazards and to which special hazard resistant design features may apply.[758] Additional details on geologic conditions, hazards, analysis methods, and assumptions used in the analysis are included in Technical Report 12, *Earth/Geology Technical Report*. Technical Report 12, *Earth/Geology Technical Report* also includes the comprehensive list of sources -- published references and unpublished reports of consultants' investigations -- that were consulted for this analysis but not cited in this section. The dates of the unpublished consultants' reports range from 1948 to 1992.

Existing geologic and topographic surface conditions at LAX were observed in the field and by reviewing aerial photographs (see Technical Report 12, *Earth/Geology Technical Report,* for a description of aerial photographs). Using this information, potential geologic hazards were identified by generally following the CDMG guidelines for environmental impact reports,[759] supplemented by industry standards. Potential geologic hazards identified in the study area include seismic hazards, slope failure, expansive soils, settlement, erosion, oil field gases, and subsidence. Geologic conditions that could be potentially affected include landforms or unique geological features.

The potential level of seismic ground shaking expected at LAX caused by earthquakes on nearby faults was quantitatively estimated using currently accepted seismic information and theoretical mathematical relationships. Where sufficient data was available, seismic ground shaking estimates were, in turn, used to make limited quantitative assessments of the potential for other related seismic hazards (liquefaction and seismic settlement) at selected locations. Seismic hazard impacts were also evaluated by referring to published reports by the CDMG and the USGS. Additional information on the seismic hazard evaluations is presented in Technical Report 12, *Earth/Geology Technical Report.*

The significance of topography (landform) alterations was evaluated by screening the project for components that could potentially affect existing prominent geologic or topographic features. Estimates

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758 City of Los Angeles, Los Angeles General Plan, Safety Element, 1996.

759 State of California, Division of Mines and Geology, DMG Note 46: Guidelines for Geologic/Seismic Considerations in Environmental Impact Reports, 1996.

of earthwork quantities[760] were evaluated and used to assess the significance of potential erosion and sedimentation, and landform and topography impacts of the LAX Master Plan build alternatives.

Other potential earth/geology related hazards were evaluated using the data sources described above and making a qualitative determination as to whether they posed a general concern in the LAX area. These hazards included tsunami and construction considerations such as earthwork and tunneling. A detailed summary of the potential geologic hazards associated with the project components of the No Action/No Project Alternative and the four build alternatives is provided in **Table F4.22-1**, Matrix of Potential Earth/Geologic Considerations for Major Master Plan Facilities.

To assess whether a given geologic hazard would result in a significant impact, the major components of the four build alternatives were reviewed and compared with the potential geologic hazards identified. For example, the significance of seismically-induced ground shaking was evaluated by identifying the project components with the potential to be affected by ground shaking and quantitatively estimating the potential magnitude of ground shaking. Based on this review, the potential for individual project components to cause new geologic hazards or accelerate existing ones was evaluated.

4.22.3 Affected Environment/Environmental Baseline

Topography and Physiography

LAX is located on the northwestern margin of the Los Angeles Basin Physiographic Province.[761] The majority of LAX lies within the areas known as the Torrance Plain and the El Segundo Sand Hills as shown in **Figure F4.22-1**, Physiographic Map. The El Segundo Sand Hills consist of a three to six mile wide belt of recent and older wind blown sand dunes stretching along the Pacific coast from the Ballona Escarpment south to the Palos Verdes Hills. The El Segundo Sand Hills overlap onto the relatively flat Torrance Plain to the east.[762] The Torrance Plain and the El Segundo Sand Hills continue south from the LAX area. The Pacific Ocean lies to the west of LAX. To the north of LAX lies Ballona Creek and the Ballona Escarpment; to the northeast and east lie the Baldwin Hills and Rosecrans Hills.

LAX lies on a relatively level area at an elevation of about 100 feet above sea level. Most of the original sand dune area to the east of Pershing Drive was graded relatively flat during initial development phases of LAX during the 1940s and 1950s. Much of the west end of LAX (from Pershing Drive west to the ocean) was previously developed with homes that were subsequently removed due to noise impacts from LAX. This area still retains some of the original sand dune landform character, with sand ridges ranging from 85 to 185 feet above sea level and closed depressions of varying height creating local relief of up to 80 feet. The LAX Northside/Westchester Southside area consists of flat to rolling terrain, with small hills and depressions with less than 20 feet of relief.

Two sites close to LAX are being considered for the construction of an off-site fuel farm under Alternative B: Scattergood Generating Station and an oil refinery located south of the airport. The Scattergood Generating Station lies in the western portion of the El Segundo Sand Hills on recent sand dunes. The oil refinery lies adjacent to, and east of, the Scattergood Generating Station and within the El Segundo Sand Hills on recent and older sand dunes. These areas also retain some of the original sand dune character, with sand ridges ranging from 85 to 185 feet above sea level; however, much of the area has been graded or altered by development.

Geology

The geology of the Los Angeles Basin can be characterized as a broad depression in the underlying "basement" rock,[763] which is overlain by a thick sequence of sediments. The geology of the area is further defined by tectonic and structural conditions, those forces and conditions that cause the earth's crust to move and produce the complex system of faults and folds transecting the basin.

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[760] Bechtel Corporation, LAX Master Plan Compilation of DEIS Input Data, Alternative C Construction Impacts, April 28, 2000. MARRS Services, Inc., LAX Master Plan Alternative D Compilation of Draft Environmental Impact Statement (DEIS) Construction Impacts Input Data, Excluding Crossfield Taxiway Projects, May 21, 2003.

[761] California Department of Water Resources, Planned Utilization of the Groundwater Basins of the Coastal Plain of Los Angeles County, Appendix A, Ground Water Geology, (CDWR Bulletin 104), 1961.

[762] California Department of Water Resources, Planned Utilization of the Groundwater Basins of the Coastal Plain of Los Angeles County, Appendix A, Ground Water Geology, (CDWR Bulletin 104), 1961.

[763] A series of rocks, generally with complex structure beneath the predominantly sedimentary rocks.

Table F4.22-1

Matrix of Potential Earth/Geologic Considerations for Major Master Plan Facilities

Master Plan Alternatives and Related Major Facilities	Slope Stability	Oil Field Subsidence	Oil Field Gas	Groundwater/ Dewatering	Settlement	Expansion	Fault Surface Rupture	Ground Shaking	Lique-faction	Seismic Stability	Seismic Slope Settlement	Tsunami, Seiche, Flooding	Tunneling	Grading	Existing Foundations
No Action/No Project Alternative															
New Taxiways (North, South Airfields)	-	-	-	-	X	X	-	-	X	-	X	-	-	X	-
2 Remote Boarding Lounges - Westside	-	-	-	-	X	-	-	X	X	-	X	-	-	X	-
Cargo Facility Improvements	-	-	-	-	X	X	X	X	X	-	-	-	-	X	X
I-405/Arbor Street Interchange	X	-	-	-	X	-	X	X	X	X	-	-	-	X	-
Century Cargo Roadway System	-	-	-	-	X	X	X	-	X	-	X	-	-	X	-
LAX Northside	-	-	-	-	X	-	-	X	X	-	X	-	-	X	X
Continental City	X	-	-	X	X	X	X	X	-	-	-	-	-	X	-
Alternative A - Added Runway North Facilities															
New Runway 24L Extension/Taxiways	-	-	-	-	X	X	X	-	X	-	X	-	-	X	-
New Taxiways over Aviation	-	-	-	-	X	X	X	-	-	-	-	-	-	X	-
New West Terminal, Satellite Concourses & Parking Structure	X	-	X	X	X	-	-	X	X	-	X	-	X	X	X
Redevelop Century Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New East Imperial Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New Admin/Maintenance Facilities	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New Flight Kitchen	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
Ring Road and Regional Roads															
West Terminal Access – Pershing	X	-	-	-	X	-	-	X	X	X	X	-	-	X	-
Westchester Parkway – Realignment/Grade Separations	X	-	-	-	X	X	X	X	X	X	X	-	-	X	-
Aviation Blvd. – Depressed Between Century & Imperial	X	-	-	X	X	X	X	-	-	X	-	-	-	X	-
I-105/Imperial – Extend South to Pershing	X	-	-	-	X	-	-	X	X	X	X	-	-	X	-
Sepulveda – New Interchange, Tunnel, Westchester to Century	X	-	-	X	X	-	X	X	X	X	X	-	X	X	-
Arbor Vitae – Interchanges	X	-	-	-	X	X	X	X	-	X	-	-	-	X	-
Demolition and Clearing of Acquisition Areas	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Westchester Southside	-	-	-	-	X	-	-	X	X	-	X	-	-	X	-
New Runway 24R/Taxiways	-	-	-	-	X	-	X	-	X	-	X	-	-	X	-
Relocate Runway 24C/Taxiways	-	-	-	-	X	-	X	-	X	-	X	-	-	X	-
Relocate Runway 24L/Taxiways	-	-	-	-	X	-	X	-	X	-	X	-	-	X	-
Upgrade Runway 25R/Taxiways	-	-	-	-	X	-	X	-	X	-	X	-		X	-
Reconstructed Runway 25L/Taxiways	-	-	-	-	X	-	X	-	X	-	X	-	-	X	X
Reconfiguration of CTA	-	-	-	-	X	X	-	X	X	-	X	-	-	X	X
Automated People Mover	X	-	X	X	X	-	-	X	X	X	X	-	X	X	X
La Cienega Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
South Cargo Complex East	-	-	-	-	X	-	-	X	X	-	X	-	-	X	X
Imperial Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New Fuel Farm	X	-	-	-	X	-	-	X	X	X	X	-	-	X	X
LAX Expressway	X	-	-	X	X	-	X	X	-	X	-	-	X	X	-
Lincoln Blvd. Interchange	-	-	-	-	X	-	-	-	X	-	X	-	-	X	-
Green Line to West Terminal	X	-	X	X	X	-	X	X	X	X	X	-	X	X	X
Alternative B - Added Runway South Facilities															
New 24L Runway Extension/Taxiways	-	-	-	-	X	-	X	X	X	-	X	-	-	X	-
New Taxiways over Aviation	-	-	-	-	X	X	X	-	X	-	X	-	-	X	-
New West Terminal, Satellite Concourses & Parking Structure	X	-	X	X	X	-	X	X	X	X	X	-	X	X	-
New La Cienega Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New East Imperial Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
Redevelop Century Cargo Complex	-	-	-	-	X	-	X	X	X	-	X	-	-	X	X
Westchester Parkway Cargo Complex	-	-	-	-	X	-	X	X	X	-	X	-	-	X	X
New Admin/Maintenance Facilities	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New Flight Kitchens	-	-	-	-	X	-	X	X	X	-	X	-	-	X	X
Ring Road and Regional Roads															
West Terminal Access – Pershing	X	-	-	-	X	-	-	X	X	X	X	-	-	X	-
Westchester Parkway – Realignment/Grade Separations	X	-	-	-	X	X	X	X	X	X	X	-	-	X	-
Aviation Blvd. – Depressed Between Arbor Vitae & Imperial	X	-	-	X	X	X	X	-	-	X	-	-	-	X	-
I-105/Imperial – Extend South to Pershing	X	-	-	-	X	-	-	X	X	X	X	-	-	X	-
Sepulveda – New Interchange, Tunnel Westchester to Century	X	-	-	X	X	-	X	X	X	X	X	-	X	X	-
Arbor Vitae - Interchanges	X	-	-	-	X	X	X	X	-	X	X	-	-	X	-
Aviation Blvd. Tunnel	X	-	-	X	X	-	X	X	X	X	X	-	X	X	-
Demolition and Clearing of Acquisition Areas	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X

Table F4.22-1

Matrix of Potential Earth/Geologic Considerations for Major Master Plan Facilities

Master Plan Alternatives and Related Major Facilities	Slope Stability	Oil Field Subsidence	Oil Field Gas	Groundwater/ Dewatering	Settlement	Expansion	Fault Surface Rupture	Ground Shaking	Lique-faction	Seismic Stability	Seismic Slope Settlement	Tsunami, Seiche, Flooding	Tunneling	Grading	Existing Foundations
Westchester Southside	-	-	-	-	X	-	-	X	X	-	X	-	-	X	-
Relocated/Replacement Runway 24R/Taxiways	X	-	-	-	X	-	-	X	X	X	X	-	-	X	X
Relocated/Replacement New Runway 24C/Taxiways	X	-	-	-	X	-	-	X	X	X	X	-	-	X	X
New Runway 24L/Taxiways	X	-	-	-	X	-	-	X	X	X	X	-	-	X	X
Reconfiguration of CTA	-	-	-	-	X	X	X	X	X	-	X	-	X	X	X
Automated People Mover	X	-	X	X	X	-	-	X	X	X	X	-	X	X	X
New Imperial Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
Off-site Fuel Farm	X	-	-	-	X	-	X	X	X	X	X	-	-	X	-
Lincoln Blvd. Interchange	-	-	-	-	X	-	-	-	X	-	X	-	-	X	-
LAX Expressway	X	-	-	-	-	-	-	-	-	-	X	-	-	X	X
Green Line to West Terminal	X	-	X	X	X	-	X	X	X	X	-	-	X	X	X
Alternative C – No Additional Runway Facilities															
Extend/Upgrade Runway 24L/Taxiways	-	-	-	-	X	X	X	-	X	-	X	-	-	X	-
Relocate/Upgrade Runway 24R/Taxiways	-	-	-	-	X	X	X	-	X	-	X	-	-	X	-
New Westside Terminal, Satellite Concourses & Parking Structure	X	-	X	X	X	-	X	X	X	X	X	-	X	X	-
Expansion of TBIT	-	-	-	-	X	X	-	X	X	-	X	-	-	X	X
Westchester Parkway Cargo Complex	-	-	-	-	X	X	X	X	X	-	-	-	-	X	X
New Admin/Maintenance/Flight Kitchen/General Aviation Facilities	X	-	-	-	X	-	-	X	X	X	X	-	-	X	X
Ring Road and Regional Roads															
West Terminal Access - Pershing	X	-	-	-	X	-	-	X	X	X	X	-	-	X	-
Westchester Parkway - Realignment/Grade Separations	X	-	-	-	X	X	X	X	X	X	X	-	-	X	-
Aviation Blvd. - Depressed Between Arbor Vitae & Imperial	X	-	-	X	X	X	X	-	-	X	-	-	-	X	-
I-105/Imperial - Extend South to Pershing	X	-	-	-	X	-	-	X	X	X	X	-	-	X	-
Sepulveda - New Interchange, Tunnel Westchester To Century	-	-	-	X	-	-	X	X	X	X	X	-	X	X	-
Arbor Vitae - Interchanges	X	-	-	-	X	X	X	X	-	X	X	-	-	X	-
Demolition and Clearing of Acquisition Areas	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Westchester Southside	-	-	-	-	X	-	-	X	X	-	X	-	-	X	X
Relocate Runway 25L	X	-	-	-	X	X	X	-	X	-	X	-	-	X	-
Realign/Widen Taxiways B, C	-	-	-	-	X	X	X	-	X	-	X	-	-	X	-
Automated People Mover	X	-	X	X	-	-	-	X	X	-	X	-	X	X	X
Underground Spine Road CTA to West Terminal	X	-	X	X	-	-	-	X	X	-	X	-	X	X	X
Manchester Square Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
Redevelop Century Cargo Complex	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New Cargo Ramp SE Corner of Airport	-	-	-	-	X	-	X	X	X	-	X	-	-	X	X
South Cargo Complex (East / West)	-	-	-	-	X	-	X	X	X	-	X	-	-	X	X
Manchester Square Cargo Complex	-	-	-	-	X	X	X	X	-	-	-	-	-	X	-
Fuel Farm – Additions to Existing	-	-	-	-	X	-	-	X	X	-	X	-	-	X	-
LAX Expressway	X	-	-	X	-	-	-	-	-	-	X	-	X	X	-
Green Line to West Terminal	X	-	X	X	X	-	X	X	X	X	X	-	X	X	X

Table F4.22-1

Matrix of Potential Earth/Geologic Considerations for Major Master Plan Facilities

Master Plan Alternatives and Related Major Facilities	Slope Stability	Oil Field Subsidence	Oil Field Gas	Groundwater/ Dewatering	Settlement	Expansion	Fault Surface Rupture	Ground Shaking	Lique-faction	Seismic Stability	Seismic Slope Settlement	Tsunami, Seiche, Flooding	Tunneling	Grading	Existing Foundations
Alternative D - Enhanced Safety and Security Plan Facilities															
North Airfield Facilities - Extend Runways 24R, 24L	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
North Airfield Facilities - New Parallel Center Taxiway F	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
North Airfield Facilities - Relocate, Realign and Widen Taxiways	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
South Airfield Facilities - Reconstruct Runway 25L	X	-	-	-	X	X	X	X	X	-	X	-	-	X	-
South Airfield Facilities - New Parallel Center Taxiway	X	-	-	-	X	X	X	X	X	-	X	-	-	X	-
South Airfield Facilities - Relocate, Realign and Widen Taxiways	X	-	-	-	X	X	X	X	X	-	X	-	-	X	-
New Ground Transportation Center - Intermodal Trans. Center	X	-	X	X	X	X	X	X	X	-	X	-	-	X	X
CTA - New Terminals 1- 4 and North Linear Concourse	X	-	-	X	X	-	X	X	X	-	X	-	-	X	X
Reconfigure Terminals 4-8	X	-	-	-	X	-	X	X	X	-	X	-	-	X	X
New Midfield Satellite Concourse	X	-	X	X	X	-	-	X	X	-	X	-	X	X	X
Reconfigure Tom Bradley Intn'l Terminal	X	-	X	X	X	-	-	X	X	-	X	-	X	X	X
Automated People Mover - CTA to Satellite Concourse (underground)	X	-	X	X	-	-	X	X	X	-	X	-	X	X	X
Automated People Mover - East of Sepulveda (above grade or cut)	X	-	X	X	-	-	X	X	X	X	X	-	-	X	X
Rent A Car Facilities	X	-	X	X	X	-	X	X	X	-	X	-	-	X	X
South Cargo Complex (Demo & 2 new bldgs)	-	-	-	-	X	-	-	X	X	-	X	-	-	X	X
Century Cargo Complex - New Building	-	-	-	-	X	X	X	X	X	-	X	-	-	X	X
New General Aviation Building , South Cargo Area	-	-	-	-	X	-	-	X	X	-	X	-	-	X	X
New CNG/LNG Facility - Arbor Vitae and Aviation	-	-	-	-	X	X	X	X	-	-	-	-	-	X	X
New Airline Maintenance Facility-West Side	-	-	-	-	X	-	-	X	X	-	X	-	-	X	-
LAX Northside	-	-	-	-	X	-	-	X	X	-	X	-	-	X	X
Demolition and Clearing of Acquisition Areas	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X

- = Not Applicable
X = Applicable

Source: Taylor-Hunter Associates, 2002; Laguna Geosciences, Inc., 2004.

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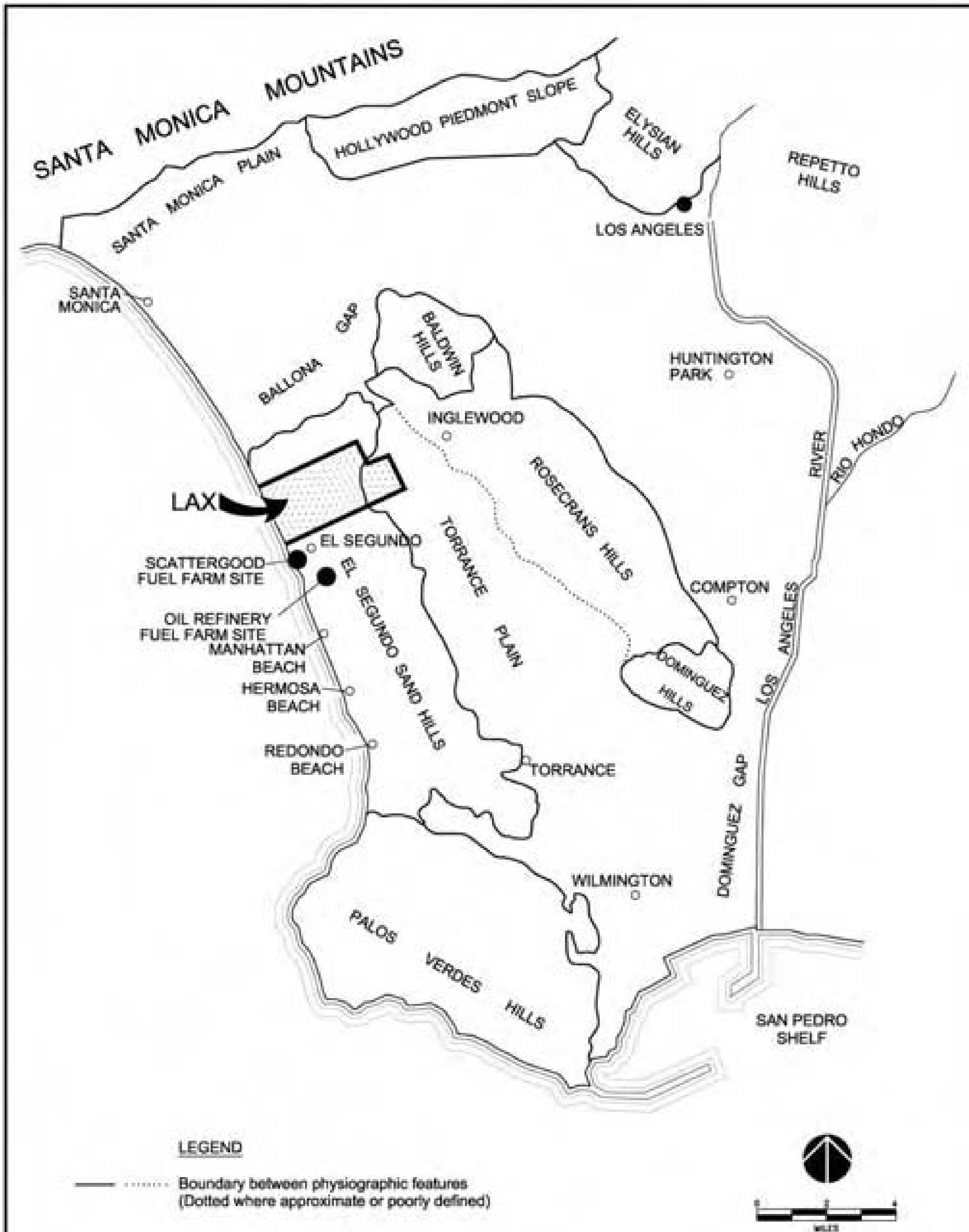

Reference: California D.W.R. Bulletin 104 (1961).

LAX Master Plan Final EIS/EIR	Physiographic Map	Figure F4.22-1

LAX and the potential off-site fuel farm sites lie within the southwestern structural block of the Los Angeles Basin. The basement rocks in the southwestern block near LAX consist of Mesozoic aged metamorphic schistose rock. The basement rock is overlain by sediments of the Miocene Puente Formation, the Pliocene Repetto and Pico Formations, the Pleistocene Lakewood Formation, Older Dune Sands of Pleistocene age, and Recent Dune Sands of Holocene age. Approximate areal extents of surface formations are illustrated in Figure 2, Geologic Map, of Technical Report 12, *Earth/Geology Technical Report*.

Varying thicknesses of artificial fill that are a result of past grading activities are also present in different areas of LAX.[764] Summary descriptions of these formations are presented below. Additional information and cross-sections showing selected boring logs from some of the geologic investigations at LAX are presented in Technical Report 12*, Earth/Geology Technical Report.*

Not all of the different formations and soils are equally suitable for bearing foundations for building structures. The Lakewood Formation is present at the ground surface over much of the central and eastern portions of LAX. The Lakewood Formation generally consists of alternating layers of dense to very dense sand, clayey sand, silty sand, and very stiff to hard silty to sandy clay and clayey silt.[765] The Lakewood Formation is typically a suitable foundation-bearing material in the LAX area, although foundations bearing in or near the local clay layers may require special design. Older Dune Sand overlies the Lakewood Formation in the central and western areas of LAX and the oil refinery fuel farm site. The sands are fine to medium grained, poorly graded, and dense to very dense. Clayey sand and clay layers are locally present at shallow depths. Scattered gravel is also present.

Older Dune Sand generally is a recommended foundation material, although, as with the Lakewood Formation, foundations bearing in or near the local clay layers may require special design. Recent Dune Sand overlies Older Dune Sand in the area extending from the beach to approximately Pershing Drive beneath the undeveloped western portion of LAX and the Scattergood Fuel Farm site. The Recent Dune Sand consists of fine to medium grained, poorly graded sand.[766]

Artificial fill of various age and quality is present at different locations within the Master Plan boundaries. Large quantities of fill were placed under the direction of the City of Los Angeles Department of Public Works (LADPW) during the extensive phase of airport development in the late 1950s and early 1960s. Several previous subsurface investigations reported the presence of artificial fill up to 23 feet deep, primarily in the Central Terminal Area (CTA). Existing artificial fill has generally not been considered a suitable foundation material in any portion of LAX by previous investigators. However, foundation design features and construction methods have been used to reduce the potential for excessive settlement at LAX. Additional information on artificial fill and typical foundations is presented in Technical Report 12*, Earth/Geology Technical Report*.

Faults

Southern California has historically been one of the more seismically active regions of the United States. Two major fault systems intersect within the Los Angeles Basin. One is the northwest trending San Andreas fault system, and the other is the east-west trending Transverse Ranges fault system. In general, these fault systems represent (or are manifestations of) a boundary between two tectonic plates of the earth's crust, known as the Pacific Plate and the North American Plate. These two crustal plates are believed to move relative to each other in response to forces within the earth. Major active faults associated with the two systems include the San Andreas, San Jacinto, Whittier-Elsinore, Palos Verdes, Newport-Inglewood, Malibu-Santa Monica, San Fernando-Sierra Madre, Hollywood-Raymond, and Santa Susana fault systems.

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764 Moore and Taber, Geotechnical Investigation, Second Level Roadway Project, Los Angeles International Airport, February 20, 1980 and Dames and Moore, Geotechnical Investigation, Proposed Fuel Facilities Expansion, Los Angeles International Airport, Los Angeles, California, for LAXFUEL Corporation, February 8, 1991.

765 California Department of Water Resources, Planned Utilization of the Groundwater Basins of the Coastal Plain of Los Angeles County, Appendix A, Ground Water Geology, (CDWR Bulletin 104), 1961.

766 California Department of Water Resources, Planned Utilization of the Groundwater Basins of the Coastal Plain of Los Angeles County, Appendix A, Ground Water Geology, (CDWR Bulletin 104), 1961.

Major fold systems[767] in the Los Angeles Basin are also a result of relative motion between the two plates, and include the east-west trending Compton and Elysian Park thrust/fold belts. The CDMG considers a fault to be active and capable of producing earthquakes if it shows evidence of movement during the last 11,000 years. The CDMG considers a fault to be potentially active if the fault shows evidence of surface displacement during the last 1.6 million years. **Figure F4.22-2**, Fault Map, shows the locations of the active faults near LAX.

The nearest dominant fault feature in the LAX vicinity is the northwest trending Newport Inglewood Fault Zone (NIFZ), which is located about three miles to the east of the airport. The NIFZ is an uplifted anticlinal structure broken up by a series of offset, parallel faults. Movement along the NIFZ has resulted in formation of the string of low hills that extend from the Baldwin Hills southeastward to Newport Beach. The movement has also produced several historic earthquakes that have affected the LAX area, including the 1933 Long Beach earthquake.

In addition to this fault, two smaller faults, the Overland and the Charnock Faults, parallel the NIFZ to the southwest near LAX. The Charnock Fault is closer to LAX and may cross LAX in the vicinity of the east end of the South Airfield runways (approximately 1.6 km from the main control tower). However, limited data exists on the Charnock Fault; its exact location in the LAX area is uncertain. In 1999, Geo-Consultant conducted a limited investigation to search for the fault in the vicinity of the east end of the airport as part of an on-going groundwater investigation at LAX. Geo-Consultant's investigation consisted of a surface geophysical survey (electrotelluric survey); no subsurface investigation was conducted as part of the investigation. Geo-Consultant concluded that the survey provided no evidence of the Charnock fault along the investigated transect (the line of survey which ran west to east from near the intersection of Airport Boulevard and Sepulveda to near the intersection of Inglewood Avenue and 104th Street). Geo-Consultant concluded that the fault is either buried more deeply in the subsurface, or moves further northeast towards the Newport-Inglewood Fault Zone and away from LAX. For the purposes of this EIS/EIR, it has been assumed that the Charnock Fault does exist in the vicinity of the eastern end of LAX and that it is potentially active as reported by the State Geologist. Projected locations of the Charnock Fault in the LAX vicinity are shown in **Figure F4.22-3**, Composite Aerial Photo Lineament Map. Additional information on the activity and earthquake generating potential of faults relevant to LAX is presented in Technical Report 12*, Earth/Geology Technical Report,* and below in *Seismic Hazards*.

Geologic Hazards

Several types of geologic hazards are associated with existing conditions at LAX. Summaries of those hazards that present a potential for impacts associated with implementation of the Master Plan alternatives are provided below. These include seismic, settlement/expansion of foundation soils, slope stability, oil field gases, and erosion hazards.

Additional details on these and other geologic hazards evaluated for the LAX Master Plan are presented in Technical Report 12*, Earth/Geology Technical Report,* and include:

- Faults and historic and anticipated earthquakes
- Seismic hazards including ground shaking and fault surface rupture
- Other hazards, including tsunami, oil field subsidence, and subsidence due to groundwater withdrawal. These other hazards are not discussed further in this section as the potential for such hazards was determined not to exist at LAX due to site elevation[768] or lack of reported occurrences/potential in the site vicinity.[769]

Seismic Hazards

The proximity of LAX to large, active faults suggests that seismic hazards will continue to affect the site during the life of existing and proposed facilities. Seismic hazards include those caused directly by the movement of the earth, such as surface fault rupture and ground shaking, and those hazards that result from the ground shaking itself, such as liquefaction and seismic settlement.

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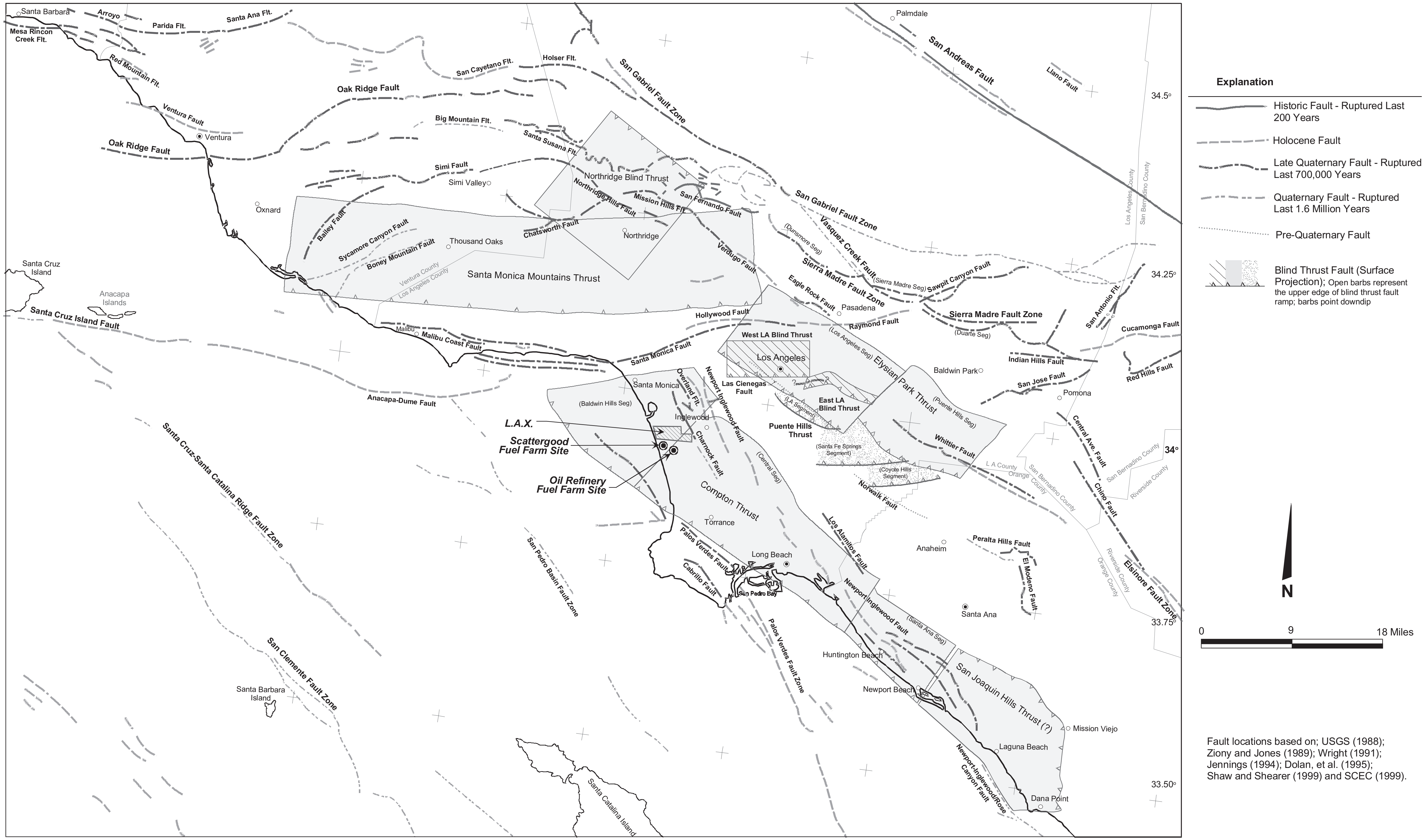
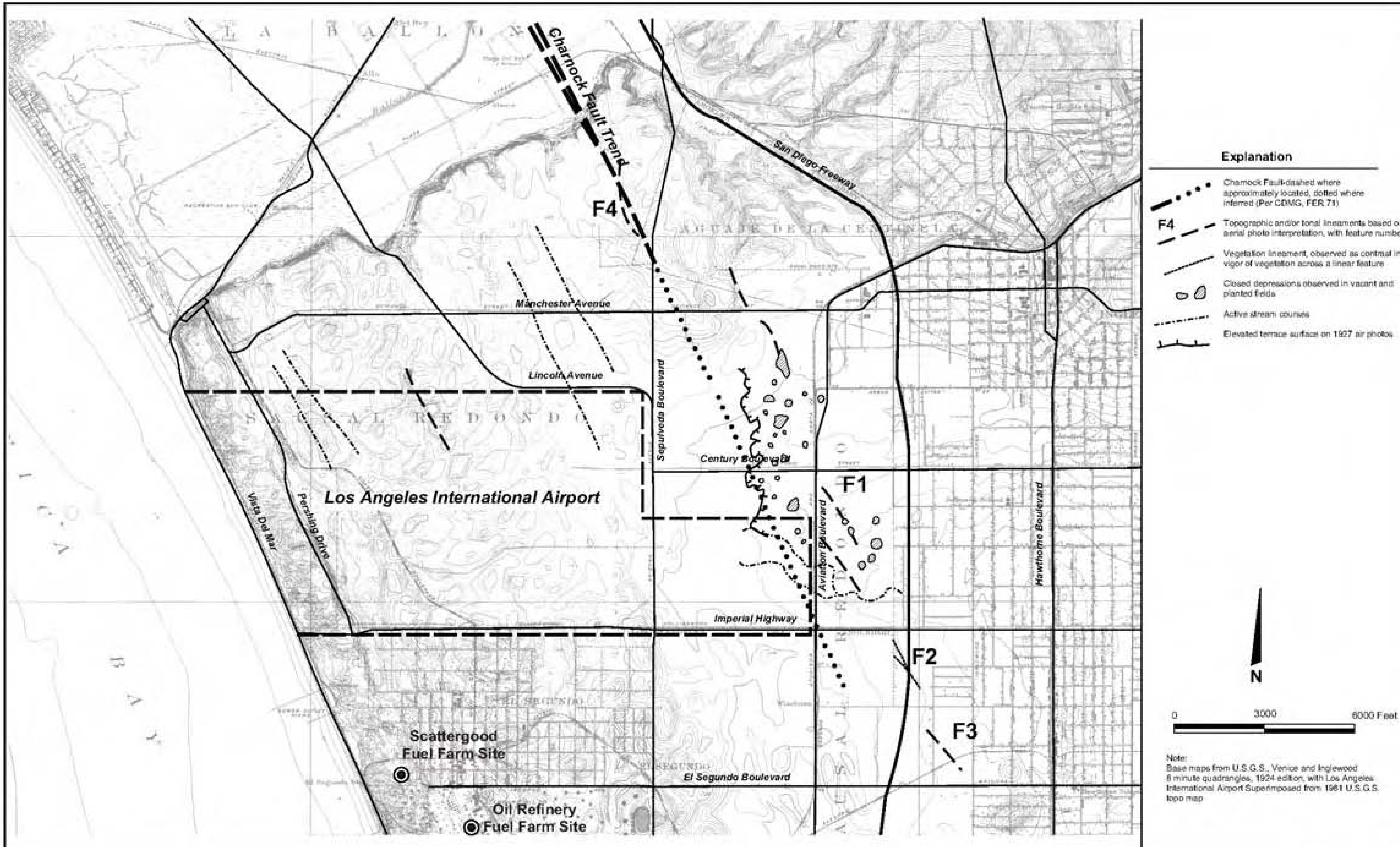
767 Folds are bends or wrinkles in rock produced when the rock was in a plastic state.

768 For example, the elevation of the site is such that a tsunami would not affect LAX.

769 For example, subsidence due to groundwater and oil withdrawal. Subsidence is the lowering of the ground surface due to the withdrawal of groundwater, oil, or other subsurface resources.



Fault locations based on; USGS (1988); Ziony and Jones (1989); Wright (1991); Jennings (1994); Dolan, et al. (1995); Shaw and Shearer (1999) and SCEC (1999).



LAX Master Plan Final EIS/EIR

Composite Aerial Photo Lineament Map

Figure F4.22-3

The size of an earthquake is often referred to as its magnitude (M), and is measured by specialized instruments known as seismographs. Earthquake magnitudes are generally recognized to range from one to nine, with magnitudes greater than five typically responsible for damage to structures. Moment Magnitude (Mw) is a similar measure that uses the physical parameters of a fault to estimate the potential size of earthquake the fault could generate (or to describe the size of an actual earthquake). Several notable earthquakes have affected the LAX area, including the 1933 Long Beach earthquake, which had a magnitude of 6.4. This earthquake was centered offshore of Newport Beach (about 54 kilometers (34 miles) southeast of LAX) and caused extensive damage in coastal areas due to settlement and liquefaction. The intensity and extent of any damage in the LAX vicinity is not known.

The most recent earthquake to cause damage in the vicinity of LAX was the January 17, 1994, Northridge earthquake (Mw 6.7), located about 32 kilometers (20 miles) north of LAX. Substantial damage was observed along coastal, beach, and harbor areas to the north and south of LAX. The nearby City of Santa Monica suffered substantial damage. There was reportedly no major damage at LAX resulting from the Northridge earthquake.[770]

Ground Shaking

Ground shaking is responsible for the majority of damage caused by earthquakes. It occurs when energy released from an earthquake travels through the earth, resulting in movement of the earth's surface and near surface materials. The level of ground shaking at a given location depends on many factors, including the size and type of earthquake, distance from the earthquake, and the soil and bedrock conditions. The size and type of construction also dictates how ground shaking affects a particular structure.

Two measures are typically used to evaluate the severity of ground shaking: local site intensity and instrumental recordings of ground movement. Local site intensity is a subjective measure based on human perception and observed response of structures. The most commonly used scale in the U.S. is the Modified Mercalli Intensity (MMI) Scale, which assigns intensity values ranging from I to XII. An MMI of 'I' generally would not be noticed by humans. An MMI of 'XII' would include nearly total destruction of most engineered structures. The MMI scale is typically used to correlate with expected levels of damage for planning studies.

For planning purposes at LAX, a maximum local intensity of IX is appropriate, as it is typical of intensities that could occur throughout the Los Angeles region. As a comparison, during the 1994 Northridge earthquake (Mw 6.7), LAX was in an area of local intensity of VI. At the same time, most of the San Fernando and Santa Clarita Valleys (where substantial damage occurred) experienced intensities of VI with relatively small areas experienced intensity IX ground shaking.[771] Additional details on ground shaking intensity and the MMI Scale are provided in Technical Report 12*, Earth/Geology Technical Report.*

The second method typically used to measure ground shaking intensity is instrumental recording of ground motion. Instrumental recordings, primarily ground acceleration, measure ground shaking in the horizontal and vertical directions. These recordings are less subjective than intensity estimates and form the basis for structural design of buildings per the Uniform Building Code (UBC). It is estimated that there is a 10 percent chance that, during the next 50 years, an earthquake in the Los Angeles region will cause peak horizontal ground accelerations (PHGA) of between 0.4 and 0.64 times the acceleration of gravity (g) in the LAX vicinity (see Technical Report 12, *Earth/Geology Technical Report*). As a comparison, the PHGA in the LAX vicinity for the 1994 Northridge earthquake is estimated as between 0.15 to 0.2 g.[772, 773]

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770 LAWA, Engineering Division.

771 Substantial damage included collapsed highway structures, damage to or destruction of thousands of residences, institutional buildings, and commercial structures, widespread disruption of utilities, and numerous landslides. The Northridge earthquake resulted in 61 deaths and $15 billion in estimated damages, with the majority of the damage in the Santa Clarita and San Fernando Valleys. (EQE International, The January 17, 1994 Northridge, California Earthquake, March 1994; University of California Geotechnical Engineering Group, "Geotechnical Aspects of the Northridge Earthquake of January 17, 1994," Geotechnical News, June 1994.)

772 Wentworth, C.M., Borcherdt, R.K., Mark, R.K., and Boore, D.M., Maps of Peak Horizontal and Vertical Accelerations Recorded for the Northridge, California, Earthquake of January 17, 1994, and General Geology of the Epicentral Region, (USGS OFR 94-197), 1994.

773 Trifunac, M.D., Todorovska, M.I. and Ivanovic, S.S., A Note on Distribution of Uncorrected Peak Ground Accelerations During

Damage at LAX caused by this level of ground shaking could be considerable, including partial or total collapse of older structures, damage to new structures, conspicuous ground cracks, and broken underground pipes and utility conduits. The potential for serious injury or loss of life due to ground shaking during such an event is high, not just due to structural failure, but from non-structural features such as falling glass, ceiling components, masonry facing, and parapets; falling heavy interior items such as tall book shelves and cabinets; and fire and explosion. Damage to local and regional lifeline facilities, such as water supply and sanitation, transportation, and medical and emergency response facilities, would compound these problems. This is a condition that exists throughout the Los Angeles region.

The potential for structural failure due to ground shaking hazards is typically minimized by designing a structure according to the provisions of the UBC and the City of Los Angeles Building Code. Because new information on seismicity and structural design is increasing, however, the building codes may not always reflect the best or most current seismic design, particularly for large or complex structures. In such cases, current design practice may provide a higher level of performance for a structure subject to ground shaking. Provisions for performing site-specific evaluations are included in the UBC. A site-specific ground motion evaluation would generally result in a design more resistant to earthquake damage than a design that is based upon general criteria only. The UBC also includes provisions for determining horizontal forces and restraint need for non-structural elements (such as, architectural elements, cabinets, equipment racks) subject to ground shaking.

Conformance with current design practice, the UBC, and the City of Los Angeles Building Code does not necessarily preclude significant damage to structures during a seismic event, as evidenced by severe structural damage resulting from the Northridge earthquake. In addition, non-structural items are often installed or placed without restraint by occupants of structures, resulting in damage and injury during a seismic event. Older structures at LAX not designed in accordance with the current version of the UBC[774] are often more susceptible to damage.

Fault Surface Rupture

Fault surface rupture is another seismic hazard that can occur during an earthquake when movement along a fault causes rupture at the ground surface. Typical horizontal and vertical surface displacements along faults during a seismic event can range from less than an inch to tens of feet, and can severely damage structures or utilities. It is typically not feasible to design a structure to withstand the direct impact of fault surface rupture. For this reason, the primary method of reducing the hazards of fault surface rupture is to avoid areas where rupture occurs. The State of California and the City of Los Angeles require that development of property located near the traces of active faults be subject to zoning restrictions stipulated by the Alquist-Priolo Earthquake Fault Zoning Act. If an area is located within an Alquist-Priolo zone, it is likely that a fault surface rupture hazard is present.

LAX is not located within an Alquist-Priolo zone. The closest such zone is associated with the NIFZ. The Charnock Fault may cross the eastern portion of LAX. The Charnock Fault is not considered active by the State of California, and therefore, is not subject to the zoning restrictions of the Alquist-Priolo Earthquake Fault Zoning Act. Regardless of the regulatory status of the Charnock Fault, it is not currently possible to mitigate the potential effects by zoning around it because its exact location in the LAX area is uncertain. Geotechnical field investigations and construction observations could discover new data on the Charnock Fault (i.e., location of a near surface trace of the fault); however, the potential for locating the fault trace, if it exists, is assumed to be low unless extensive field exploratory work were performed. Even if such exploratory work were performed, the nature of much of the Lakewood Formation and Older Dune Sand Formation materials in the area could make identification of any near surface fault trace difficult, and it is not certain that any future ruptures would occur along older traces.

The likelihood of surface rupture occurring on the Charnock Fault, either independently or in conjunction with movement on the NIFZ or other faults, is considered to be low; however, the potential does exist. If the Charnock Fault were to rupture, it is estimated that up to 0.7 m (2.3 feet) of horizontal and 0.5 m (1.6 feet) of vertical displacement could occur at depth. The actual amount of surface displacement caused by the rupture at depth is difficult to estimate given the relatively unconsolidated nature of the near surface soil, but would typically be some fraction of the rupture displacement at depth. The

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the Northridge, California, Earthquake of 17, January, 1994, in Soil Dynamics and Earthquake Engineering, 13, p. 187-196. 1994.

774 The UBC is updated regularly. The UBC that most cities were using at the time of the EIS/EIR analysis was from 1997.

possibility of fault surface rupture or co-seismic ground deformation[775] along a previously unidentified fault also exists, although the potential is impossible to quantify.

Additional information regarding the potential for, and nature of, fault surface rupture in the LAX vicinity is provided in Technical Report 12*, Earth/Geology Technical Report*.

Liquefaction, Seismic Settlement, and Seismic Slope Failure

Liquefaction is a seismic hazard that occurs when strong ground shaking causes saturated granular soil (such as sand) to liquefy and lose strength. This loss of strength can result in settlement, tilting, and in extreme cases, toppling of structures. The susceptibility of soil to liquefy tends to decrease as the density of the soil increases and the intensity of ground shaking decreases. The depth to groundwater at LAX is generally greater than 90 feet, which would indicate that the site has a very low susceptibility to liquefaction. However, perched groundwater[776] conditions have been noted in the upper 20 to 60 feet at some locations at LAX, and the density of sand deposits in the upper 30 feet is generally considered to be low to medium dense (see Technical Report 12*, Earth/Geology Technical Report*). Liquefaction could, therefore, potentially occur in very localized areas; however, the overall potential for liquefaction at LAX is considered low.

Strong ground shaking will also tend to densify loose to medium dense deposits of partially saturated granular soils and could result in seismic settlement of foundations and the ground surface at LAX. Due to variations in material type, seismic settlements would tend to vary considerably across LAX, but are generally estimated to be between negligible and 0.5 inch (see *Technical Report 12, Earth/Geology)*. Such settlement could affect some features such as utility connections, but typically would not cause severe damage to structures; therefore, the overall potential for damaging seismically-induced settlement is considered to be low.

Seismically-induced ground shaking can also cause slope-related hazards through various processes including slope failure, lateral spreading,[777] flow liquefaction, and ground lurching.[778] Because existing slopes in the LAX vicinity are relatively small in area and of low angle and height (less than 15 feet) the overall potential for such failures is considered to be low.

The California Department of Conservation (CDC) is mandated by the Seismic Hazards Act of 1990[779] to identify and map the state's most prominent earthquake hazards in order to help avoid damage resulting from earthquakes. The CDC's Seismic Hazard Zone Mapping Program charts areas prone to liquefaction and earthquake-induced landslides throughout California's principal urban and major growth areas. According to the Seismic Hazard Map for the Inglewood Quadrangle, no potential liquefaction zones are located within the LAX area. Isolated zones of potential seismic slope instability are identified near the western edge of the airport, within the dune area.

Additional information regarding the potential for, and nature of, liquefaction, seismic settlement, and slope stability in the LAX vicinity is provided in Technical Report 12*, Earth/Geology Technical Report.*

Settlement/Expansion of Foundation Soil

Settlement of foundation soils beneath engineered structures or fills typically results from the consolidation and/or compaction of the foundation soils in response to the increased load induced by the structure or fill. Settlement or collapse can also occur during construction due to tunneling or excavation where large quantities of earth material are removed, or from dewatering of saturated deposits. Some

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775 Co-seismic ground deformation: Movement (deformation) occurs along a fault (which probably does not produce large earthquakes of its own) in response to an earthquake on another nearby fault(s). This type of triggered movement still produces ground rupture along the fault and can significantly damage underground utilities, or other structures built across the fault. Triggered slip of this type was observed in the 1989 Loma Prieta (and possibly the Northridge) earthquake, and has been observed in other regions following large earthquakes.

776 Groundwater, generally shallow, that is isolated and not connected to an aquifer.

777 Lateral Spreading: Deformation of very gently sloping ground (or virtually flat ground adjacent to an open body of water) that occurs when cyclic shear stresses caused by an earthquake induce liquefaction, reducing the shear strength of the soil and causing failure and "spreading" of the slope.

778 Ground Lurching: Ground-lurching (and related lateral extension) is the horizontal movement of soil, sediments, or fill located on relatively steep embankments or scarps as a result of earthquake-induced ground shaking. Damage includes lateral movement of the slope in the direction of the slope face, ground cracks, slope bulging, and other deformations.

779 Public Resources Code 2690-2699.6.

settlement is typically expected beneath most new structures; however, excessive or long-term settlement can lead to damage including tilting, cracking, poor drainage, and breaks in utility line connections.

The presence of undocumented and typically weak artificial fill at LAX creates the potential for settlement problems, particularly in the CTA. The Lakewood Formation also includes some silt and clay layers prone to settlement (see *Geology* above). However, foundation design features and construction methods can reduce the potential for excessive settlement at LAX, and the overall potential for damaging settlement is considered low. Additional information regarding the potential for, and nature of, settlement in the LAX vicinity is provided in Technical Report 12, *Earth/Geology Technical Report*.

Expansive soils are typically composed of certain types of silts and clays that have the capacity to shrink or swell in response to changes in soil moisture content. Shrinking or swelling of foundation soils can lead to damage to foundations and engineered structures including tilting and cracking. Fill materials located in some portions of the LAX area could be prone to expansion, and some portions of the Lakewood Formation found beneath the eastern portion of LAX may also be susceptible, due to their higher content of clay and silt. As for settlement, foundation design features and construction methods can reduce the potential for excessive expansion of soil at LAX, and the overall potential for damage due to expansive soil is considered low.

Slope Stability

Slope failure generally occurs when the driving force induced by the weight of the earth materials within a slope exceeds the strength of those materials. When not initiated by an earthquake, an unstable slope condition can arise from a number of causes, including increased moisture content, over steepening of the slope angle, removals at the toe of the slope, and loading at the top of the slope. Slope failure can result in damage to equipment and structures and injury or loss of life. Most current permanent slopes in LAX are typically less than 15 feet and consist of granular materials not prone to deep-seated failure. No major slope stability problems have been reported in the geotechnical investigations reviewed for the LAX area or the off-site fuel farm sites (see *References,* Technical Report 12, *Earth/Geology Technical Report*).

Oil Field Gases

Oil field gases (and similar gases from other sources), including methane and hydrogen sulfide, are hazardous and have the potential to concentrate in underground structures during construction and operation. No oil field gases have been previously reported in the LAX area, but the presence of the Hyperion Oil Field beneath and to the south of LAX makes this a potential concern.

Erosion

Soil erosion refers to the process by which soil or earth material is loosened or dissolved and removed from its original location. Erosion can occur by many different processes; but in the LAX vicinity, it is most likely to occur when bare soil is exposed to moving water or wind. The result of erosion can be gullied surfaces, denuded areas, wind blown sand and silt (fugitive dust), and sediment-impacted waterways, storm water systems, roads, and nearby properties. Erosion is often both the cause, and the result, of slope failure. Temporary construction slopes and new unprotected slopes created during earthwork construction are other potential sources of erosion. Erosion of earth surfaces at LAX is relatively minor, due primarily to the relatively flat topography over much of the site, which results in more stable soil conditions. Some gullies have formed in slopes at the southwest portion of the airport, and there appear to be some areas of moving sand to the west of Pershing Drive in the Habitat Restoration Area (see Section 4.11, *Endangered and Threatened Species of Flora and Fauna*). The rate of movement is not known; however, there has been no problem reported with sand blowing onto Pershing Drive or airport operational areas.[780] For these reasons, the overall potential for damaging erosion is considered to be low.

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780 Los Angeles World Airports, Environmental Management Bureau.

4.22.4 Thresholds of Significance

4.22.4.1 CEQA Thresholds of Significance

A significant earth/geology impact would occur if the direct and indirect changes in the environment that may be caused by the particular build alternative would potentially result in one or more of the following future conditions:

- Substantial damage to structures or infrastructure, or exposure of people to substantial risk of injury, as a result of the creation or acceleration of a geologic hazard.
- Sediment runoff (erosion) that could not be contained or controlled on-site.
- Destruction, permanent covering, or material and adverse modification of one or more distinct and prominent geologic or topographic features.

These thresholds of significance are utilized because they address potential concerns relative to geologic hazards and landform alteration associated with the Master Plan build alternatives, namely seismic hazards (ground shaking, surface rupture, liquefaction, seismic settlement, and seismic slope failure), non-seismic settlement, expansive soils, slope stability, oil field gases, and erosion. The thresholds reflect those contained in the *Draft L.A. CEQA Thresholds Guide*[781] that are relevant to this project, as well as relevant issues identified in the suggested Initial Study Checklist contained in the State CEQA Guidelines.

4.22.4.2 Federal Standards

The FAA *Airport Environmental Handbook* does not require that this environmental topic be addressed; therefore, no federal standards apply to the following analysis.

4.22.5 Master Plan Commitments

No Master Plan commitments for earth/geology are proposed.

4.22.6 Environmental Consequences

The four build alternatives and, to some extent, the No Action/No Project Alternative, each contain major components with potential earth/geology-related impacts. A detailed summary of the major components considered as part of the project alternatives and their geological considerations and impacts is provided in **Table F4.22-1**.

4.22.6.1 No Action/No Project Alternative

Earthquake-Induced Ground Shaking

Conditions under the No Action/No Project Alternative would expose additional facilities and people to seismically-induced ground shaking compared to baseline conditions. The new facilities would include Continental City, LAX Northside, the Century Cargo facilities, and the Commuter Terminal. Exposure of people to ground-shaking hazards would increase over baseline conditions in proportion to the increase in peak hour passengers as shown in Table F3-1, Summary of Activity by Alternative - 2015, in Chapter 3, *Alternatives,* and in proportion to the increase in employees as shown in Section 4.4.1, *Employment/Socio-Economics.* The potential for injury would increase under the No Action/No Project Alternative compared to baseline conditions given the increased number of passengers in the terminals and employees working on the airport.

As with baseline conditions, the level of ground shaking could be severe, with the potential to cause structural damage and injury. As noted previously, this is a condition that exists throughout the Los Angeles region.

The potential for structural failure due to ground-shaking hazards would be minimized by designing structures according to the UBC and the City of Los Angeles Building Code. Specific requirements for geotechnical and seismic investigations are included in the codes and would be implemented. The UBC

[781] City of Los Angeles, Draft LA CEQA Thresholds Guide, May 14, 1998.

provisions for determining horizontal forces and restraint requirements for non-structural elements subject to ground shaking would also be implemented. The City of Los Angeles, Department of Building and Safety would be responsible for reviewing designs and construction for conformance with the codes.

Because the understanding of earthquakes and structural design is changing relatively rapidly, the building codes may not always reflect the best or most current seismic design, particularly for large or complex structures located close to a fault. In such cases, current design practice may be able to provide a higher level of performance for a structure subject to ground shaking. Given that LAX is very close to two strike-slip faults and a blind-thrust fault, the design-basis ground motions could require evaluation on a site-specific basis, depending on the nature of the specific structure. Provisions for site-specific evaluations are included in the UBC. A site-specific ground motion evaluation would generally result in a design more resistant to earthquake damage.

Earthquake Fault Surface Rupture

The potential exists for surface rupture and co-seismic ground deformation in the eastern portion of LAX near the projected location of the Charnock Fault (see **Figure F4.22-3**), either independently or in conjunction with movement along the NIFZ or other local faults. Proposed improvements associated with the No Action/No Project Alternative would expose Continental City, the Century Cargo facilities, and the Century Cargo roadway system to potential fault surface rupture in this area.

As indicated in subsection 4.22.3, *Affected Environment/Environmental Baseline*, the estimated ground surface displacement associated with a rupture on the Charnock Fault ranges from negligible levels to 0.7 meter. Hazards associated with a 0.7 meter rupture could include damage to, or failure of, structures, potentially resulting in injury to persons. This is a condition that is not unique in the Los Angeles region. As discussed in subsection 4.22.3, *Affected Environment/Environmental Baseline*, the potential for rupture of the Charnock Fault is considered low, and the potential for damage to any specific structure associated with the No Action/No Project Alternative (and for injury to persons within or around the new or existing structures) is considered to be lower.

Earthquake-Induced Liquefaction and Settlement

Strong ground shaking anticipated to occur during an earthquake at the site would potentially densify loose to medium dense deposits of sand that could result in seismic settlement of foundations, pavements, and the ground surface. As indicated in subsection 4.22.3, *Affected Environment/Environmental Baseline,* very localized areas with generally low to moderate susceptibility to liquefaction may be present throughout LAX. Construction of new facilities under the No Action/No Project Alternative would expose these facilities, and greater numbers of passengers and visitors anticipated with this alternative, to potential earthquake-induced settlement and liquefaction. Improvements that may be susceptible to liquefaction and settlement under the No Action/No Project Alternative include LAX Northside, the Century Cargo facilities, the Century Cargo roadway system, and the expanded Runway 24R and new taxiways.

Based on an assumed earthquake on the combined Compton and Elysian Park faults, estimated settlement would tend to vary considerably across the LAX area, generally between negligible levels and 0.5 inch. Seismic settlement and loss of foundation support due to liquefaction would have the potential to damage structures.

Improvements associated with the No Action/No Project Alternative would be designed according to the requirements of the State of California, the UBC, the City of Los Angeles Building Code and Grading Code, and current design practice. These requirements dictate that the potential for liquefaction be investigated for all projects during preliminary design. Established measures exist for remediation of seismically-induced settlement and liquefaction prone areas where identified. These remediation procedures include:

- ♦ Densification of susceptible materials by vibro-replacement, deep dynamic compaction, or other ground improvement techniques
- ♦ Replacement of loose materials with imported dense, non-liquifiable materials
- ♦ Removal and re-compaction of loose in-situ materials
- ♦ The use of deep foundations extending below loose or potentially liquifiable materials

Non-Seismic Settlement

New structures under the No Action/No Project Alternative would be subject to settlement induced by the weight of the structures or heights of new fill. Improvements that may be susceptible to settlement under the No Action/No Project Alternative include Continental City, LAX Northside, the Commuter Terminal, and the Century Cargo facilities.

The potential for settlement-related problems would be greater for structures with foundations in more compressible materials, such as areas of LAX underlain by existing artificial fill materials or by clay and silt within the Lakewood Formation. Fills or new structures placed adjacent to existing structures could also cause settlement and damage to existing structures.

Settlement of structures would be evaluated in accordance with guidelines of the state and the Building Code of the City of Los Angeles. Site-specific investigations of geotechnical conditions would be performed in accordance with these regulations and would provide the basis for geotechnical design. Typical design features used to remediate soft or loose soil or limit settlement include:

- Removal and re-compaction of loose foundation materials
- Replacement of soft materials with imported select fill
- Surcharging to consolidate soft materials prior to construction
- Compaction grouting and other ground improvement methods
- Construction of geosynthetic reinforced building pads
- The use of deep footings, stone piers, piles, or other deep foundation systems to avoid the settlement prone materials

Existing structures subject to settlement induced by construction of adjacent fills or structures, or construction de-watering would be monitored for movement before (baseline measurement), during, and after construction (until settlement was complete). Existing structures can be protected from excessive settlement induced by adjacent construction through various methods, including:

- Providing adequate separation between old and new structures
- Underpinning or deepening the existing foundations
- Isolating existing structures from adjacent settlement stress via slurry wall (or similar)
- Grouting the foundation and subgrade areas of the existing structure

Expansive Soils

New structures under the No Action/No Project Alternative could be subject to the effects of expansive soils. As discussed under subsection 4.22.3, *Affected Environment/Environmental Baseline*, expansive soils are typically composed of certain types of silts and clays that have the capacity to shrink or swell in response to changes in moisture content. Shrinking or swelling of foundation soils can lead to damage to foundations and engineered structures including tilting and cracking. Fill materials located in some portions of the LAX area could be prone to expansion, and some portions of the Lakewood Formation found beneath the eastern portion of LAX may also be susceptible. Improvements that may be exposed to expansive soils under the No Action/No Project Alternative include Continental City, and the Century Cargo facilities.

The potential for expansive soils to damage structures would be evaluated in accordance with guidelines of the state and the Building Code of the City of Los Angeles. Site-specific investigations of geotechnical conditions would be performed in accordance with these regulations and would provide the basis for geotechnical design. Typical design features used to remediate expansive soil or limit movements include:

- Replacement of expansive materials with imported select fill
- Chemical treatment
- Physical devices to control changes in soil moisture (such as cutoff barriers or active moisture conditioning systems)
- The use of deep footings and raised structural elements to avoid the expansive materials

Construction Considerations

Earth-related construction considerations under the No Action/No Project Alternative include grading and earthwork activities, changes to topography (landforms), erosion, stability of temporary construction slopes and excavations, and settlement of existing structures (addressed under *Non-Seismic Settlement* above).

Limited grading would be required for the construction of the planned taxiways and commuter terminal. More extensive grading may be required for LAX Northside, Continental City, and the Century Cargo roadway system. According to an EIR prepared for the LAX Northside project, grading would result in 600,000 to 2.5 million cubic yards of exported earth.[782, 783] Much of the excavated material would be replaced as fill; however, import fill may be necessary. The LAX Northside Development Project EIR states that measures to mitigate grading impacts would include development of an erosion control plan and identification of a site needing fill near LAX to which the surplus earth could be transported. Grading-related changes to landforms associated with the No Action/No Project Alternative would include leveling the existing rolling topography at the LAX Northside site. No mitigation for alteration of topography is provided in the EIR.

Grading would result in temporary slope and vertical excavations, which would have the potential to fail. Grading would generate fugitive dust as described in Section 4.6, *Air Quality*, and expose earth materials to erosion. Grading activities may result in excavation of contaminated soil materials as described in Section 4.23, *Hazardous Materials*, and would result in additional truck trips in the LAX vicinity, as described in Section 4.3.2, *Off-Airport Surface Transportation,* and Section 4.6, *Air Quality*.

Grading would be performed in accordance with grading plans reviewed and approved by the City of Los Angeles and/or Caltrans. Site-specific geotechnical investigations would be performed and provide the basis for these grading plans. The geotechnical investigations would provide recommendations for reducing the impacts of grading, including recommendations for temporary slopes and excavations, fill placement, erosion control, and dust control. These construction recommendations and procedures could include:

- Temporary erosion control plan features (as outlined in the Best Management Practice Handbook, developed by the California Stormwater Quality Task Force),[784] such as silt fences, geotextiles and mats; temporary drains and swales; earth dikes; straw bale barriers; sand bag barriers; rock filters; and sediment traps and basins
- Use of temporary road surfaces (such as gravel) and wetting for dust suppression
- Construction of temporary slopes and excavations in accordance with CalOSHA Construction Safety Order 1542, including such features as shoring, shields, sloping, and benching

4.22.6.2 Alternative A - Added Runway North

Earthquake-Induced Ground Shaking

Under Alternative A, additional facilities and people (relative to baseline conditions) would be exposed to seismically-induced ground shaking through 2015 and the design life of the improvements. Potential impacts would occur as a result of increased passenger activity under Alternative A as well as the construction of new facilities. The new facilities would include new runways and taxiways; the new West Terminal Area; reconfigured CTA; the Automated People Mover; new maintenance, cargo, and ancillary facilities; a new fuel farm; roadway improvements; the LAX Expressway; Westchester Southside; and the Green Line to the West Terminal Area. Exposure of people to ground-shaking hazards would increase over baseline conditions in proportion to the increase in peak hour passengers shown in Table F3-1, Summary of Activity by Alternative - 2015, in Chapter 3, *Alternatives*, and in proportion to the increase in employees shown in Section 4.4.1, *Employment/Socio-Economics*. The potential for injury would

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782 Earth that cannot be used on-site and must be disposed of elsewhere is considered "exported." Imported fill is earth that is hauled to the site from another source.

783 City of Los Angeles, Department of Airports, Final Environmental Impact Report, LAX North Side Development Project, April 1983.

784 Camp Dresser & McKee, Larry Walker & Associates, Uribe Associates and Resources Planning Associates, California Storm Water Best Management Practice Handbooks, Developed by the California Stormwater Quality Task Force, March 1993.

increase under Alternative A compared to baseline conditions given the increased number of passengers in the terminals and employees working on the airport. Additional details on project elements potentially affected by ground shaking are provided in **Table F4.22-1**.

As described under the No Action/No Project Alternative, the level of ground shaking could be severe, with the potential to cause structural damage and injury. As previously noted, this is a condition that exists throughout the Los Angeles region. The potential for ground-shaking hazards due to structural failure would be minimized to a less than significant level under Alternative A by designing structures according to the provisions of the UBC and the City of Los Angeles Building Code. The design-basis ground motions could require evaluation on a site-specific basis, depending on the nature of the specific structure. The City of Los Angeles, Department of Building and Safety would be responsible for reviewing designs and construction for conformance with the codes.

Earthquake Fault Surface Rupture

As with the No Action/No Project Alternative, a low potential exists for surface rupture and co-seismic ground deformation in the eastern portion of LAX near the projected location of the Charnock Fault (see **Figure F4.22-3**), either independently or in conjunction with movement along the NIFZ or other local faults. Implementation of Alternative A would expose additional structures and people to potential fault surface rupture in this area. These improvements include the new runways and taxiways, new maintenance and ancillary facilities, new and redeveloped cargo facilities (including the redeveloped Century Cargo complex, Imperial and New East Imperial Cargo complexes, and the La Cienega Cargo complex), roadway improvements, LAX Expressway, and the Green Line extension. Additional details on project elements potentially affected by fault surface rupture are provided in **Table F4.22-1**.

As discussed above, the potential for rupture of the Charnock Fault is considered low, and there is no regulatory requirement to address the potential. As with the No Action/No Project Alternative, hazards associated with a 0.7 meter rupture on the Charnock Fault could include damage to, or failure of, structures, potentially resulting in injury to persons. Such damage is a condition that is not unique in the Los Angeles region.

Because the potential for damage at LAX is considered low, and the potential for damage to any structure proposed under Alternative A (and for injury to persons using the new facilities) is considered to be lower, the impact of fault surface rupture is considered less than significant.

Earthquake-Induced Liquefaction And Settlement

As with the No Action/No Project Alternative, strong ground shaking anticipated at the site could result in seismic settlement of foundations, pavements, and the ground surface. Estimated settlements vary considerably across the LAX area, generally between negligible levels and 0.5 inch. Seismic settlement and loss of support due to liquefaction would have the potential to damage structures. Under Alternative A, improvements that may be exposed to earthquake-induced liquefaction and settlement could include the new West Terminal Area, new ancillary facilities, a new fuel farm, new cargo facilities, ring road and regional roads, runways and taxiways, tunnels, and the Green Line. Additional details on project elements potentially affected by liquefaction and seismic settlement are provided in **Table F4.22-1**.

As with the No Action/No Project Alternative, improvements under Alternative A would be designed according to the requirements of the State of California, the UBC, the City of Los Angeles Building Code, and current design practice. These requirements dictate that the potential for seismic settlement and liquefaction be investigated for all projects during preliminary design. Established measures for remediation of seismically-induced settlement and liquefaction-prone areas are described under the No Action/No Project Alternative and would be the same for Alternative A.

As a result of the low potential for liquefaction and seismic settlement, the requirements to conduct geotechnical investigations during design, and to design and implement remedial measures, the impacts of seismic settlement and liquefaction associated with Alternative A would be less than significant.

Non-Seismic Settlement

As with the No Action/No Project Alternative, new structures under Alternative A would be subject to settlement induced by the weight of the structures or heights of new fill. Improvements that may be susceptible to settlement under Alternative A could include most of the major project elements. Details on project elements potentially affected by settlement are provided in **Table F4.22-1**.

As described under the No Action/No Project Alternative, the potential for settlement-related problems is greater for structures founded over more compressible materials, such as fill materials known to be present in the CTA, or clay and silt materials of the Lakewood Formation. Settlement of structures would be evaluated in accordance with the Building Code of the City of Los Angeles. Site-specific investigations of geotechnical conditions would be performed in accordance with these regulations and provide the basis for geotechnical design. Typical design features used to remediate soft or loose soil or limit settlement are described above (see subsection 4.22.6.1, *No Action/No Project Alternative*) and would be the same for Alternative A.

Existing structures subject to settlement induced by construction of adjacent fills or structures, or construction de-watering, would be monitored for movement and could be protected from excessive settlement induced by adjacent construction through various methods as described under the No Action/No Project Alternative. Large aboveground fuel tanks, such as those for the relocated tank farm, would be vulnerable to damage from settlement. Typical large tank design would require monitoring of tank bottom settlement during initial loadings and installation of collection drains to provide early detection of leaks. If a geological hazard were to damage a tank, the containment wall would contain released products, as described in Section 4.24.3, *Safety*.

Design and construction of the Alternative A project components would be reviewed by the City of Los Angeles, Department of Building and Safety or Caltrans, as applicable. Compliance with requirements to conduct site-specific geotechnical investigations during design and to design and implement remedial and protective measures would ensure that the impacts of non-seismic settlement under Alternative A would be less than significant.

Expansive Soils

As with the No Action/No Project Alternative, new structures under Alternative A could be subject to the effects of expansive soils. As discussed under subsection 4.22.3, *Affected Environment/Environmental Baseline,* fill materials in portions of the LAX area could be prone to expansion, and some portions of the Lakewood Formation found beneath the eastern portion of LAX may also be susceptible. Improvements that may be exposed to expansive soils under Alternative A are listed in **Table F4.22-1**.

The potential for expansive soils to damage structures would be evaluated in accordance with guidelines of the state and the Building Code of the City of Los Angeles. Site-specific investigations of geotechnical conditions would be performed in accordance with these regulations and provide the basis for geotechnical design. Typical design features used to address expansive soils described under the No Action/No Project Alternative would be the same for Alternative A.

Compliance with requirements to conduct site-specific geotechnical investigations during design and to design and implement remedial and protective measures, such as those listed under the No Action/No Project Alternative, would ensure that the impacts of expansive soils would be less than significant.

Slope Stability

New permanent slopes would be constructed under Alternative A. Under certain conditions, permanent slopes can become unstable and slope failure can result (see subsection 4.22.3, *Affected Environment/Environmental Baseline*). Alternative A project components that may include substantial permanent slopes include the new West Terminal Area, new fuel farm, roadway improvements, the LAX Expressway, new taxiways over Aviation Boulevard, the Automated People Mover, and the Green Line. Additional details on project elements potentially affected by slope instability are provided in **Table F4.22-1**.

New permanent slopes would be investigated, designed, and constructed in accordance with guidelines of the state and the Building Code of the City of Los Angeles. Site-specific investigations of geotechnical conditions would be performed in accordance with these regulations and provide the basis for geotechnical design. Established design procedures exist for increasing the stability of slopes to acceptable levels, including:

- Lowering the slope angle
- Mechanical earth retaining systems (such as retaining walls, soil nailing, mechanically stabilized earth)
- Improvement of weak materials (using grouting, surcharging, dynamic compaction, etc.)
- Removal of weak materials and replacement with stronger material
- Lowering of groundwater levels

Design and construction of new permanent slopes would be reviewed by the City of Los Angeles, Department of Building and Safety or Caltrans, as applicable. Compliance with requirements to conduct site-specific geotechnical investigations during design and to design and implement remedial measures would ensure that the impacts of slope stability under Alternative A would be less than significant.

Construction Considerations

As with the No Action/No Project Alternative, earth-related construction considerations under Alternative A would include grading and earthwork activities, alteration of topography (landforms), erosion, stability of temporary construction slopes and excavations, and settlement of existing structures (addressed under *Non-Seismic Settlement* above). Alternative A construction considerations would also include tunneling, which is addressed below separately from other construction considerations.

Alternative A project components that may require substantial grading include the West Terminal Area, ancillary facilities, new fuel farm, new cargo complexes, new runways and taxiways, the ring road and regional roads, Westchester Southside, and the Green Line.

Total earthwork volumes estimated for Alternative A are 12,369,430 cubic yards of cut (5,485,625 cubic yards of which would be unsuitable for replacement as fill) and 16,517,184 cubic yards of fill, resulting in a net import fill requirement of 9,633,379 cubic yards. As discussed under the No Action/No Project Alternative, grading operations would result in temporary slope and vertical excavations, which would have the potential to fail and expose earth materials to erosion. Grading operations would also create potential impacts discussed in other sections. They would generate fugitive dust as described in Section 4.6, *Air Quality*, and grading and earthwork would potentially expose existing underground utilities as addressed in Section 4.25, *Public Utilities*. Contaminated soil and groundwater may be encountered during excavation as described in Section 4.23, *Hazardous Materials*, and additional truck trips in the LAX vicinity would result, as described in Section 4.3.2, *Off Airport Surface Transportation*, and evaluated in Section 4.6, *Air Quality*.

Grading-related changes to topography (landforms) associated with Alternative A would include leveling the existing rolling topography at the Westchester Southside site. Because most of this area was previously developed and the existing landforms highly modified, this is not considered to be a significant impact. Under Alternative A, grading of a 320 square foot area for navigational aids would be performed in the Habitat Restoration Area west of Pershing Drive. This grading would be performed adjacent to an existing access road. Additional details regarding impacts to species resident in the area and mitigation for these impacts are presented in Section 4.11, *Endangered and Threatened Species of Flora and Fauna*. Although the dunes are considered to be a distinct topographic feature, because of the small area involved, the overall topography of the Dunes would not be altered. Consequently, this impact would be less than significant.

As with the No Action/No Project Alternative, grading would be performed in accordance with a grading plan reviewed and approved by the City of Los Angeles and/or Caltrans, as applicable. Site-specific geotechnical investigations would be performed and provide the basis for these grading plans. The geotechnical investigations would provide recommendations for reducing the impacts of grading and earthwork, including recommendations for temporary slopes and excavations, fill placement, erosion control, and dust suppression. These construction recommendations and procedures as described previously under the No Action/No Project Alternative would be the same for Alternative A. Compliance with requirements to conduct site-specific geotechnical investigations during design and to design and implement construction procedures such as those listed previously under the No Action/No Project Alternative would ensure that the impacts of grading and earthwork for Alternative A would be less than significant.

Construction of tunnels could result in settlement, ground loss, and earth movement, which could affect or damage the ground surface, utility lines, roadways, and nearby structures. Existing underground utilities would also need to be considered (see discussions in Section 4.25, *Public Utilities*). Tunnel construction and underground excavation would be associated with components of Alternative A including the West Terminal Area, reconfiguration of the CTA, West Terminal Area access via Pershing Drive, Aviation Boulevard (where depressed between Century Boulevard and Imperial Highway), Sepulveda Boulevard (where tunneled between Westchester Parkway and Century Boulevard), the Automated People Mover, the LAX Expressway, and the Green Line.

Construction of certain Alternative A tunnels could be performed using cut and cover techniques, but underground excavation of sections of certain tunnel alignments would probably be necessary where existing structures or tunnel depth would preclude cut and cover construction.

Tunnel construction would be conducted to minimize settlement using proven tunneling techniques (such as cut and cover or shielded tunnel boring machines). Monitoring of the ground surface and existing structures for early signs of deformation would typically be performed during tunnel construction. Design and construction of proposed improvements would be reviewed by the City of Los Angeles, Department of Building and Safety, or Caltrans, as applicable. Implementation of approved design plans and construction procedures would ensure that the impacts of tunneling for proposed improvements would be less than significant.

Oil Field Gases

Although no oil field gases have been previously reported in the LAX area, the presence of oil fields and production facilities in the vicinity of LAX makes this a potential concern. Oil field gases, if they occur, would most likely be encountered during the deeper excavation for the West Terminal Area, the Automated People Mover, and the Green Line, although they can affect surface facilities as well.

Gas monitoring would be conducted during construction of underground structures in accordance with CalOSHA construction safety orders. Depending on the results of the monitoring, oil field gas conditions may need to be evaluated in accordance with guidelines of State of California, Department of Conservation, Division of Oil and Gas and Geothermal Resources (DOGGR), the Building Code of the City of Los Angeles, and the City of Los Angeles Fire Department. Site-specific investigations of gas conditions may need to be performed in accordance with these regulations and would provide the basis for designing mitigation measures to be employed during construction and operation, as necessary. Established methodologies exist for mitigation of oil field gases, including:

- closed-face excavation/tunneling (earth pressure balanced methodology)
- excavation/muck treatment to neutralize gases
- pre-construction treatment to neutralize gases
- removal/remediation of point or local source areas (such as abandoned oil wells)
- isolation of permanent structures by use of impermeable liners or other elements
- ventilation (passive or active) of permanent facilities

Compliance with requirements to conduct gas monitoring during construction and to conduct site-specific investigations (if necessary) would ensure that the impacts of oil field gases would be less than significant.

4.22.6.3 Alternative B - Added Runway South

Earthquake-Induced Ground Shaking

Under Alternative B, impacts associated with earthquake-induced ground shaking would be similar to those under Alternative A. Additional facilities and people (relative to baseline conditions) would be exposed to seismically-induced ground shaking through 2015 and the design life of the improvements. The new facilities would also be very similar to those for Alternative A, the primary differences being runway and taxiway layouts, cargo and ancillary facilities, and an off-site (as opposed to on-site) fuel farm. These differences would not significantly alter impacts associated with earthquake-induced ground shaking described under Alternative A. Exposure of people to ground-shaking hazards would increase over baseline conditions in proportion to the increase in peak hour passengers shown in Table F3-1, Summary of Activity by Alternative - 2015, in Chapter 3, *Alternatives*, and in proportion to the increase in employees shown in Section 4.4.1, *Employment/Socio-Economics*. The potential for injury would increase under Alternative B compared to baseline conditions given the increased number of passengers in the terminals and employees working on the airport. Additional details on Alternative B project elements potentially affected by ground shaking are provided in **Table F4.22-1**.

As described under the No Action/No Project Alternative and Alternative A, the level of ground shaking could be severe, with the potential to cause serious structural damage and injury. As previously noted, this condition exists throughout the Los Angeles region. As with the No Action/No Project Alternative and Alternative A, the potential for ground shaking hazards due to structural failure would be minimized to a less than significant level under Alternative B by designing structures according to the provisions of the UBC and the City of Los Angeles Building Code.

Earthquake Fault Surface Rupture

Potential impacts from earthquake fault surface rupture and/or co-seismic ground deformation in the eastern portion of LAX would be the same as those for Alternative A. Potential impacts would occur as a result of increased passenger activity under Alternative B, as well as the construction of new facilities. These new facilities would be very similar to those for Alternative A, the primary differences being runway and taxiway layouts, cargo and ancillary facilities, and an Off-Site (as opposed to On-Site) Fuel Farm. These differences would not significantly alter impacts associated with earthquake fault surface rupture described for Alternative A. Additional details on Alternative B project elements potentially affected by fault surface rupture are provided in **Table F4.22-1**.

The hazards of earthquake fault surface rupture and co-seismic ground deformation would be the same as those associated with the No Action/No Project Alternative and Alternative A, and could include damage to, or failure of, structures, potentially resulting in injury to persons. This condition is not unique in the Los Angeles region. Because the potential for damage at LAX is considered low, and the potential for damage to structures proposed under Alternative B (and for injury to persons using the new facilities) is considered to be lower, the impact of fault surface rupture is considered less than significant.

Other Geologic Hazards

The potential impacts associated with other geologic hazards -- namely earthquake-induced liquefaction and settlement, non-seismic settlement, expansive soils, slope stability, construction considerations, and oil field gases -- under Alternative B would be essentially the same as those for Alternative A. Alternative B would involve many of the same Master Plan improvements, the same increase in passenger activities and the same level of development associated at Westchester Southside as Alternative A. There would be minor differences in project components that would be susceptible to, or affected by, various geologic hazards as identified in **Table F4.22-1**. Under Alternative B, total earthwork volumes are estimated to include 13,575,360 cubic yards of cut (5,784,391 cubic yards of which would be unsuitable for placement as fill) and 19,979,314 cubic yards of fill, resulting in a net import fill requirement of 12,188,345 cubic yards. Impacts of Alternative B associated with navigational aids would be similar to Alternative A, but the configuration would be slightly different due to the addition of a south runway.

As with Alternative A, compliance with requirements to conduct site-specific geotechnical investigations during design and to design and implement remedial and protective measures would ensure that the potential impacts from these geologic hazards and geotechnical issues under Alternative B would be less than significant.

4.22.6.4 Alternative C - No Additional Runway

Earthquake-Induced Ground Shaking

The potential impacts of earthquake-induced ground shaking under Alternative C would be generally the same as those for Alternatives A and B. As with Alternatives A and B, under Alternative C, additional structures and people (relative to baseline conditions) would be exposed to seismically-induced ground shaking through 2015 and the design life of the improvements. The new facilities would be similar to those for Alternatives A and B, the primary differences being smaller scale runway and taxiway improvements, cargo and ancillary facilities layouts, and fuel farm configuration as well as the construction of the underground spine road. These differences would not significantly alter impacts associated with earthquake-induced ground shaking under Alternative C. Exposure of people to ground-shaking hazards would increase over baseline conditions in proportion to the increase in peak hour passengers shown in Table F3-1, Summary of Activity by Alternative - 2015, in Chapter 3, *Alternatives,* and in proportion to the increase in employees shown in Section 4.4.1, *Employment/Socio-Economics*. The potential for injury would increase under Alternative C compared to baseline conditions given the increased number of passengers in the terminals and employees working on the airport. Additional details on Alternative C project elements potentially affected by ground shaking are provided in **Table F4.22-1**.

As described under the other project alternatives, the level of ground shaking could be severe, with the potential to cause structural damage and injury. As noted throughout, this is a condition that exists throughout the Los Angeles region.

As with the other build alternatives, the potential for ground shaking hazards due to structural failure would be minimized to a less than significant level under Alternative C by designing structures according to the UBC and the City of Los Angeles Building Code.

Earthquake Fault Surface Rupture

Under Alternative C, the potential impacts of earthquake fault surface rupture and co-seismic ground deformation in the eastern portion of LAX would be the same as those for Alternatives A and B. Implementation of Alternative C would expose additional facilities and people would be exposed to potential fault surface rupture in this area. This alternative would increase passenger activities over baseline conditions, although to a lesser degree than the other build alternatives. The new facilities would be very similar to those proposed for Alternatives A and B, the primary differences being smaller scale runway and taxiway improvements, cargo and ancillary facilities layouts, and fuel farm configuration as well as the construction of the underground spine road. These differences would not significantly alter impacts associated with earthquake fault surface rupture under Alternative C. Additional details on Alternative C project elements potentially affected by fault surface rupture are provided in **Table F4.22-1**.

The hazards of fault surface rupture and co-seismic ground deformation under Alternative C would be the same as those for the other alternatives. They could include damage to, or failure of, structures, potentially resulting in injury to persons. This condition is not unique in the Los Angeles region.

Because the potential for damage at LAX is considered low, and the potential for damage to structures associated with Alternative C (and for injury to persons using the new facilities) is considered to be lower, the impact of fault surface rupture is considered less than significant.

Other Geologic Hazards

Impacts from other geologic hazards - namely earthquake-induced liquefaction and settlement, non-seismic settlement, expansive soils, slope stability, construction considerations, and oil field gases - under Alternative C would be essentially the same as those for Alternatives A and B. Alternative C would involve many of the same Master Plan improvements as the other build alternatives, although, overall, the level of development would be reduced. This alternative would increase passenger activities over baseline conditions, although to a lesser degree than Alternatives A and B. There would be minor differences in project components that would be susceptible to, or affected by, various geologic hazards, as identified in **Table F4.22-1**. Under Alternative C, total earthwork volumes are estimated to include 12,109,430 cubic yards of cut (5,285,625 cubic yards of which are unsuitable for fill) and 16,517,184 cubic yards of fill, resulting in a net import fill requirement of 9,693,379 cubic yards. Impacts of Alternative C associated with navigational aids would be similar to Alternatives A and B, but the configuration would be slightly different because no new runways would be added.

As with Alternatives A and B, compliance with requirements to conduct site-specific geotechnical investigations during design and to design and implement remedial and protective measures would ensure that the impacts associated with these geologic hazards under Alternative C would be less than significant.

4.22.6.5 Alternative D - Enhanced Safety and Security Plan

Earthquake-Induced Ground Shaking

The potential impacts of earthquake-induced ground shaking under Alternative D would be generally the same as those for Alternatives A, B, and C. As with Alternatives A, B, and C, under Alternative D, additional structures and people (relative to baseline conditions) would be exposed to seismically-induced ground shaking through 2015 and the design life of the improvements. The new facilities would be of a similar type as those associated with Alternatives A, B, and C. Exposure of people to ground-shaking hazards would increase over baseline conditions in proportion to the increase in peak hour passengers. The potential for injury would increase under Alternative D compared to baseline conditions given the increased number of passengers in the terminals. Additional details on Alternative D project elements potentially affected by ground shaking are provided in **Table F4.22-1.**

As under the other project alternatives, the level of ground shaking could be severe, with the potential to cause structural damage and injury. As noted previously, this is a condition that exists throughout the Los Angeles region. As with the other build alternatives, the potential for ground shaking hazards due to structural failure would be minimized to a less than significant level under Alternative D by designing structures according to the UBC and the City of Los Angeles Building Code.

Earthquake Fault Surface Rupture

Under Alternative D, the potential impacts of earthquake fault surface rupture and co-seismic ground deformation in the eastern portion of LAX would be higher than those for Alternatives A, B, and C. As discussed above and in Technical Report 12, *Earth/Geology Technical Report* (subsection 2.2), the Charnock Fault may extend towards, and possibly beneath, LAX in the vicinity of the east end of the proposed GTC or west of the GTC and beneath the proposed RAC facility and APM (see **Figure F4.22-3**). The likelihood of surface rupture occurring is considered low; however, the potential does exist. Implementation of Alternative D would expose additional facilities and people to potential fault surface rupture in this area relative to the other alternatives. This alternative would increase passenger activities over baseline conditions, although to a lesser degree than the other build alternatives. The new facilities would be very similar to those proposed for Alternatives A, B, and C, the primary differences being the placement of the GTC, ITC, and APM system on the east side of the airport. Additional details on Alternative D project elements potentially affected by fault surface rupture are provided in **Table F4.22-1**.

The hazards of fault surface rupture and co-seismic ground deformation under Alternative D would be similar to those for the other alternatives, including damage to, or failure of, structures, potentially resulting in injury to persons. This condition is not unique in the Los Angeles region.

The nature and even the existence of the Charnock Fault in the LAX vicinity is uncertain. As discussed above and in Technical Report 12, *Earth/Geology Technical Report* (subsection 2.2), the Charnock Fault is not considered active by the State of California and is not subject to the zoning restrictions of the Alquist-Priolo Earthquake Fault Zoning Act. It is not currently possible to mitigate the potential effects by zoning around the fault because its exact location in the LAX area is uncertain. Because the potential for damage at LAX is considered low, and the potential for damage to structures associated with Alternative D (and for injury to persons using the new facilities) is considered to be lower, the impact of fault surface rupture is considered less than significant.

Other Geologic Hazards/Construction Considerations

Potential impacts associated with other geologic hazards, namely earthquake-induced liquefaction and settlement, non-seismic settlement, expansive soils, slope stability, construction considerations, and oil field gases under Alternative D would be essentially the same as those for Alternatives A, B, and C. Alternative D would involve many of the same type of improvements as the other build alternatives, although, overall, the level of development would be reduced. This alternative would increase passenger activities over baseline conditions, although to a lesser degree than the other build alternatives. There would be differences in project components that would be susceptible to, or affected by, various geologic hazards, as identified in **Table F4.22-1**.

Earth-related construction considerations would be essentially the same as those for Alternatives A, B, and C. Under Alternative D, total earthwork volumes are estimated to include 4,121,926 cubic yards of cut (1,264,870 cubic yards of which are unsuitable for fill) and 1,400,666 cubic yards of fill, resulting in a net disposal fill requirement of 1,456,390 cubic yards.

As with Alternatives A, B, and C, compliance with requirements to conduct site-specific geotechnical investigations during design and to design and implement remedial and protective measures would ensure that the potential impacts associated with these geologic hazards under Alternative D would be less than significant.

4.22.7 Cumulative Impacts

As discussed in subsection 4.22.3, *Affected Environment/Environmental Baseline*, Southern California is an area of relatively high seismic activity. Hazards associated with this seismic activity include those due to ground shaking, fault surface rupture, liquefaction, and settlement. Other geologic hazards are dependent on local conditions and would not necessarily apply to other past, present, and probable future projects in the vicinity of LAX, including landforms, expansive soil, slope stability, fault surface rupture, or settlement. Identification of these local hazards relies on site-specific investigations and they are not considered to be cumulative in nature.

4.22.7.1 No Action/No Project Alternative

Under the No Action/No Project Alternative, additional facilities and people would be exposed to seismically-induced ground shaking and other earthquake-related hazards compared to baseline conditions. As with baseline conditions, the level of ground shaking could be severe, with the potential to cause structural damage and injury. As noted previously, this is a condition that exists throughout the Los Angeles region.

Regional projects, including Playa Vista and infill development, would also expose additional facilities and people to seismically-induced ground shaking hazards. The impact of increased exposure of facilities and people to ground shaking hazards resulting from the No Action/No Project Alternative, in conjunction with regional projects, would be reduced by designing structures in accordance with the requirements of the UBC and the City of Los Angeles Building Code. Specific requirements for geotechnical and seismic investigations are included in the codes and would be implemented. The UBC provisions for determining horizontal forces and restraint requirements for non-structural elements subject to ground shaking would also be implemented. The City of Los Angeles Department of Building and Safety would be responsible for reviewing designs and construction for conformance with the codes.

Other geologic hazards are dependent on local conditions and would not necessarily apply to other projects in the vicinity of LAX, including landforms, expansive soil, slope stability, fault surface rupture, or settlement. Identification of these local hazards relies on site-specific investigations and they are not considered cumulative in nature.

4.22.7.2 Alternatives A, B, and C

As previously discussed in subsection 4.22.6, *Environmental Consequences*, and similar to the No Action/No Project Alternative, development under Alternatives A, B, and C would increase the number of facilities and people exposed to seismically-induced ground shaking and other earthquake-related hazards. As with baseline conditions and the No Action/No Project Alternative, the level of earthquake-induced ground shaking could be severe, with the potential to cause structural damage and injury. As noted previously, this is a condition that exists throughout the Los Angeles region.

Regional projects that would expose additional facilities and people to seismically-induced ground shaking hazards include the Playa Vista Project, the development of Manchester Square under Alternative A (independent of the Master Plan), and infill development. The impacts of increased exposure of facilities and people to seismically-induced ground shaking hazards would be reduced to a less than significant level by designing structures in accordance with the requirements of the UBC and the City of Los Angeles Building Code.

Other geologic hazards are dependent on local conditions and would not necessarily apply to other projects in the vicinity of LAX, including landforms, expansive soil, slope stability, fault surface rupture, or settlement. Identification of these local hazards relies on site-specific investigations and they are not considered cumulative in nature.

4.22.7.3 Alternative D - Enhanced Safety and Security Plan

Similar to the No Action/No Project Alternative, additional facilities and people would be exposed to seismically-induced ground shaking and other earthquake-related hazards compared to baseline conditions. Regional projects, including Playa Vista and infill development, would also expose additional facilities and people to seismically-induced ground shaking hazards. The impact of increased exposure of facilities and people to ground shaking hazards resulting from Alternative D, in conjunction with regional projects, would be reduced to a less than significant level by designing structures in accordance with the requirements of the UBC and the City of Los Angeles Building Code.

Other geologic hazards are dependent on local conditions and would not necessarily apply to other projects in the vicinity of LAX, including landforms, expansive soil, slope stability, fault surface rupture, or settlement. Identification of these local hazards relies on site-specific investigations and they are not considered cumulative in nature.

4.22.8 Mitigation Measures

Under Alternatives A, B, C, and D potential impacts associated with ground shaking, fault surface rupture, liquefaction, seismic settlement, non-seismic settlement, expansive soils, slope stability, oil field gas, and construction would be less than significant; therefore, no mitigation is required.

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