Technical Report
LAX Master Plan EIS/EIR

12. Earth/Geology Technical Report

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Prepared for:

Los Angeles World Airports

U.S. Department of Transportation
Federal Aviation Administration

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1. INTRODUCTION

This Supplemental Report presents additional information to support the assessment of potential earth/geology impacts associated with implementation of the Los Angeles International (LAX) Airport Master Plan. This report provides data and analysis in support of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the LAX Master Plan pursuant to the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).

This report provides information regarding the affected environment and methodologies used to determine project impacts that is supplemental to the material presented in Section 4.22, *Earth/Geology*, of the EIS/EIR. Impacts associated with the information contained in this Supplemental Report are addressed in the EIS/EIR section.

The EIS/EIR evaluates four alternatives, including a No Action/No Project Alternative and three build alternatives (Alternatives A, B, and C). The study area for the earth/geology analysis includes the existing airport and the total (composite) area considered for acquisition under the three build alternatives, the Aircraft Noise Mitigation Program (ANMP) acquisition areas (Manchester Square and Belford), the off-site fuel farm sites, and the LAX Expressway alignments.

2. AFFECTED ENVIRONMENT/ENVIRONMENTAL BASELINE

The supplemental information presented in the following sections was derived from published references (as noted) and unpublished reports of consultant investigations from the LAWA files. Some of the data presented below are based on data from numerous sources in the LAWA files, and in such cases, the references are not listed within the text. However, these sources are listed in Section 4, *References*, at the end of this report. Additional information on existing conditions is presented in the Section 4.22, *Earth/Geology*, of the EIS/EIR.

2.1 Geology and Soils

2.1.1 Stratigraphy

In the vicinity of LAX (including Manchester Square, Continental City, LAX Northside/Westchester Southside, and the LAX Expressway alignments), the stratigraphy generally consists of a basement of Mesozoic schistose rock, overlain by the Miocene Puente Formation, the Pliocene Repetto and Pico Formations, the Lakewood Formation and, in the western areas, Older Dune Sands of Pleistocene age, and Recent Dune Sands of Holocene age. Analysis of air photos from the 1920s also indicates Holocene aged alluvium deposits may occupy local drainage channels at LAX as well. **Figure 1**, Generalized Stratigraphic Column, presents a generalized stratigraphic column for these formations.

Older Dune Sand immediately underlies the ground surface in the majority of the airport area including LAX Northside/Westchester Southside, with the exception of the portion east of Sepulveda Boulevard, and the extreme western portion. The Lakewood Formation is exposed in the eastern portion of the airport, and Recent Dune Sand is exposed in the extreme western area. Approximate areal extents of these formations are illustrated in **Figure 2**, Geologic Map. Cross-sections showing selected boring logs from some of the geotechnical and geologic investigations at LAX are presented in **Figure 3**, Cross Sections.

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. Older Dune Sand overlies the Lakewood Formation, and generally is composed of sand and silty sand. 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. Recent Dune Sand overlies Older Dune Sand, and is exposed in the area extending from the beach to approximately Pershing Drive.

The Recent Dune Sand consists of fine to medium grained, poorly graded sand. In the vicinity of the Scattergood Fuel Farm site and the oil refinery fuel farm site, as shown in **Figure 4**, Physiographic Map, the stratigraphy generally consists of a basement of Mesozoic schistose rock, overlain by the Miocene Puente Formation, the Pliocene Repetto and Pico Formations, the Lakewood Formation and Older Dune Sands of Pleistocene age, and Recent Dune Sands of Holocene age. Recent dune sand underlies the entire Scattergood Fuel Farm Site and the extreme western portion of the oil refinery located south of the airport. Older Dune Sand underlies the majority of the oil refinery.

2.1.2 Artificial Fill

Based on a review of geotechnical investigations conducted at LAX, artificial fill of varying thickness, age, and quality is present at different locations in the LAX area. Large amounts of fill were placed under the direction of the Los Angeles City Department of Public Works (LADPW) during the extensive phase of airport development in the late 1950s and early 1960s. No comprehensive source documenting the presence of artificial fill at LAX was discovered during review of LAWA files; however, most of the investigations reported at least some amounts of artificial fill, particularly in the Central Terminal Area (CTA). Several of the subsurface investigations included in the LAWA files reviewed reported the presence of artificial fill up to 23 feet in the CTA.

As part of the EIS/EIR, numerous investigation documents from the LAWA files were reviewed in an effort to map the presence of fill materials at LAX (see Section 4, *References*). However, the amount and general quality of information on fill location is very limited. The scope and area covered by most reports is relatively small, and reliable information on the depth of the fill is often lacking. The reports in the LAWA files only cover certain areas, with no information on the majority of the airport area. Comparisons between historic and current topographic maps were also made; however, because the map scales masked significant elevation differences and uncertainties regarding relative baseline elevations, no conclusions regarding the location of artificial fill could be developed.

2.1.3 Typical Foundations

Typical structures at LAX include multi-story passenger terminal buildings, aircraft cargo and maintenance structures, elevated roadway structures, roadway and runway structural pavements, and tall towers. Typical subsurface structures beneath LAX include utility conduits and pipelines, subterranean basement structures, subterranean pedestrian walkways, subterranean roadways, and large diameter tunnels, including the Coastal Interceptor Sewer, the North Outfall Sewer, and the North Central Outfall Sewer.

Most engineered structures located in the airport area are founded in either the Lakewood Formation or Older Dune Sand. The Lakewood and Older Dune Sand Formations are typically suitable foundation bearing material although foundations bearing in or near the local clay layers may require special design. Recent Dune Sand occurs on the extreme western edge, where currently few structures are located. Existing artificial fill has generally not been considered a suitable foundation material in any portion of LAX by previous investigators. Older Dune Sand serves as a foundation for structures in the majority of the central and west LAX area, while in the portion of the airport east of Sepulveda Boulevard, the Lakewood Formation generally is the foundation material.

Conventional spread footings and mat foundations are common foundations for structures in the airport area, based on a review of geotechnical investigation reports in LAWA files. Conventional spread footings are typically founded 24 inches below grade or into natural soils. Typical recommendations for allowable bearing pressures for continuous footings in the Older Dune Sands have been between 2,000 to 5,000 pounds per square foot (psf). Recommended bearing pressures for spread footings in the Lakewood Formation were as high as 6,000 psf (for a subterranean structure.) A mat foundation in Older Dune Sand was two feet thick and was designed using an allowable bearing pressure of 1,500 psf. A mat foundation in the Lakewood Formation was designed for an allowable bearing capacity of 6,000 psf. Deepened foundations are utilized in areas of deep fill and typical recommended diameters for piles range from 18 inches for parking structures to eight feet for elevated roadways.

2.2 Faults and Earthquakes

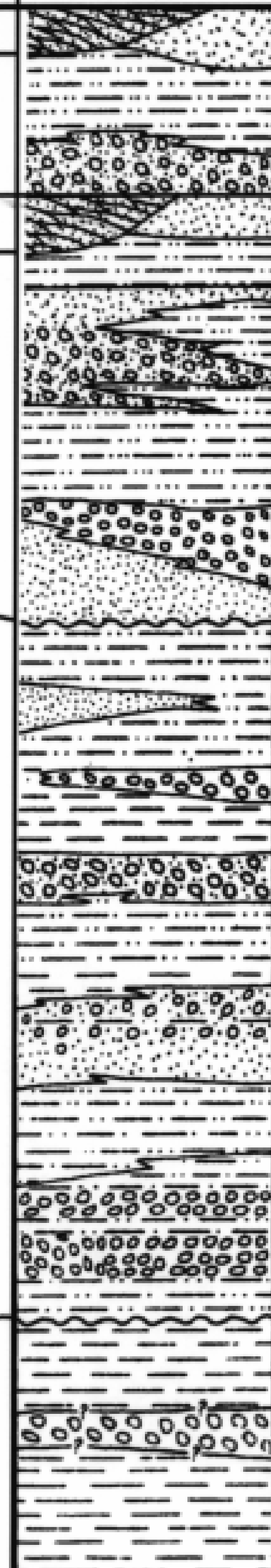
2.2.1 Faults

Southern California is one of the more seismically active regions of the United States. Numerous faults capable of causing earthquakes are located throughout the Los Angeles Basin as shown in **Figure 5**, Fault Map.

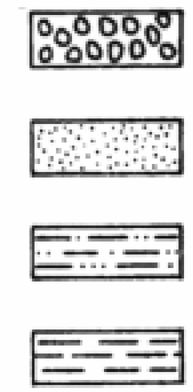
In general these faults represent a boundary between two tectonic plates of the earth's crust, known as the Pacific Plate and the North American Plate. These two crustal plates move relative to each other in response to forces within the earth. In the Los Angeles Basin, this plate movement typically occurs along

SYSTEM	SERIES	FORMATION	AQUIFER AND AQUICLUDE	MAX. THICKNESS (FEET)	PREVIOUS FORMATION NAMES*	PREVIOUS AQUIFER NAMES*
QUATERNARY	RECENT	ACTIVE DUNE SAND	SEMIPERCHED	60	ALLUVIUM	SEMIPERCHED †
		ALLUVIUM	BELLFLOWER AQUICLUDE	140		
			GASPUR	120		GASPUR †
	UPPER PLEISTOCENE		BALLONA	40		"50 FOOT GRAVEL"
		OLDER DUNE SAND	SEMIPERCHED	200	TERRACE COVER	
			BELLFLOWER AQUICLUDE		PALOS VERDES SAND	SEMIPERCHED †
		LAKEWOOD FORMATION	EXPOSITION ARTESIA	140	UNNAMED UPPER PLEISTOCENE	
			GARDENA	160		GARDENA †
			GAGE	160		'200 FOOT SAND"
		UNCONFORMITY			LOCAL UNCONFORMITY	
	LOWER PLEISTOCENE	SAN PEDRO FORMATION	HOLLYDALE	100	SAN PEDRO FORMATION	
			JEFFERSON	140		
			LYNWOOD	200		"400 FOOT GRAVEL" †
			SILVERADO	500		SILVERADO †
			SUNNYSIDE	500		
		LOCAL	UNCONFORMITY			
TERTIARY	UPPER PLIOCENE	PICO FORMATION	UNDIFFERENTIATED		PICO FORMATION	

LITHOLOGY



LEGEND OF LITHOLOGY



* DESIGNATIONS AND TERMS UTILIZED IN "REPORT OF REFEREE" DATED JUNE 1952 PREPARED BY THE STATE ENGINEER COVERING THE WEST COAST BASIN

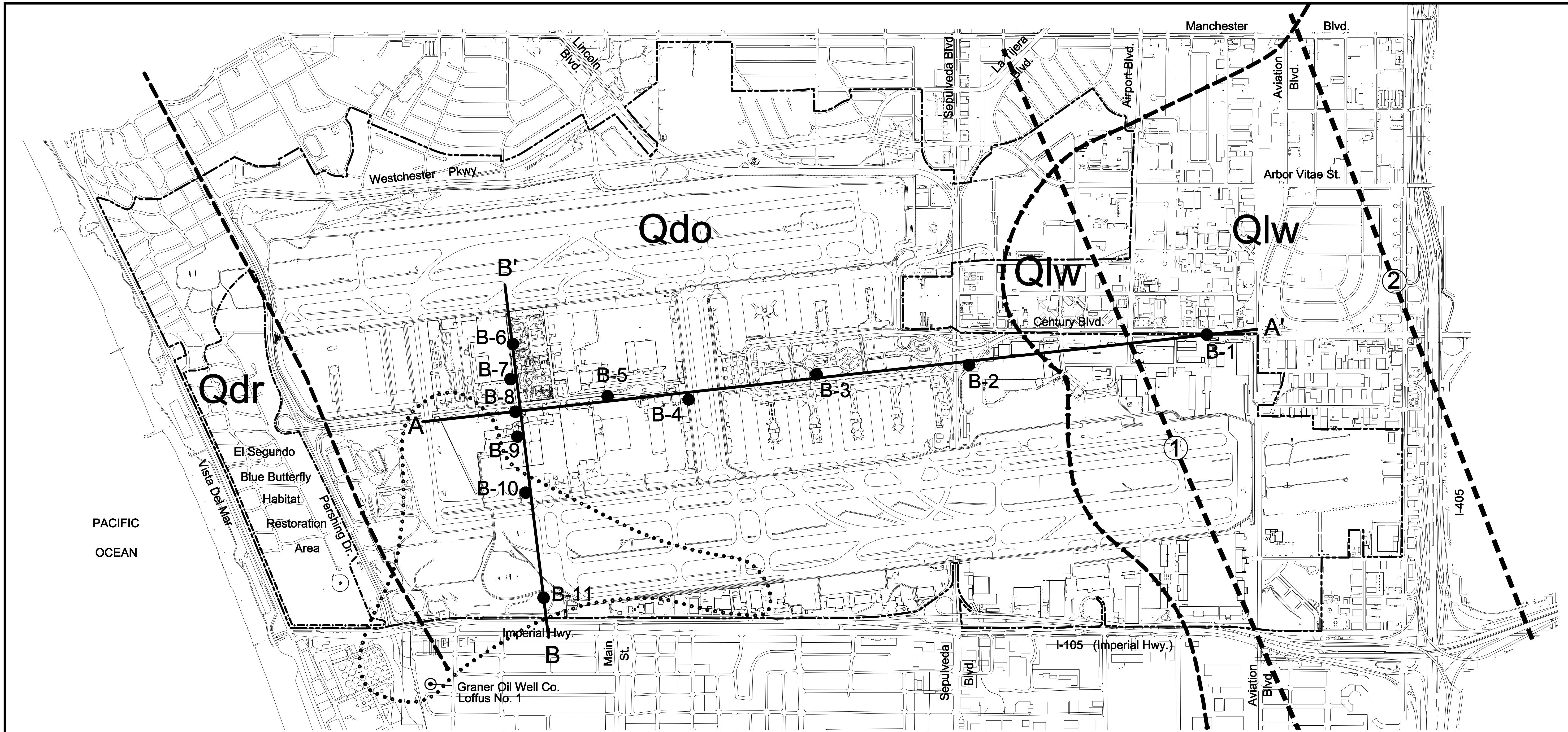
† DESIGNATED AS "WATER BEARING ZONES" IN ABOVE NOTED REPORT OF REFEREE

REFERENCE: CALIFORNIA DEPT. WATER RESOURCES, BULLETIN 104 (1961).

Los Angeles International Airport Master Plan

Generalized Stratigraphic Column
Coastal Plain of Los Angeles County

Figure 1



LEGEND

Notes:

Borings from: CDM, 1994, Boring B-1
Moore & Taber, 1980, Boring B-2
Ralph Stone & Co., Inc. 1991, Boring B-3
HLA 1993, Borings B-4, B-6 & B-7
ENSR, 7-1994, Borings B-8, B-9 & B-10
Leroy Crandall & Associates, 4-1989, B-5 & B-11

300' 600' 1,800'
600' 0 1,200'

Qdr — Recent Dune Sand

Qdo — Older Dune Sand

Qlw — Lakewood Frromation

Geologic Contact

A—A' Location of cross section (See Figure 5)

(1) Approximate Location of Charnock fault (Leroy Crandall, 1989, CDMG FER, 1978)

(2) Approximate Location of Charnock Fault (DWR, 1961)

Location of Boring

Approximate Location of Hyperion Oil Field (Leroy Crandall, 1989)

LAX Existing Property Line

El Segundo Blue Butterfly Habitat Restoration Area

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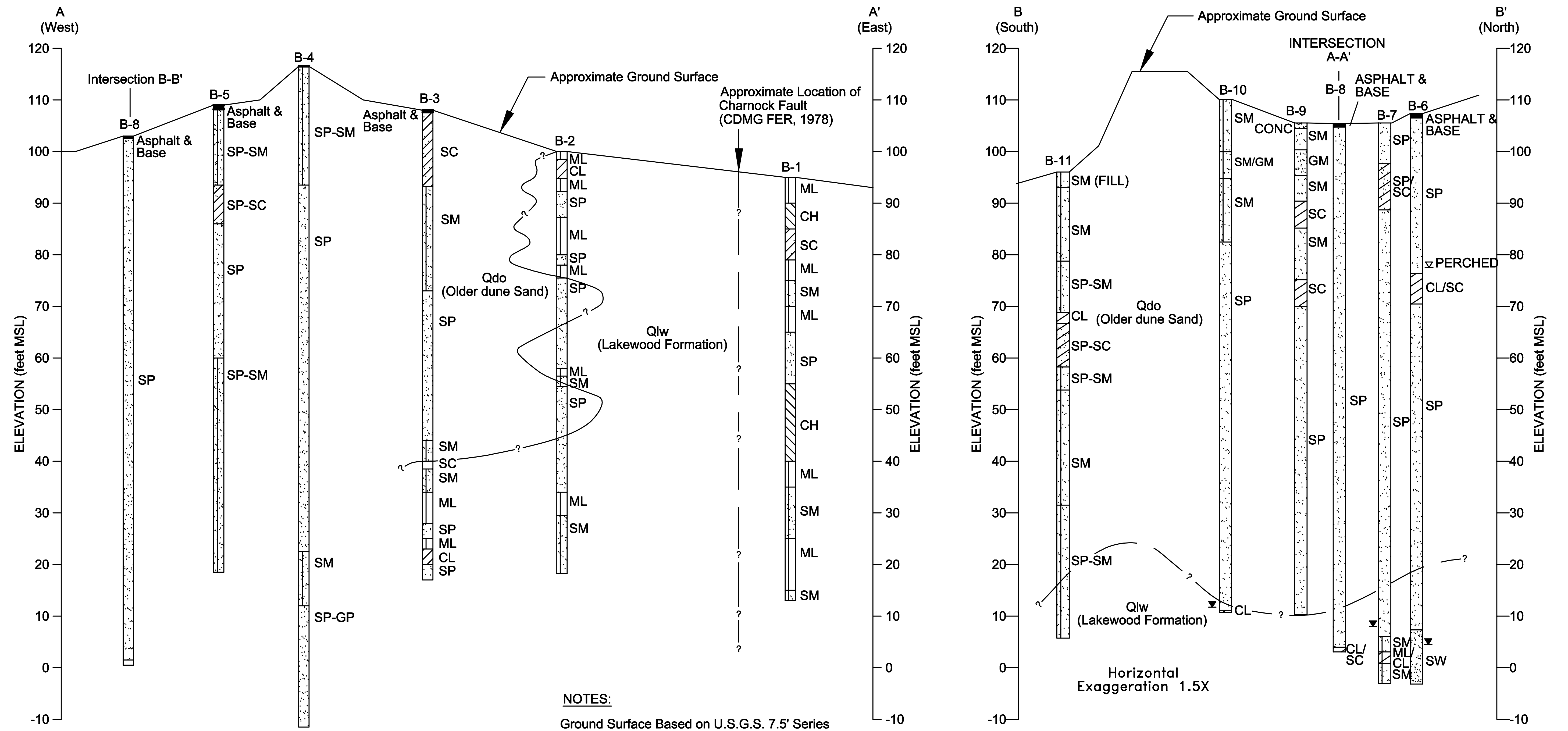
GEO2A.DWG Alt-Excond

Los Angeles International Airport Master Plan

Geologic Map

Figure 2



NOTES:

Ground Surface Based on U.S.G.S. 7.5' Series Topographic, Venice Quadrangel 1964, Photorevised 1981, and Elevations From Borings B-2, B-4, B-5, B-6, B-7 and B-11.

Borings from: CDM, 1994, Boring B-1
Moore & Taber, 1980, Boring B-2
Ralph Stone & Co., Inc. 1991, Boring B-3
HLA 1993, Borings B-4, B-6 & B-7
ENSR, 7-1994, Borings B-8, B-9 & B-10
Leroy Crandall & Associates, 4-1989, Borings B-5 & B-11

U.S.C.S. SYMBOLS

SP - Poorly Graded Sand
SW - Well Graded Sand
SM - Silty Sand
SC - Clayey Sand
GM - Silty Gravel
ML - Silt or Sandy Silt
CL - Clay Low Plasicity or Sandy Clay
CH - Clay high Plasticity

0 10' 20'
Horizontal & Vertical Scale

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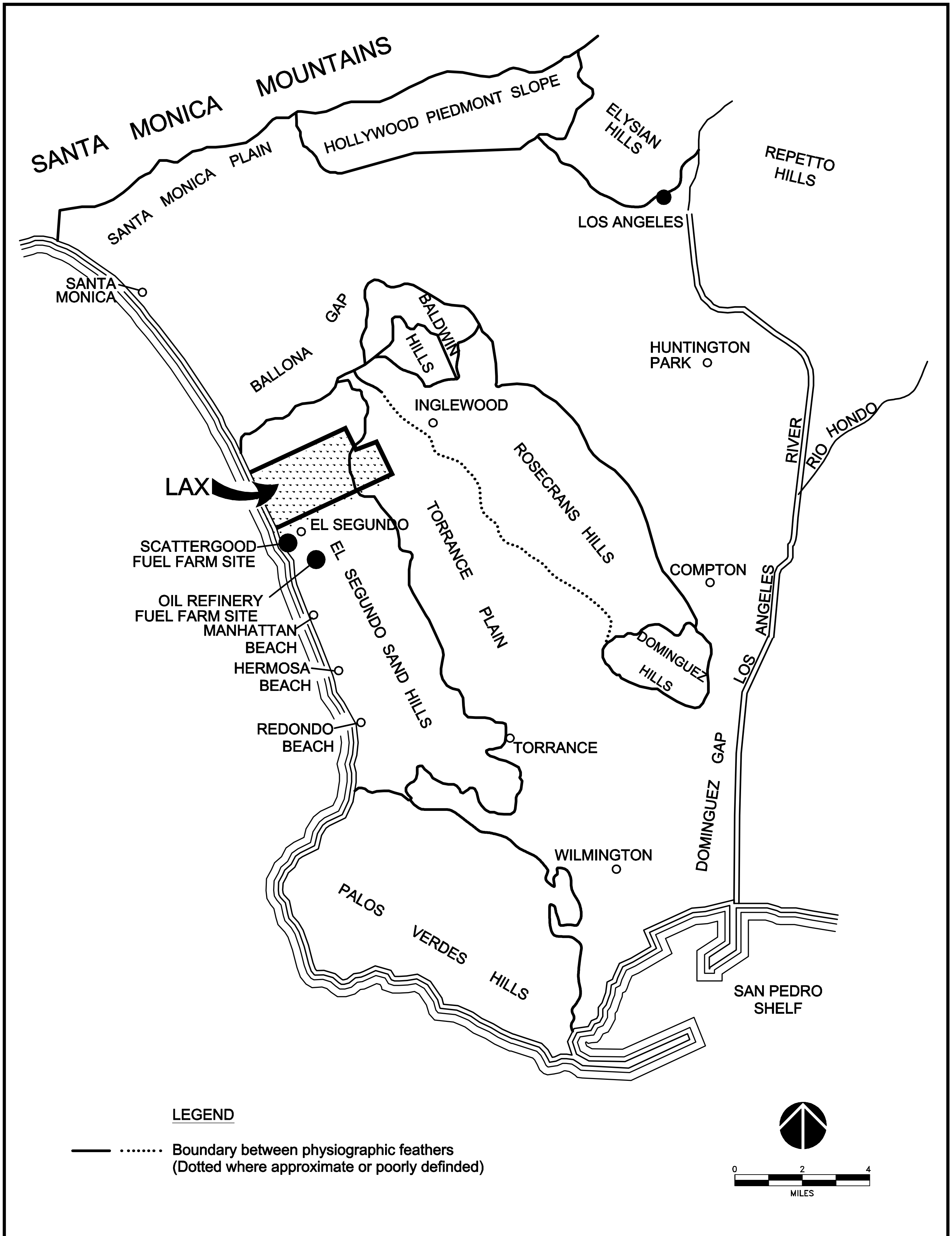
Los Angeles International Airport Master Plan

Cross Sections A-A' and B-B'

Figure 3



Reference: California D.W.R. Bullet in 104 (1961).

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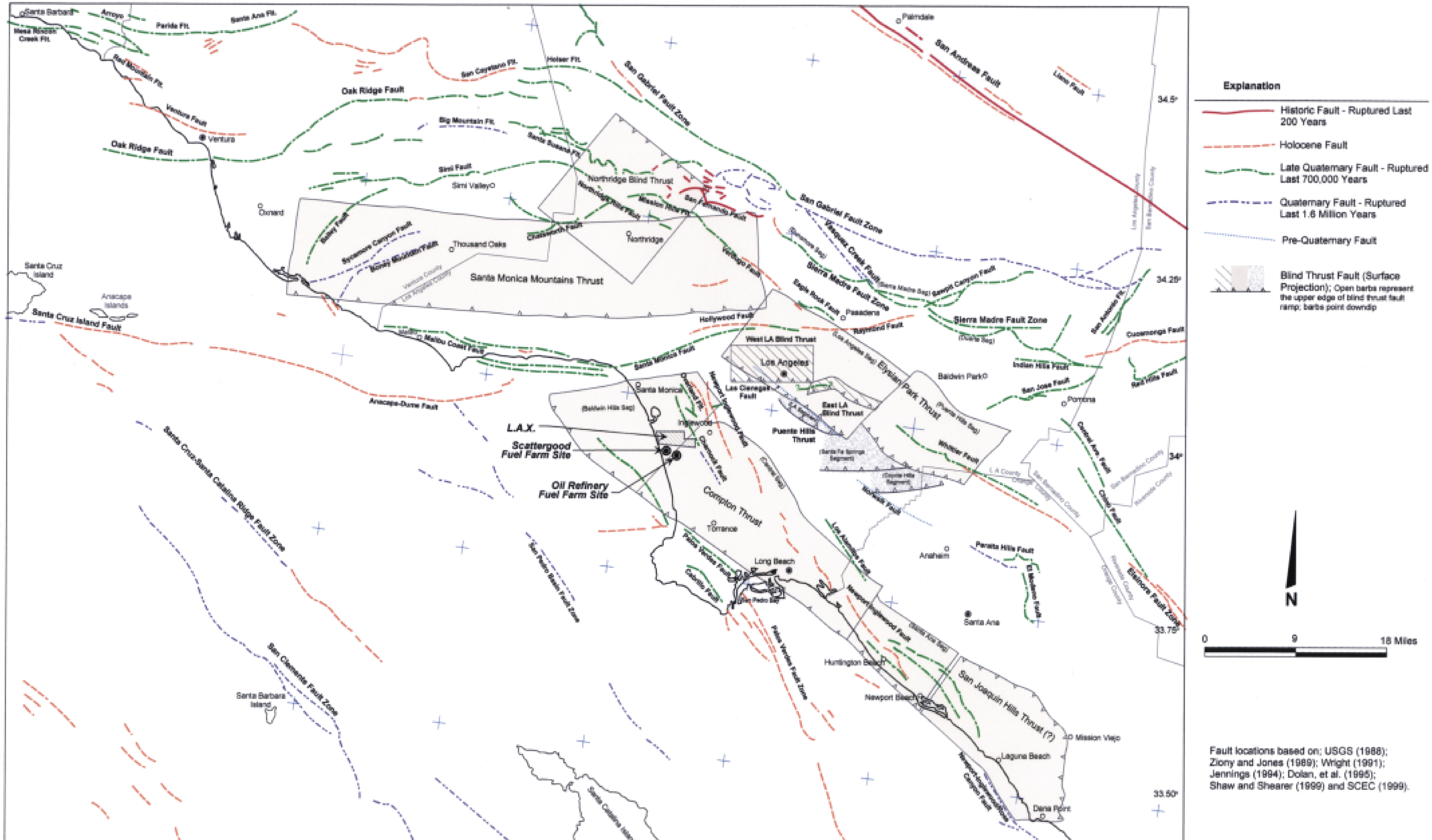
Los Angeles International Airport Master Plan	Physiographic Map	Figure 4



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).

Los Angeles International Airport Master Plan

Fault Map

Figure 5

faults and related fold belts. When movement along one of these faults occurs, it can occur relatively slowly and continuously, or it can occur episodically and relatively quickly. It is this later type of fault movement that can result in rapid releases of large amounts of energy and cause earthquakes (or seismic events). Faults are classified by the California Department of Conservation, Division of Mines and Geology (CDMG), as "active" if there is evidence of movement along the fault within the last 11,000 years.

The nearest dominant fault feature in the LAX vicinity is the 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.

Two smaller faults, the Overland and the Charnock Faults, parallel the NIFZ to the southwest. The Overland Fault is considered potentially active (see **Figure 5**). The Charnock Fault lies to the west of the Overland Fault, and is also considered potentially active. The nature and even the existence of the Charnock Fault in the LAX vicinity is uncertain. Review of previous technical reports indicate the fault may extend towards and possibly beneath LAX in the vicinity of the east end of runways 25 RL. These reports include shallow, deep, and groundwater data from existing water wells, geophysical logs, soil borings, test pits and water level data.

The Charnock Fault was identified[1] as a groundwater barrier. They noted that the fault appeared to offset the base of the lower Pleistocene San Pedro Formation by 140 feet (42.7 m, east side down). The fault fails to displace the "50-foot gravel" (pre-Holocene or earliest Holocene age) of the Ballona Gap, but does appear to offset upper Pleistocene terrace deposits. The fault has apparently not been observed at the surface. Its attitude (orientation of the fault plane) is unknown, but it is presumed to have a near-vertical dip.[2] By analogy with the nearby Newport-Inglewood Fault, which has a similar orientation, the Charnock is typically considered to be a strike-slip fault. The east-side down displacement of the San Pedro Formation, however, indicates that the fault exhibits a significant vertical component of displacement in addition to strike-slip offset. Evidence exists for displacements on the Charnock Fault of approximately 140 feet in late Pleistocene units, but no displacements in Holocene units have been reported. Because the Charnock Fault does not displace Holocene deposits, it is considered a low potential fault.

Poland et al.[3] reported that the fault dies out to the southeast of the Ballona Gap before reaching the vicinity of LAX. The California Department of Water Resources reports that the fault extends southward past LAX to Gardena, but that groundwater barrier effect of the Charnock Fault decreases to the south the south of the Ballona Gap.[4] However, another investigation of groundwater flow directions for the Silverado Aquifer in the vicinity of the east end of LAX suggest that the effect is still present in the LAX area.[5] Here, groundwater flows in a southeasterly direction towards the trace of the Charnock Fault, where the fault impedes flow but is not a barrier to flow toward the domestic well fields in the Inglewood-Hawthorne area. A Fault Evaluation Report by CDMG indicates the trace of Charnock Fault extending through the LAX area.[6] Aerial photographs reviewed for the LAX EIS/EIR show some evidence of linear features which could indicate faulting in the area of the projected trace of the Charnock Fault near LAX as shown in **Figure 6**, Composite Aerial Photo Lineament Map.

In 1999, Geo-Consultant conducted a limited investigation method 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.[7] Geo-Consultants performed a surface geophysical survey (electotelluric survey). No subsurface investigation was conducted as part of the investigation. Geo-Consultants 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

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1 Poland, J.F., et al., Geology 1 Hydrology and Chemical Character of Groundwater in the Torrance-Santa Monica Area, California (USGS 1461), 1959; Castle, R.O., Surficial Geology of the Beverly Hills and Venice Quadrangles, California, 1960.

2 Smith, T.C., Fault Evaluation (FER-71), 1978.

3 Poland, J.F., et al., Geology, Hydrology and Chemical Character of Groundwater in the Torrance-Santa Monica Area, California (USGS 1461), 1959; Castle, R.O., Surficial Geology of the Beverly Hills and Venice Quadrangles, California, 1960.

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

5 Mclaren Environmental Engineering, Site Investigation and Evaluation of Remedial Measures Report, May 8, 1987.

6 Smith, T.C., Fault Evaluation (FER-71), 1978.

7 Geo-Consultants, Inc., Geological and Geophysical Survey for Ground-Water Characterization, Charnock Fault Evaluation, August 25, 1999:

the intersection of Airport Boulevard and Sepulveda to near the intersection of Inglewood Avenue and 104th Street). Geo-Consultants 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.

2.2.2 Earthquake Generating Characteristics of Faults Affecting LAX

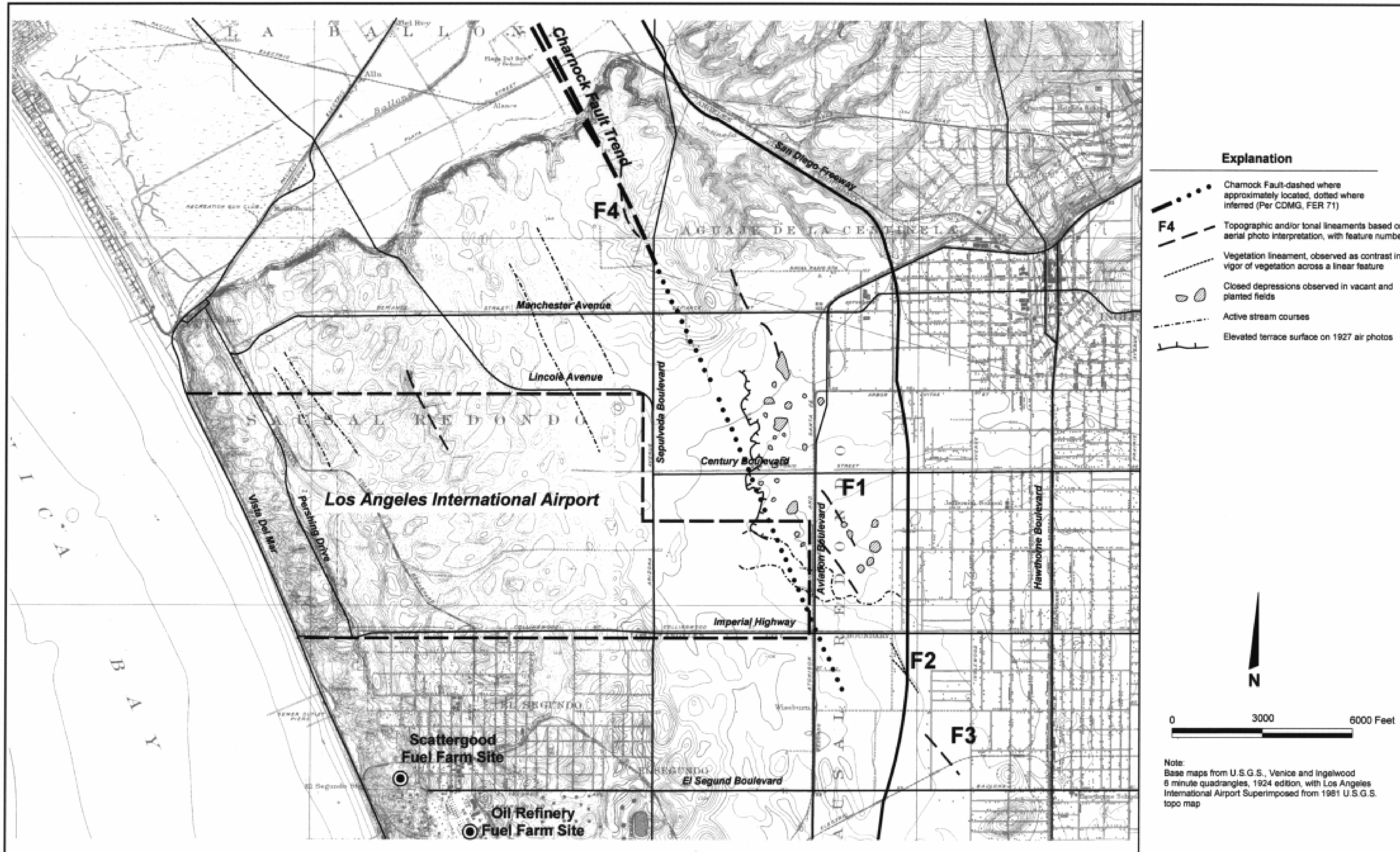
Over the past century, efforts have been made to quantify earthquake (or seismic) activity for research and planning purposes. Two common methods for measuring and recording seismic activity in Southern California are; 1) human observations of damage intensity to engineered structures and, 2) instrumental readings. Observed intensity data are relatively easy to gather, but somewhat subjective. Much of the early intensity data was obtained by collection, review, and analysis of mission records, newspaper articles, letters, diaries, and other sources. Several scales have been developed to rank intensity observations. 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. A MMI of 'I' generally would not be noticed by humans. A MMI of 'XII' would include nearly total destruction of most engineered structures. Detailed descriptions of Mercalli intensities are presented in **Table 1**, Abridged Modified Mercalli Intensity Scale.

Table 1

Abridged Modified Mercalli Intensity Scale

Intensity	Description
I	Not felt except by a very few under especially favorable circumstances.
II	Felt by only a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of a truck. Duration estimated.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Railway lines bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

Source: California Department of Conservation, Division of Mines and Geology, Planning Scenario for a Major Earthquake on the Newport-Inglewood Fault Zone, Special Publication 99, 1988.



Los Angeles International Airport Master Plan	Composite Aerial Photo Lineament Map	Figure 6

Instrumental readings and analysis of recordings or seismograms provide data on earthquake size (i.e., magnitude), and location or epicenter, among other things. In the 1930s, Charles Richter developed the magnitude scale. The magnitude (M) of an earthquake is based on the maximum-recorded amplitude of motion measured by a Wood-Anderson seismograph normalized to a distance of 100 km. An increase in magnitude from six to seven represents a ten-fold increase in the recorded peak motion. Earthquake magnitudes greater than five are generally responsible for damage to structures. The generally recognized upper bound for earthquake magnitudes is between eight and nine. Instruments can also record the ground acceleration caused by an earthquake. The earthquake induced acceleration value is commonly measured as a decimal fraction of the earth's gravitational constant. For example, an earthquake producing a ground acceleration of ½ that of earth's gravity would be rated as "0.5 g."

It is important to note that an earthquake's magnitude is a constant value independent of other factors. However, intensity values, ground acceleration, and seismic shaking are dependent on many different factors, including distance from the earthquake location or epicenter, and rock or soil types. Therefore, an earthquake of a given magnitude would produce different seismic intensities at different locations.

Scientists have known for some time that earthquakes are associated with movement along faults in the earth's crust. In an effort to quantify and study earthquakes' characteristics, scientists have created what are known as seismic source models (SSM). An SSM identifies the location and characteristics of fault(s) or seismogenic sources within a particular area. Within the last ten years, several dozen seismic source models (SSM) have been developed for Southern California by various researchers. In order to provide estimates of future seismic shaking, also known as strong ground motion, CDMG and the Southern California Earthquake Center (SCEC) have developed detailed SSMs. Estimates of strong motion can be used by engineers, planners, emergency service organizations and others for design of structures, land use planning, and emergency response. The type of SSM used effects the estimates of future strong motion used for design and planning purposes at LAX. Several different SSMs were referred to in reports for previous LAX projects, and components of different SSMs were used in the evaluation of ground shaking for the EIS/EIR as described in Section 3, *Methodology,* below.

It is unlikely that ruptures associated with large earthquakes are truly independent from all other faults in the region. There is evidence from both historic and prehistoric earthquakes that fault rupture on two or more faults may occur during a "single" earthquake. Earthquakes that rupture multiple fault segments would result in increased estimates of magnitude, particularly in the use of moment magnitude (Mw). Moment magnitude is directly related to the size of the rupture area. Therefore, for purposes of this study, seismogenic source regions were considered as both individual and multiple faults.

Shown in **Table 2**, Fault Source Parameters, are the significant seismogenic (capable of rapid strain energy release resulting in a tectonic earthquake) faults or source zones in the general LAX area. Also shown in the table are estimated source/site distances and estimated significant earthquake magnitudes for each seismogenic source.

The maximum credible earthquake (MCE) is defined in CDMG Note 43 as "the maximum earthquake that appears capable of occurring under the presently known tectonic framework." The MCEs presented in **Table 2** are moment magnitudes (Mw) obtained from (1) the most recent Fault Parameter Data Tables available on the CDMG Seismic Hazard web page**,** and (2) recent scientific publications. These estimates of moment magnitude were based on fault area (i.e., the length and width of the fault) and the definition of moment magnitude by Hanks and Kanamori.[8]

2.2.3 Historic Earthquakes

The Los Angeles Basin has experienced a number of significant earthquakes since the first record of a significant event in 1769. **Table 3**, Historic Seismicity of the LAX Vicinity, summarizes the events with a magnitude greater than 5 within a distance of 100 kilometers of LAX. Additional details are provided below for some of these earthquakes as they relate to the LAX vicinity. Possibly the first historic earthquake affecting the LAX area was on September 24, 1827. People in Los Angeles reportedly ran outdoors in panic. Thirty years later in 1857, the Fort Tejon earthquake shook California. Intensities from this magnitude (M) 7.5+ earthquake may have reached VI to VII in the LAX vicinity.

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8 Hanks, T.C. and Kanomori, H., A moment magnitude scale, Journal of Geophysical Research, Vol. 84, pp. 2348-2350,1979.

Table 2

Fault Source Parameters

Fault Zone[1] (source)	Closest Map Distance to LAX (Site B, km)	Slip Rate[2] (mm/yr.)	Maximum Credible Earthquake (MCE) Moment Magnitude[3]	Maximum Credible Earthquake (MCE) Estimated MCE[4]
Strike-slip				
1. Newport-Inglewood	5.1	0.1 – 1.2	6.9	7.0
(Charnock-Overland)	1.6	LQ	-	6.5
2. Palos Verdes	9.4	3.0	7.1	7.0
(Cabrillo)	21	H	-	6.5
3. San Andreas (Mojave segment)	72	34	7.5	7.5
4. San Andreas (Coachella to Carrizo Segment)	72	20-35	7.9	8.0
5. San Clemente	71	1.5	7.9	7.25
6. San Gabriel	39	0.5	7.0	7.5
7. Whittier – Elsinore	37	2.5-3.0	7.1	7.5
Dip-slip and Blind				
8. Anacapa – Dume	30	3	7.3	-
9. Channel Islands Thrust	64	1.5	7.4	-
10. Compton	0	1.4	6.8	-
11. Elysian Park	13	1.5	6.9	7.0
12. Hollywood-Santa Monica-Malibu Coast	13	1.0 – 1.5	7.3	-
13. Oakridge (fault ruptured 1/17/94 Northridge earthquake)	29	1.6	-	6.7+
14. Puente Hills	17	0.5-2	6.5	-
15. Raymond	28	0.1-0.22	6.5	-
16. Santa Monica Mountains	18	1-4	7.3	-
17. Santa Susana	42	5-7	6.6	7
18. Sierra Madre-San Fernando	36	0.6	7.0+	7.5
19. Simi-Santa Rosa	50	1.0	6.7	7.5
20. Verdugo	30	2.5	6.7	6.75

Distance = Estimated source/subject site distance.
H = Evidence of Holocene fault rupture (Jennings, 1994). Slip rate data not available.
LQ = Evidence of Late Quaternary fault rupture (Jennings, 1994). Slip rate data not available.

[1] Hauksson (1990), Jennings (1994), Dolan and others (1995), Mualchin (1996).
[2] Peterson and Wesnousky (1994), Dolan and others (1995), CDMG (1996), Johnson and others (1996), Walls and others (1998), Rubin and others (1998), SCEC (1999), Shaw and Shearer (1999).
[3] Moment magnitude, Dolan and others (1995), Shaw and Shearer (1999). Refer to Earthquakes and Seismicity.
[4] Estimated Maximum Credible Earthquake (Mualchin, 1996).

Source: Taylor-Hunter Associates, Inc., 2000.

An event in June of 1920 caused extensive damage in the Inglewood area. The earthquake was one of a series of more than 100 events that occurred in the Los Angeles area between February and the end of September, 1920. In August of 1930, an offshore earthquake in Santa Monica Bay caused cracking and slope failures along Palisades Park bluff north of Venice and a two-foot tsunami at Santa Monica.

The largest historic earthquake to affect the area around and near LAX most likely occurred on March 11, 1933 south of Los Angeles. The event, known as the Long Beach earthquake (M 6.4), was centered offshore south of Newport Beach, along the NIFZ (the NIFZ is believed to be capable of generating a maximum credible earthquake of 6.9. The fault rupture appears to have propagated to the northwest. Extensive damage occurred in coastal areas due to settlement and liquefaction. Intensities of VII were common in the LAX vicinity. The actual type and extent of damage at LAX is not clear. Several smaller earthquakes were felt in the area in 1938 and 1939. The 1938 and 1939 events occurred to the south in the Long Beach/Huntington Beach area.

Table 3

Historical Seismicity (M>5) of the LAX Vicinity (100 km radius)

Earthquake	Date	Moment Magnitude (Mw)	Local Magnitude (M>5)	Latitude	Longitude	Epicentral Distance (km)
Los Angeles Basin	7/28/1769	-	6.0	34.0	118.0	38
Wrightwood	12/8/1812	-	7.0	34.4	117.7	84
Los Angeles Region	9/24/1827	-	5.5	34.0	119.0	55
Los Angeles Region	7/11/1855	-	6.0	34.1	118.1	33
Fort Tejon	1857		7.5			
San Bernardino Region	12/16/1858	-	6.0	34.0	117.5	84
Pico Canyon	5/19/1893	-	5.8	34.1	119.4	94
Lytle Creek Region	7/30/1894	-	6.0	34.3	117.6	84
Lytle Creek Region	7/22/1899	-	5.8	34.3	117.5	92
Glen Ivy Hot Springs	5/15/10	-	5.5	33.7	117.4	97
Los Angeles Region	6/20					
San Bernardino Region	7/23/23	-	6.0	34.0	117.3	102
Santa Monica Bay	8/30					
Long Beach	3/11/33	-	6.3	33.6167	117.9667	54
Gardena	1941					
Redondo/Gardena	6/19/44					
San Fernando	2/9/71	6.6	-	34.4112	118.4007	52
Point Magu	2/21/73	-	5.2	34.0667	119.0333	60
Point Magu	1/1/79	-	5.2	33.9433	118.6817	26
Santa Barbara Island	9/4/81	-	5.5	33.8094	119.1181	68
Whittier Narrows	10/1/87	5.9	-	34.0613	118.0785	33
Pasadena	12/3/88	-	5.0	34.1412	118.1327	33
Malibu	1/18/89	-	5.0	33.9167	118.6267	21
Sierra Madre	6/28/91	5.8	-	34.2590	118.0010	51
Northridge	1/17/94	6.7	-	34.2133	118.5370	32

Source: Robert E. Wallace ed., USGS Professional Paper 1515, 1990, and USGS earthquake catalogues.

Another Santa Monica Bay earthquake occurred on October 11, 1940 (M 4.6). Some damage was reported along the coast at Manhattan Beach and Redondo Beach. Nearly a year later, in late 1941, several earthquakes caused damage in Gardena, south and east of LAX. The largest event was M 5.4. On June 19, 1944, two events caused some damage in Redondo Beach and easterly near Gardena.

With the exception of several minor events, the general region was relatively quiet until the San Fernando earthquake of February 9, 1971 (M 6.5; Mw 6.6). Local observed intensities at LAX for this earthquake were on the order of VI. Another offshore earthquake occurred on September 4, 1981. The 1981 M 5.5 event induced relatively minor damage at Marina del Rey. No damage to LAX was reported following the October 1, 1987 Whittier earthquake (Mw 5.9). Local observed intensities at LAX for this earthquake were approximately V to VI. Another earthquake (M 5.0) in the Malibu area occurred on January 19, 1989. The event caused minor damage in the Malibu area. Significant damage at LAX was not reported for any of the 1971 through 1989 earthquakes.

The most recent earthquake to cause damage in the vicinity of LAX was the January 17, 1994 Northridge earthquake (Mw 6.7). Strong shaking, recorded on accelerographs through the Los Angeles Basin, may have reached 0.15 to 0.2 times the acceleration of gravity in the LAX vicinity. Liquefaction was observed along coast beach and harbor areas, to the north and south of LAX. Regional MMIs were on the order of VI to VII. Several slope failures occurred to the north along coastal bluffs in Santa Monica and Pacific Palisades. The City of Santa Monica suffered substantial damage. There was no major damage at LAX.

2.3 Hydrogeology

LAX is situated within the West Coast Groundwater Basin. The West Coast Groundwater Basin is contained by the Ballona Escarpment to the north, the NIFZ to the east, the Palos Verdes Hills to the south, and the Pacific Ocean to the west. Groundwater flow in the West Coast Groundwater Basin is controlled by hydrologic properties of unconsolidated, permeable Quaternary sediments that are partially separated by less permeable aquitards. Groundwater beneath LAX is not used for drinking water (see Section 4.23, *Hazardous Materials*, of the EIS/EIR).

Regional groundwater flow in the West Coast Basin is generally in a westerly direction toward the Pacific Ocean. However, historical dewatering in and around the LAX vicinity has exposed the groundwater to saltwater encroachment. A seawater intrusion abatement project has been implemented by the Los Angeles County Department of Public Works. The project, deemed successful, created an injection well barrier (an elongated groundwater high paralleling the coast) that runs south of LAX. Thus, approximately west of Sepulveda Boulevard, groundwater flows westerly; this is considered to be a brackish water area. Approximately east of Sepulveda Boulevard, groundwater flows to the east.

Groundwater occurs in several aquifers within the West Coast Groundwater Basin. Water bearing units and aquitards include the localized semiperched aquifer, the upper and lower Bellflower aquitards, and the Gage aquifer, respectively. The Gage Aquifer is underlain by the El Segundo Aquiclude and the Silverado Aquifer.

Locally, semiperched groundwater exists in discontinuous, unconfined clay lenses in the Lakewood Formation and Older Dune Sand. In the LAX vicinity, discontinuous perched groundwater is encountered at depths of approximately 20 to 60 feet. Additional details regarding perched groundwater are presented in the discussion of liquefaction later in this report.

The upper and lower Bellflower Aquiclude (also known as the Manhattan Beach Aquiclude), corresponds to the upper and lower portions of the Lakewood Formation, and houses the Gage Aquifer (also known as the 200 Foot Sand). The Gage Aquifer is unconfined and groundwater observation wells indicate that average water levels are at 100 to 110 feet below ground surface and that the general flow direction is toward the southeast.

The El Segundo Aquiclude underlies the Gage Aquifer and is estimated to be 40 to 100 feet thick. It contains the Silverado Aquifer, which occurs throughout coastal portions of the Los Angeles Basin, and is the most productive aquifer in the basin. Located within the San Pedro Formation, the Silverado Aquifer ranges from 100 to 500 feet thick. In the LAX vicinity, west of the Gardena syncline, the El Segundo Aquitard is discontinuous allowing the Gage Aquifer to merge with, and become indistinguishable from, the Silverado Aquifer.

2.4 Geologic Hazards

2.4.1 Seismic Hazards

Seismic hazards are caused by, or associated with, earthquakes (see EIS/EIR Section 4.22, *Earth/Geology* discussion of Seismic Hazards). These hazards commonly include co-seismic fault surface rupture and associated regional tectonic deformation (i.e., uplift and subsidence), strong motion or seismic vibratory shaking (ground shaking), liquefaction, slope failures, seismic settlement, seismic sea waves (i.e., tsunami), seiches, and flooding due to dam and/or dike failure. Most of these seismic hazards are discussed in the Seismic Hazards section of Section 4.22, *Earth/Geology*, of the EIS/EIR. Additional details on these hazards and their relevance to conditions at LAX are discussed below.

2.4.1.1 Fault Surface Rupture and Co-seismic Ground Deformation

Fault surface rupture occurs during an earthquake when movement along the fault displaces or causes deformation at the ground surface. Horizontal and/or vertical surface displacements along faults during a seismic event can range from zero to tens of feet. The Alquist-Priolo Fault Zoning Act was enacted by the State of California in 1972 to mitigate the damage caused by fault rupture during an earthquake. Under this act, faults throughout the state are evaluated for surface rupture potential, and fault zones are established around active faults.[9] Although no earthquake fault zones lie within the LAX Master Plan boundaries, the NIFZ is regulated by the Act, and lies close to LAX.

Although the site is not located within an existing Alquist-Priolo Earthquake Fault Zone, the Charnock Fault may be located near or through portions of the site (see **Figure 2**) as discussed in Section 2.2.1, *Faults*. Review of available geologic literature indicates the Charnock Fault has displaced Quaternary to Late Quaternary units; however, no offset of Holocene units has been reported. The potential for surface rupture associated with the Charnock Fault is considered low. Nevertheless, the existing data cannot

[9] Hart, E., et al., Fault-Rupture Hazard zones in California, Alquist – Priolo Earthquake Fault Zoning Act with Index to Earthquake Fault Zone Maps, (Pub. 49), 1997.

preclude surface rupture of the Charnock Fault at LAX during the life of the facility either independently or in conjunction with movement along the NIFZ or other yet unidentified fault(s).

The Charnock Fault may extend beneath LAX in the vicinity of the east end of Runways 25 R,L. It appears theoretically capable of rupturing in a Mw~6.5 event, corresponding with 0.7 m of horizontal and 0.5 m of vertical displacement at depth (see Section 3, *Methodology*). Some surface rupture would be anticipated in such an event where the Holocene overburden measures less than about 12.5 m (41 feet) in thickness. Where the primary rupture extends to within 5 m (16 feet) of the surface, the resultant surface rupture pattern would consist of a 1.2 m (4 feet) wide fault zone, across which about 0.7 m of horizontal and 0.25 m of vertical offset (down to the east) may be anticipated. Where the overburden thickness is greater than 5 m (but less than 12.5 m), the fault zone would likely be wider, but the overall offsets lower than those indicated above. Sympathetic (triggered) slip due to earthquakes on nearby faults may occur at depth along the Charnock Fault, but would appear unlikely to result in surface rupture along the fault trace.

The potential impacts of such a rupture include moderate to severe damage to the runway or other structures at LAX. FAA regulations stipulate that any three-inch or larger hole in a runway necessitates shutdown of airport operations.

Localized folding and distributed ground fracturing associated with active faulting (known as co-seismic ground deformation) are common in active seismogenic regions such as Southern California. These types of geologic structures are often characterized at the surface as active fold scarps or monoclinal warps. The California Seismic Safety Commission recommended to the Governor in their recent report entitled *Turning Loss to Gain* that the CDMG, as part of its Seismic Hazards Mapping Program, "…expand the categories of seismic hazards to create a new hazard zone to address ground deformation associated with folding and fracturing."

These types of geologic structures can present considerable risks to structures intended for human occupancy. Ground deformation of this type is not considered significant unless it results in substantial elevation changes, shortening, or ground displacement (i.e., fracturing). It is difficult to accurately predict the locations of future co-seismic ground deformation. Potentially significant co-seismic ground deformation during the typical 50-year design life of a new facility in the LAX vicinity cannot be precluded based on the available data. However, the potential for damage to the LAX area from such an event is probably similar to that of other areas of the Los Angeles Basin located within similar proximity to the NIFZ or other active faults.

2.4.1.2 Ground Shaking

The proximity of LAX to large, active faults suggests that strong ground shaking could occur at the site during the design life of the airport. Two measures are typically used to evaluate the severity of ground shaking: local site intensity and instrumental recordings of ground movement. Both of these measures are dependent on the magnitude of the earthquake, and distance from the causative fault. The ground shaking would tend to be greater as the magnitude increases and the distance from the fault decreases.

Local site intensity, recorded in the U.S. using the MMI scale, is a subjective measure based on human perception and observed response of civil facilities. Descriptions of observations and damage associated with these intensities are provided in **Table 1**. Most of the Los Angeles Basin could potentially be subjected to a local MMI intensity of IX.

CDMG has produced several documents related directly to planning for postulated ground shaking intensity, including one that directly covers LAX entitled *Planning Scenario for a Major Earthquake on the Newport-Inglewood Fault Zone.* This document hypothesizes a particular earthquake on the NIFZ, and projects associated hypothetical ground shaking and ground failure. CDMG has indicated that local site intensities of VIII to IX could be experienced at LAX should a magnitude 7 earthquake occur on the NIFZ. Based on those hypothetical assumptions, certain facilities would be damaged, including LAX.

Instrumental recordings of ground motion, primarily ground acceleration, measure ground shaking in the horizontal and vertical directions with time. Instrumental recordings are the basis for structural design of buildings per the Uniform Building Code (UBC). The Los Angeles Basin and LAX are in seismic zone 4 (highest) per the UBC, indicating that the highest seismic acceleration forces be used in the design of structures.

The expected level of instrumental ground shaking at a location is typically estimated either for (1) a given earthquake scenario (deterministic method), or (2) a given likelihood of occurring (probabilistic method).

Both of these methods have different advantages and disadvantages and applicability to different types of projects. For the purposes of the EIS/EIR, both results of a probabilistic estimate by the State and a deterministic estimate performed for the EIS/EIR are provided.

The results of nationwide probabilistic analyses of ground shaking performed by the U.S. Geological Survey (USGS) and state-wide probabilistic analyses performed by CDMG indicate that peak horizontal ground accelerations corresponding to a 475-year annual return period of between 0.4 and 0.5g are expected to occur at LAX. This hazard level (475-year annual return period) is generally consistent with UBC design for normal structures.

For purposes of the EIS/EIR, the deterministic method was used to estimate the expected peak level of ground shaking for 24 different earthquake scenarios at three site locations (see Section 3, *Methodology,* and Tables 6, 7 and 8). Based on this analysis, the peak horizontal and vertical accelerations are estimated to be 0.63 and 0.55g, respectively, resulting from a magnitude 7.3 earthquake on the combined Compton and Elysian Park faults. A magnitude 6.9 earthquake on the NIFZ is expected to produce peak horizontal and vertical accelerations of 0.41 and 0.35g, respectively.

Detailed analyses of strong ground shaking close to the faults that occurred during the 1992 Landers, 1994 Northridge, and 1995 Hyogo-Ken (Kobe, Japan) earthquakes indicate that ground shaking at higher levels than previously anticipated can occur in close vicinity of the rupturing fault. These findings have affected changes to ground motion design provided in the most recent version of the UBC (1997). In addition, analysis of ground motions from these earthquakes suggests that stronger ground shaking can occur in the direction of rupture propagation. These "rupture directivity" effects are currently being used to evaluate the response of long-period structures, such as tall buildings and long bridges. Given that LAX is within 5 km of several active faults, the design-basis ground motions could be developed on a site-specific basis, including rupture directivity effects, depending on the nature of the individual project. Rupture directivity effects would typically include increases in spectral acceleration (a measurement of ground shaking) at periods of one second or greater. The greatest increase to account for these effects would tend to occur at periods of four seconds or greater.

The Seismic Hazard Mapping Act of 1990 (also known as the Brown Act) was enacted, in part, to address seismic hazards not included in the Alquist-Priolo Act, including strong ground shaking. Under this Act, the State Geologist is assigned the responsibility of identifying and mapping seismic hazard zones. Detailed maps showing levels of ground shaking hazards have not been published; however, a statewide map depicting ground shaking hazard on a regional scale for a certain seismic probability was published in 1999. There is currently no schedule for developing more detailed maps of ground shaking hazard in the LAX area.

2.4.1.3 Liquefaction

Liquefaction is a phenomenon that can occur in saturated granular soil during significant ground shaking. Liquefaction has also been reported in some clayey soils. Liquefaction can result in loss of ground strength and ground failure. The susceptibility of soil to liquefy tends to decrease as the density of the soil increases and the level of ground shaking decreases. The density of Quarternary-age sand deposits in the upper 30 feet is generally considered to be low to dense. Based on numerous studies of liquefaction, soil must be below groundwater level in order to liquefy. 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 conditions have been noted in the upper 60 feet at some locations at LAX. The thickness of saturated sand in perched groundwater layers would need to be on the order of several feet for liquefaction to occur. **Table 4**, Depth to Perched Water at Selected Locations, and **Figure 7**, Depth to Perched Water of Selected Locations, summarize some of the locations where perched water has been observed in the LAX area. The perched water information was collected from various references of investigation in the LAX area (see Section 4, *References*). A review of these references indicates that the presence of perched water varies greatly with area and possibly with time of year; information on the thickness of the saturated layer is typically missing.

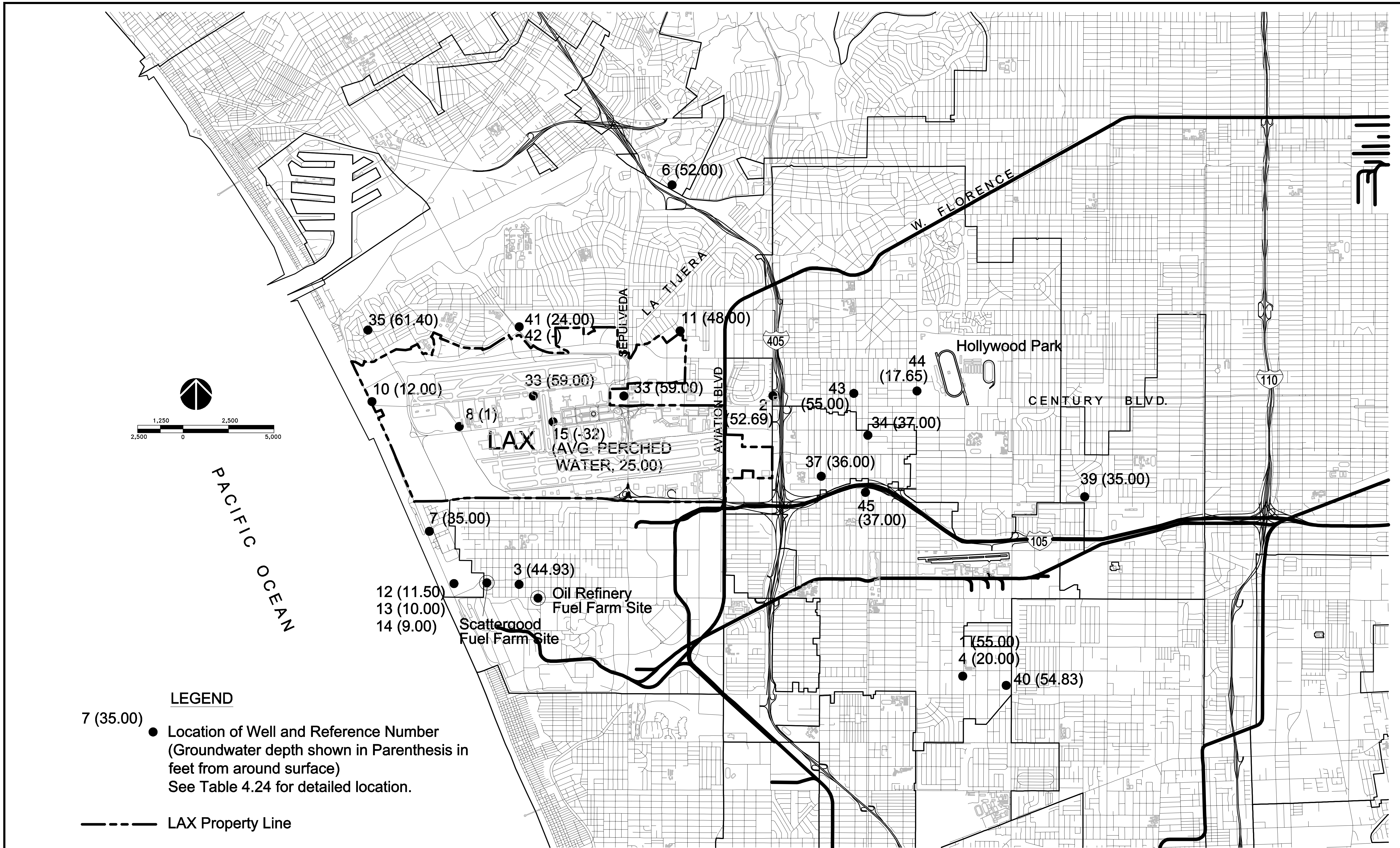

FIG7.DWG

10/04/00 11:20 AM

TAYOR-HUNTER

Los Angeles International Airport Master Plan

Depth to Perched Water at Selected Locations

Figure
7

Table 4

Depth to Perched Water at Selected Locations

Map Location	Facility	Address	Well No.	Depth to Perched Water	Date	Reference	Notes
1	76 Products Station	12806 S. Prairie Ave. Hawthorne, CA 90250	I-11006	55.00		RWQCB, 1998	
2	ARCO Gas Station	5201 W. Century Blvd. LA, CA 90045	90045030 7	52.69		RWQCB, 1998	
3	ARCO Gas Station	105 E. El Segundo Blvd. El Segundo, CA 90245	I-05008	44.93		RWQCB, 1998	
4	ARCO Gas Station	4009 W. Rosecrans Ave. Hawthorne, CA 90250	R-01869	20.00		RWQCB, 1998	
5	CALTRANS - Lennox	I-105/I-405 Interchange Lennox, CA 90304	90304002 5	40.00		RWQCB, 1998	
6	Chevron Gas Station	5975 Centinela Ave. LA, CA 90045	I-07144	52.00		RWQCB, 1998	
7	Continental Airlines Maintenance Base	7300 World Way West LA, CA				IT Corporation 4/91	"…however some perched zones may occur locally."
8	Delta - LAX Facility	SE Corner of Century and Sepulveda	MW-2B	10.00	2/1/1991	ERM-West, February 1991	
9	Dockweiler Beach Service Yard	8255 Vista del Mar Pl. Playa del Rey, Ca 90293	90293004 3	12.00		CA Water Quality Control Board	
10	Hertz Rent-a-Car	9029 Airport Drive LA, CA	TCB-2	48.00	12/17/1992	TERRA VAC	"Perched groundwater encountered at 48'feet
11	City of LA Hyperion Treatment Plant	12000 Vista del Mar Playa del Rey, CA 90293	90293003 4	35.00		RWQCB, 1998	
12	Hyperion Full Secondary Facilities	11400 Block of Vista del Mar Blvd. El Segundo, CA	B-1	11.50	1/19/1994	Geotechnical Investigation Report, City of Los Angeles	"Groundwater encountered at 13 feet at 0930. Rose to 11.5 feet at 0940.
13	Hyperion Full Secondary Facilities	11400 Block of Vista del Mar Blvd. El Segundo, CA	B-2	10.00	1/19/1994	Schaefer Dixon Associates 9/88	"Groundwater encountered at 10 feet below ground surface."
14	Hyperion Full Secondary Facilities	11400 Block of Vista del Mar Blvd. El Segundo, CA	B-3	9.00	1/19/1994	Schaefer Dixon Associates 9/88	"Groundwater encountered at 9 feet below ground surface. Recovered to 8'9" after 30 minutes."
15	LAXFUEL	LAXFUEL Facilities		4.00		Dames & Moore 2/8/91	"Saturated soft zone between 3 and 4 feet"
16	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West, LA, CA	S-1	24.00	10/8/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 24 feet during drilling."
17	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-2	24.50	10/8/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 24.5 feet during drilling."
18	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World	S-5	25.00	10/14/1992	Harding Lawson Associates 1/11/93	"Groundwater encountered at approximately 25 feet during drilling."

Table 4

Depth to Perched Water at Selected Locations

Map Location	Facility	Address	Well No.	Depth to Perched Water	Date	Reference	Notes
		Way West , LA, CA					
19	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-6	25.00	11/2/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 25 feet during drilling."
20	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-31	27.50	11/10/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 27.5 feet during drilling."
21	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-36	25.50	11/11/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 25.5 feet during drilling."
22	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-38	25.50	11/11/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 25.5 feet during drilling."
23	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-39	25.00	11/11/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 25 feet during drilling."
24	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-40	24.50	11/12/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 24.5 feet during drilling."
25	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-42	25.50	11/12/1992	Harding Lawson Associates 1/11/93	"…perched groundwater encountered at approximately 25.5 feet during drilling."
26	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-43	28.00	11/13/1992	Harding Lawson Associates 1/11/93	"Groundwater encountered at approximately 28 feet during drilling."
27	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-46	23.50	11/12/1992	Harding Lawson Associates 1/11/93	"perched groundwater encountered at approximately 23.5 feet during drilling."
28	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West, LA, CA	S-47	28.00	11/12/1992	Harding Lawson Associates 1/11/93	"Groundwater encountered at approximately 28 feet during drilling."
29	LAXFUEL	7261, 7253, 7275, 7259, 7257, 7265, 7251 World Way West , LA, CA	S-55	26.00	11/16/1992	Harding Lawson Associates 1/11/93	"Groundwater encountered at approximately 26 feet during drilling."
30	LAXFUEL	6900, 6940, 6949, and 6950 World Way West , LA, CA	BIII-10	41.50	6/24/1993	Harding Lawson Associates 6/25/94	
31	LAXFUEL	6900, 6940, 6949, and 6950 World Way West , LA, CA	BIII-11	41.00	6/22/1993	Harding Lawson Associates 6/25/94	
32	LAXFUEL	6900, 6940, 6949, and 6950 World Way West , LA, CA	MW-43	40.00	6/23/1993	Harding Lawson Associates 6/25/94	
33	LAX Second Level	Adjacent to Los Angeles		59.00	10/1/1979	Moore & Taber Consulting	"Water seepage was encountered near

Table 4

Depth to Perched Water at Selected Locations

Map Location	Facility	Address	Well No.	Depth to Perched Water	Date	Reference	Notes
	Roadway Project	International Airport Terminals				Engineers	Sepulveda Boulevard in Borings 1 and 10. This water is…located at about elevation 59."
34	Lennox Car Wash	10709 S. Hawthorne Blvd. Lennox, CA 90304	I-05677	37.00		RWQCB, 1998	
35	Mobil Gas Station	449 W. Manchester Blvd. Playa del Rey, CA 90293	90293002 5	61.40		RWQCB, 1998	
36	North Outfall Sewer			30 to 50		Leroy Crandall And Associates 4/89	"…two borings drilled in the residential area of Westchester north of Manchester Boulevard. The two water levels were at elevations of about 40 to 50 feet above sea level." ; "Additionally, perched water may appear above impermeable clay of silt lenses in alluvium, older dune sand or Lakewood Formation units as noted in Boring 24..."
37	Pacific Bell Facility	11206 S. Inglewood Lennox, CA 90304	90304001 6	36.00		RWQCB, 1998	
38	Sepulveda Blvd. Subway	Sepulveda Blvd. Under the Airport, WO 71954	1	38.00	1/22/1968	LADPW 11/67	"…at 38' …water seepage."
39	Skip's Body Shop	4439 W. Imperial HWY, Hawthorne, CA 90250	I-15457	35.00		RWQCB, 1998	
40	Southern CA Water Co.	14401 Chadron Ave. Hawthorne, CA 90250	I-12808	54.83		RWQCB, 1998	
41	Tract 3486 Lots 1-12	North of LAX	2	24.00	6/2/1982	GEO-SYSTEMS, Inc. 8/11/83	"Slight amount of free water (perched)"
42	Tract 3486 Lots 1-12	North of LAX	34		6/7/1983	GEO-SYSTEMS, Inc. 8/11/83	"7'-9' Caving & Water Seepage"
43	United Oil Station	4520 W. Century Blvd. Inglewood, CA 90304	R-13682	55.00		RWQCB, 1998	
44	Unocal Gas Station	4000 W. Century Blvd. Inglewood, CA 90304	I-09966	17.65		RWQCB, 1998	
45	Unocal Gas Station	4410 W. Imperial HWY Lennox, CA 90304	I-09887	37.00		RWQCB, 1998	

As indicated above, the Seismic Hazard Mapping Act of 1990 was enacted, in part, to address seismic hazards not included in the Alquist-Priolo Act, including liquefaction and other ground failures induced by seismic activity. Currently, the CDMG has begun mapping the seismic hazard zones associated with the LAX area, and preliminary seismic hazard maps identifying areas potentially subject to liquefaction were recently published for the area within the Master Plan boundaries. This map indicates that the LAX area, including the Scattergood and oil refinery fuel farm sites, and LAX Expressway, are not zoned by the state for liquefaction hazard potential. However, for the purposes of the Draft EIS/EIR, it is concluded that liquefaction could potentially occur in very localized areas of Quarternary-age sands saturated by perched water (see Section 3, *Methodology*). Therefore, generally low susceptibility to liquefaction may be present in the LAX area, including the Scattergood Fuel Farm site, the oil refinery site, and the LAX Expressway alignments.

2.4.1.4 Seismic Slope Stability

Slope failure occurs when the driving force induced by the weight of the earth materials within the slope exceed the shear strength of those materials. During seismic shaking, the ground surface is subjected to accelerations which can cause an increase in the apparent weight and driving force of earth materials, and a slope which was stable under static gravity loads can fail. Review of historic seismicity and close proximity of the area to significant fault zones clearly indicates that the LAX area is subject to future strong seismic ground motion. Slopes that could be subject to seismic instability are located in the LAX vicinity to the west of Pershing Drive, and at the Scattergood and oil refinery fuel farm sites.

As with liquefaction under the Seismic Hazard Mapping Act of 1990, the CDMG has begun mapping the seismic hazard zones associated with the LAX area, and preliminary seismic hazard maps identifying areas potentially subject to earthquake induced landslides were recently published for the LAX area. The preliminary maps indicate the presence of potentially unstable slopes near the west end of LAX. Because these slopes are typically in Quarternary dune sand deposits, the risk of large scale and deep seated failure is probably low. Other slopes at LAX are generally flat (typically less than 30 percent) and low in relief (typically less than 15 feet). The potential for seismic slope instability associated with these slopes is also considered to be low.

2.4.1.5 Seismic Settlement

Strong ground shaking can 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 ½ inch (see Section 3, *Methodology*). Such settlement could affect some facilities, such as utility connections, but typically would not cause severe damage to structures; therefore, the overall potential for damaging seismically-induced settlements is considered to be low.

2.4.1.6 Tsunami, Seiche, and Flooding

Tsunamis are among the most potentially destructive natural phenomena to threaten coastal areas in California. Tsunamis are generated by seismic shaking of the sea floor, submarine landslides, rock falls into bays, and exploding volcanic islands. These events displace sea water and impulsively generate wave trains. Of greatest concern in Southern California is the potential for local fault-generated tsunamis.

A tsunamis' size and intensity relates to: the magnitude and depth of the reasonable earthquake; volume, shape and magnitude of any sea floor displacement; and, water depth or the amount of water displaced. Thus, most historically significant tsunamis are generated by seismic thrusting events which occur at oceanic trenches. Strike slip earthquake events historically have not caused great tsunamis.

In Southern California, plate movement is accommodated mainly by strike slip faults; thus, locally generated tsunamis pose little danger. Trans-oceanic tsunamis also have negligible effects in Southern California. Van Dorn attributes low tsunamis heights in Southern California with the complex basin-ridge bathymetry of the wide Southern California borderland terrace.[10] Essentially, tsunami wave amplitude is diminished by Southern California's complex submerged topography.

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[10] Van Dorn, "Instrumentation and Observations," Tsunamis Proceedings of the National Science Foundation Workshop, 1979.

Houston combined historical data and numerical modeling to predict 100- and 500-year tsunami heights.[11] For the LAX area, predicted 100- and 500-year tsunami heights are 4.2 and 6.0 feet, respectively. In reference to the predicted tsunami height values, it should be noted that (1) the historic tsunami record may not be long enough to allow meaningful extrapolation to future events; (2) the predicted heights are not the maximum creditable heights; and (3) the 100- and 500-year intervals do not specify a time period, rather they represent a probability over time. Due to the elevation of LAX (100 feet above sea level), there is no risk of tsunamis directly affecting LAX, the potential fuel farm sites, or the LAX Expressway alignment.

Seiches are oscillations and waves generated in an enclosed body of water by seismic shaking. Because there are no closed bodies of water at LAX, seiches are not a hazard at LAX. No dams or dikes are located within the LAX vicinity; therefore, flooding due to a dam or dike failure during an earthquake is not considered a potential hazard at LAX.

2.4.2 Volcanic Hazards

No volcanoes or volcanic activity have been identified in the vicinity of LAX.

2.4.3 Settlement

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. Some settlement occurs beneath most engineered structures and is typically accounted for in the foundation design, or mitigated prior to construction. Problems can occur when settlement is greater than was anticipated during design, particularly if the settlement is greater beneath one part of the structure than the rest (known as differential settlement). Settlement is generally of greater concern in silty and clayey soils because of the relatively larger settlements and longer periods over which settlement occurs. Sandy soils tend to settle relatively less and more quickly upon application of initial load.

Settlement or collapse can also occur due to tunneling or excavation activities where large quantities of earth material are removed. This removal can result in a redistribution of earth stresses and subsequent vertical and lateral movement of the material surrounding the tunnel or excavation. Water pressure can also cause surrounding earth material to “flow” into an excavation or tunnel when such excavations are below a groundwater table. If not properly prevented or accounted for, such earth movements can result in damage to existing structures located in the vicinity of the excavation or tunnel.

The amount of settlement required to cause damage varies with the type of structure. Typically, when the ratio of differential settlement/distance is greater than 0.001 there is potential for damage. This ratio is approximately equivalent to one inch of differential settlement over a distance of 30 feet. Based on a review of the geotechnical investigations performed in the vicinity of LAX and the off-site fuel farm sites (see Section 4, *References*), excessive or problematic settlement of geologic materials has not typically been a concern. Generally, the major portion of settlement for typical structures is limited to a relatively rapid recompression of the typically sandy soils.

2.4.4 Oil Field Subsidence/Oil Field Gas

The removal of oil, gas, and other fluids from oil field reservoir materials can create voids that can collapse and may result in eventual ground surface subsidence. Ground surface subsidence can result in differential settlement and cause damage to engineered structures. Subsidence has been documented in several oil fields in the vicinity of LAX, including the Inglewood and Playa del Rey fields, which are located to the north and northeast of LAX. The Inglewood Oil Field may be experiencing subsidence at a rate of 0.2 feet per year. However, LAX is not located within the subsidence bowl, the center of which is located about seven miles to the north, near the corner of La Cienega Boulevard and Stocker Street.

The El Segundo and Hyperion Oil Fields lie beneath and to the south of LAX. Subsidence has not been recognized in the El Segundo Oil Field or in the Hyperion Oil Field.

Oil field gas (methane, hydrogen sulfide) can migrate from oil field reservoirs upward through earth materials or as a result of disposal of oil field by-products in the near-surface soils. If gas migrates towards, or is released near, the surface, it can accumulate in shallow earth materials, construction

[11] Houston, J.L., Type 19 Flood Insurance Study: Tsunami Predictions for Southern California: US Army Corps of Engineers Waterways Experiment Station (Technical Report HL-79-2), 1980.

related depressions, and engineered structures. Such accumulations of gas can lead to exposure of workers, fires, or explosions. Oil field gas seepage has not been reported in the LAX area; however, due to the presence of the Hyperion Oil Field, the potential for the presence of oil field gas seepage may exist, particularly for deeper subterranean structures.

2.4.5 Subsidence Due to Groundwater Withdrawal

The removal of groundwater from subsurface aquifers can cause the collapse of voids in aquifer materials and lead to ground surface subsidence which can, in turn, cause damage to engineered structures. Although groundwater is pumped from, as well as injected into, the West Coast Basin aquifers that lie beneath the LAX vicinity, the withdrawals are apparently in general balance with influx and no groundwater withdrawal-related subsidence has been reported in the geotechnical investigations reviewed for the LAX area.

3. METHODOLOGY

The general assumptions and methods listed below were used to identify and evaluate earth-related conditions and potential impacts associated with the No Action/No Project Alternative and the three build alternatives.

- Soil and bedrock materials described in the referenced documents reviewed for the LAX vicinity are typical of the conditions at the sites of proposed LAX Master Plan facilities.
- Groundwater conditions described in referenced documents for the LAX vicinity are accurate and representative of the conditions at the sites of proposed Master Plan facilities.
- Land use planning for mitigation of seismic hazards has not been considered for the purposes of the EIS/EIR, in accordance with the general approach of the Safety Element of the City of Los Angeles.
- Construction phasing and sequencing plans for the various major earthwork projects would be coordinated to minimize the need for imported fill material. The general approaches listed below were used to identify and evaluate earth-related conditions and impacts. Details regarding the specific methodology follow, where appropriate.
- Identification of Geologic and Geotechnical Conditions and Potential Hazards - Reports of geological, geotechnical and environmental investigations and conditions from the files of LAWA, California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR), CDMG, USGS, and others were reviewed to assess the general nature of earth materials and geologic environment and potential hazards within the LAX Master Plan area. Guidelines published by CDMG were followed to identify existing conditions and potential impacts associated with the LAX Master Plan.
- Construction - Individual LAX Master Plan project components were assessed in accordance with CDMG guidelines for potential geological and geotechnically related impacts caused by construction activities (e.g., slope stability, grading, erosion, settlement, etc.).
- Oil fields – Using data from DOGGR, oil fields located in the vicinity of LAX Master Plan areas were identified. LAX Master Plan project components located over oil fields were identified.
- Evaluation of Seismic Ground Shaking – Using fault location and characteristic data summarized by CDMG, The Earthquake Engineering Research Institute, USGS, and attenuation relationships developed by various researchers, fault source and general ground response parameters were estimated for three widely distributed locations across LAX. Additional details of this evaluation are provided below.
- Liquefaction and Seismically Induced Settlement Potential - Using data from historic topographic surveys and air photos, data from recent work by CDMG under the seismic hazards mapping program and data from consultants' investigation reports, the potential for liquefaction and seismically induced settlement was evaluated for a specific location using procedures described by Seed et al.[12] Additional details of these evaluations are provided below.

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[12] Seed, H.B., et al., "Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations," Journal Geotechnical Engineering Division, ASCE, December 1985.

- Evaluation of the Potential for Fault Surface Rupture – Using data from historic topographic surveys and air photos, data from recent work by CDMG under the seismic hazards mapping program and consultants' investigation reports, the potential for fault surface rupture was assessed and potential areas subject to potential fault surface rupture were identified on **Figure 2,** and **Figure 5**. Additional details of the air photo interpretation used in this evaluation are provided below.

The following describes the analyses conducted to determine the potential presence of geologic/geotechnical hazards and conditions within the Master Plan boundaries. **Table 5**, Matrix of Potential Earth/Geologic Considerations for Major Master Plan Facilities, summarizes the major components considered as part of the various project alternatives and the associated geological and geotechnical considerations and/or impacts.

3.1 Fault Surface Rupture Potential – Estimate of Magnitude of Displacement

As discussed above, a low potential exists for surface rupture along the Charnock Fault in the vicinity of the eastern end of LAX either independently or sympathetically in response to movement on other faults. In the following discussion, the theoretical magnitude of a primary displacement of the Charnock Fault is outlined. More likely, but less potentially damaging, would be sympathetic (triggered) rupture of the fault in response to an earthquake on the Newport-Inglewood or other local seismic source faults. The likely maximum magnitude of the offset would be a few centimeters along the existing fault trace. The fault trace does not extend to the ground surface, however, and the small magnitude of the triggered offset is unlikely to propagate upwards any great distance through the overlying, unfaulted. Recent deposits (see discussion below). Hence, triggered offset on the Charnock Fault is not anticipated to result in notable surface effects.

3.1.1 <u>Surface Rupture due to Vertical Displacement</u>

Wehmiller and others[13] report an absolute age of 0.7 to 1.8 million years for the lower Pleistocene epoch, and Ponti and Lajoie[14] report a minimum age of about 800,000 years for the top of the San Pedro Formation. If deposition of the San Pedro Formation commenced about 1 million years ago and was correlative with displacement on the Charnock Fault, the vertical offset rate on the fault would be approximately 0.04 mm per year (42.7 m/1,000,000 years). If it is assumed that the latest movement on the fault occurred immediately prior to Holocene time and that the fault is still active at the calculated long-term rate, rupture of the fault could result in as much as ~0.5 m of vertical offset at depth. Because the fault is not exposed at the surface in the LAX area, any rupture at depth would have to propagate through recent sedimentary deposits to evidence surface rupture.

Experimental studies by Cole and Lade[15] indicate that a normal fault that ruptures in bedrock beneath a poorly consolidated granular overburden must exhibit a vertical displacement equal to at least 4 percent of the total height of the overburden to enable the rupture to propagate to the surface. For the estimated vertical displacement described above (0.5 m), the vertical component of the rupture would not be anticipated to propagate to the surface through more than about 12.5 m (41 feet) of unconsolidated overburden.

3.1.2 <u>Surface Rupture due to Strike-Slip Displacement</u>

The horizontal slip rate on the Charnock Fault has not been determined. However, it is likely to be considerably less than the slip rate on the nearby NIFZ, which exhibits notable surficial geomorphic expression (compared with the complete lack of surface expression of the Charnock Fault). In an investigation of a graben located on a right stepover of the NIFZ, Grant et al.[16] reported an apparent

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[13] Wehmiller, J.F., et al., "Correlation and Chronology of the Pacific Coast Marine Terrace Deposits of the Continental United States by Fossil Amino Acid Stereochemistry – Technique Evaluation, Relative Age," <u>Kinetic Model Ages and Geologic Implications (USGS 77-680)</u>, 1977.

[14] Ponti, D.J. and K.R. Lajoie, "Chronostratigraphic Implications for Techtonic Deformation of Palos Verdes and Signal Hills, Los Angeles Basin, California," <u>The Regressive Pleistocene Shoreline, Coastal Southern California: South Coast Geological Society</u>, 1992.

[15] Cole, D.A. and P.V. Lade, "Influence Zones in Alluvium over Dip-Slip Faults," <u>Journal of Geotechnical Engineering</u>, 1984.

[16] Grant, L.B., et al., "Paleoseismicity of the North Branch of the Newport-Inglewood Fault Zone in Huntington Beach, California, from Cone Penetration Test Data," <u>Seismological Society of America Bulletin</u>, 1997.

vertical separation of 0.22 to 0.36 mm/yr across the fault splay. The minimum horizontal slip rate of the fault in the same vicinity was estimated at 0.34 to 0.55 mm/yr. If a similar geometric relationship holds for the Charnock Fault, a horizontal slip rate of about 0.06 mm/yr may be reasonable for the fault.

If, as before, the latest movement on the fault is assumed to have occurred immediately prior to Holocene time and that the fault is still active at the calculated long-term rate, rupture of the fault could result in as much as ~0.7 m of horizontal offset at depth. Combined with the vertical component, overall throw of the fault would then measure about 0.86 m. Assuming a 15 km long rupture length and a 15 km deep seismogenic source region yields a Mw~6.4 for such an event[17, 18] a value consistent with the 6-1/2 maximum credible earthquake on the fault assigned by Mualchin.[19]

Rupture attenuation estimates in alluvium, such as those described by Cole and Lade[20] (1984), have not been obtained for strike-slip ruptures. However, Emmons[21] reported the results of sand box experiments in which strike-slip offset was shown to produce a zone of faulting centered over a basal rupture. The offset on the principal rupture was always observed to become distributed across numerous minor faults with a distributed rupture displacement in the overlying zone. Although the minimum offset required to establish a rupture extending to the surface was not reported for these experiments, multiple rupture surfaces were shown extending to the surface after 2 inches of translational movement in a 14-inch deep shear box (i.e., offset corresponding to 14 percent of the total depth). Horizontal offset of 0.7 m should therefore be anticipated to propagate through a minimum of 5 m (16 feet) of unconsolidated overburden. In the absence of other information, the 12.5 m estimate reported above for vertical displacements should be used as a minimum depth of unconsolidated overburden through which a primary rupture on the Charnock Fault could propagate.

Due to the expected rapid upward branching of the primary fault offset into numerous splays, the translational offset on any individual rupture surface at the surface should be expected to diminish with increasing depth of overburden, although currently there is no way to quantify this effect. A corresponding widening of the fault zone should also be anticipated where the fault is propagating through unconsolidated overburden deposits. Again using the model results of Emmons,[22] a 3-1/2 inch wide fault zone was observed to form at the surface of the 14-inch deep shear box after 2 inches of translational displacement. Scaled to the field model, this would correspond to a 1.2 m (4 feet) wide zone of fault disruption in the case of propagation through 5 m of overburden.

3.1.3 Summary and Conclusions

The Charnock Fault is considered to be potentially active. However, 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. It appears theoretically capable of rupturing in a Mw~6-1/2 event, corresponding with 0.7 m of horizontal and 0.5 m of vertical displacement 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. Some surface rupture would be anticipated in such an event where the Holocene overburden measures less than about 12.5 m (40 feet) in thickness. Where the primary rupture extends to within 5 m (16 feet) of the surface, the resultant surface rupture pattern would consist of a 1.2 m (4 feet) wide fault zone, across which about 0.7 m of horizontal and 0.25 m of vertical offset (down to the east) may be anticipated. Where the overburden thickness is greater than 5 m (but less than 12.5 m), the fault

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[17] Wells, D.L. and K.J. Coppersmith, "New Empirical Relationships Among Magnitude, Rupture Length, Rupture Area, and Surface Displacement," Seismological Society of America Bulletin, 1994.

[18] Dolan, J.F., et al., "Prospects for Larger or More Frequent Earthquakes in the Los Angeles Metropolitan Region," Science, 1995.

[19] Mualchin, L., Caltrans California Seismic Hazard Map, California Department of Transportation, 1996.

[20] Cole, D.A. and P.V. Lade, "Influence Zones in Alluvium over Dip-Slip Faults," Journal of Geotechnical Engineering, 1984.

[21] Emmons, R.C., "Strike-Slip Rupture Patterns in Sand Model," Tectonophysics, 1969.

[22] Emmons, R.C., "Strike-Slip Rupture Patterns in Sand Model," Tectonophysics, 1969.

Table 5

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 Settlement	Tsunami, Seiche, Flooding	Tunneling	Grading	Existing Foundations
No Action/No Project Alternative 2005, 2015															
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 – Five Runway North Airfield Facilities 2005															
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	-
Alternative A – Five Runway North Airfield Facilities 2015															
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 Five Runway South Facilities 2005															
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	-

Table 5

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 Settlement	Tsunami, Seiche, Flooding	Tunneling	Grading	Existing Foundations
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
Westchester Southside	-	-	-	-	X	-	-	X	X	-	X	-	-	X	-
Alternative B – Five Runway South Airfield Facilities 2015															
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 - Four Runway Facilities 2005															
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
Alternative C - Four Runway Facilities 2015															
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

Source: Taylor-Hunter Associates, 2000.

zone would likely be wider, but the overall offsets lower than those indicated above. Sympathetic (triggered) slip due to earthquakes on nearby faults may occur at depth along the Charnock Fault, but would appear unlikely to result in surface rupture along the fault trace. The possibility of fault surface rupture or co-seismic ground deformation along a previously unidentified fault also exists, although the potential cannot be quantified with currently available data.

3.2 Ground Shaking Analysis

A deterministic analysis of the potential levels of ground shaking in the LAX area was performed for the purposes of the EIS/EIR. Maximum instrumental ground shaking, in terms of peak horizontal and vertical ground acceleration, was estimated by considering the characteristics of maximum credible earthquake events identified in **Table 2**, and the distance between the seismic sources for these events and LAX (deterministic method). Given that LAX is over two miles long in an east-west direction, the ground shaking at three “sub-sites” in or near LAX were evaluated in order to consider potential differences in ground shaking hazard across the site. These three sub-sites are: the proposed West Terminal (referred to as Site A); the existing main control tower near the center of LAX (referred to as Site B); and, the intersection of the I-405 and I-105 freeways to the southeast of LAX (referred to as Site C).

Three SSM relationships were used to evaluate peak horizontal ground acceleration, and two attenuation relationships were used to evaluate peak vertical ground accelerations, at the three sub-sites. These relationships, termed attenuation relationships, were derived from databases of instrumental recordings during previous earthquakes. These relationships are dependent on the distance from the fault, the magnitude of the earthquake, the type of faulting mechanism, and the general subsurface stratigraphy. More than one relationship was used in order to compute an average for each earthquake scenario. The distances used to calculate the deterministic ground-shaking values for these faults are to the down-dip projection of the faults (5 km depth, into the seismogenic source region).

As shown in **Tables 6, 7,** and **8**, Deterministic Ground Motion Estimates for Sites A, B, and C, respectively, a different means of calculating the closest distance is used for each of the three relationships. In addition, the characterization of site subsurface conditions differs. For relationships by Abrahamson and Silva[23] and Campbell,[24] the site was categorized as being a deep soil site. However, attenuation relationships by Boore, Joyner, and Fumal[25] require an estimate of the shear wave velocity in the upper 30 meters of the ground surface in order to categorize the subsurface conditions. In the area of LAX, two profiles of shear wave velocity have been reported by the USGS. One profile, near the southwest corner of LAX, has an average shear wave velocity of 310 m/sec in the upper 30 meters. Another profile, near the northeast corner of LAX has an average shear wave velocity of 390 m/sec. The differences in the average shear wave velocity at these two locations may be attributable to differences in geology. At the southwestern site, the soils are primarily younger; at the northeastern site, the soils are primarily older.

For purposes of the ground motion estimates reported herein, Site A was assumed to correspond to the lower shear wave velocity profile (Class C); Site C was assumed to correspond to the higher shear wave velocity profile (Class B); and Site B was assumed to have a shear wave velocity profile between these two (using the average of the results for Class B and Class C).

[23] Abrahamson, N.A., and W.J. Silva “Equations for Estimating Horizontal Response Spectran and Peak Acceleration from Western North American Earthquakes: A Summary of Recent Work,” Seismoligical Research Letters, January 1997.

[24] Campbell, K.W., “Attention Relationships for Shallow Crustal Earthquakes Based on California Strong Motion Data,” Seismological Research Letters, January 1997.

[25] Boore, D.M., et al., Estimation of Response Spectra and Peak Accelerations from Western North American Earthquakes (USGS 94-127), 1994.

Table 6

Deterministic Ground Motion Estimates for Site A

Fault	M_w	Fault Type	Closest Distance (km)				PHGA Estimate (g)			PVGA Estimate (g)		
			r_{jb}[1]	r_{seis}[2]	r_{rup}[3]	BJF[4]	Campbell[5]	A & S[6]	Average	Campbell	A & S	Average
Strike-Slip												
Newport-Inglewood	6.9	SS	7.7	8.3	7.7	0.36	0.41	0.45	0.41	0.35	0.35	0.35
Palos Verdes	7.1	SS	7.4	8.0	7.4	0.40	0.43	0.37	0.40	0.39	0.38	0.39
San Andreas (Mojave Segment)	7.5	SS	74.0	74.1	74.0	0.10	0.08	0.08	0.09	0.06	0.05	0.06
San Andreas (Coachello to Carrizo Segment)[7]	7.9	SS	74.0	74.1	74.0	0.12	0.12	0.10	0.11	0.09	0.06	0.08
San Clemente	8	SS	67.6	67.7	67.6	0.14	0.14	0.11	0.13	0.11	0.07	0.09
San Gabriel	7.0	SS	40.2	40.3	40.2	0.12	0.11	0.10	0.11	0.08	0.07	0.08
Whittier-Elsinore	6.8	SS	38.6	38.7	38.6	0.11	0.10	0.10	0.10	0.07	0.07	0.07
Dip-Slip												
Anacapa-Dume	7.3	RO	27.4	29.6	27.4	0.23	0.21	0.18	0.21	0.14	0.13	0.14
Hollywood	6.4	RO	16.1	18.0	16.1	0.21	0.22	0.23	0.22	0.13	0.14	0.14
Hollywood-Santa Monica-Malibu Coast[7]	7.3	RO	12.6	13.7	12.6	0.40	0.42	0.31	0.38	0.32	0.27	0.30
Malibu Coast	6.7	RO	16.1	17.3	16.1	0.25	0.27	0.22	0.25	0.17	0.17	0.17
Raymond	6.5	RO	30.3	31.4	30.3	0.14	0.12	0.12	0.13	0.07	0.08	0.08
Santa Monica	6.6	RO	12.6	13.7	12.6	0.28	0.32	0.26	0.29	0.21	0.20	0.21
Santa Susana	6.6	RS	40.9	43.5	40.9	0.12	0.08	0.11	0.10	0.05	0.06	0.06
Sierra Madre	6.7	RS	36.7	39.9	36.7	0.14	0.10	0.12	0.12	0.06	0.07	0.07
Sierra Madre-San Fernando[7]	7.0	RS	36.7	38.9	36.7	0.16	0.12	0.14	0.14	0.08	0.08	0.08
Simi-Santa Rosa	6.7	RS	48.0	50.0	48.0	0.11	0.07	0.09	0.09	0.04	0.05	0.05
Verdugo	6.7	RS	30.9	34.1	30.9	0.15	0.12	0.14	0.14	0.07	0.08	0.08
Blind Faults												
Channel Islands Thrust	7.4	RS	61.2	61.7	61.7	0.13	0.09	0.11	0.11	0.06	0.05	0.06
Compton	6.8	RS	0.0	8.6	8.6	0.62	0.49	0.52	0.54	0.37	0.51	0.44
Elysian Park	6.9	RS	15.4	18.4	18.4	0.28	0.28	0.31	0.29	0.19	0.27	0.23
Compton-Elysian Park[7]	7.3	RS	0.0	8.6	8.6	0.81	0.53	0.57	0.64	0.44	0.61	0.53
Oak Ridge (1/17/94 Northridge earthquake on this fault)	6.9	RS	28.0	38.7	38.7	0.18	0.12	0.13	0.14	0.07	0.07	0.07
Santa Monica Mountains	7.3	RS	16.1	21.3	21.3	0.34	0.30	0.28	0.31	0.21	0.22	0.22
Puente Hills Thrust												
L.A. Segment	6.5	RS	25.9	26.4	26.4	0.15	0.14	0.15	0.15	0.09	0.09	0.09
S.F. Springs	6.5	RS	25.9	26.4	26.4	0.15	0.14	0.15	0.15	0.09	0.09	0.09
Coyote Hills	6.5	RS	33.1	33.5	33.5	0.12	0.11	0.13	0.12	0.06	0.07	0.07

1 r_{jb}: The closest horizontal distance to the vertical projection of the rupture (the "Joyne-Boone distance").
2 r_{seis}: The closest distance to the seismogenic rupture surface (assumes that near-surface rupture in sediments is non-seismogenic (Marone and Sholz, 1998).
3 r_{rup}: The closest distance to the rupture surface.
4 Site Class B (Avg. Vs= 390 m/s) & r_{jb}: PHGA corresponds to geometric mean of PGA from the two orthogonal horizontal components.
5 Soil Site & r_{seis}: PHGA corresponds to geometric mean of PGA from the two orthogonal horizontal components.
6 Deep Soil Site & r_{rup}: PHGA corresponds to arithmetic mean of PGA from the two orthogonal horizontal components.
7 Multiple rupture scenarios.

Source: Independent analysis by Bing Yen & Associates, Inc., 1998.

Table 7

Deterministic Ground Motion Estimates for Site B

		Fault	Closest Distance (km)				PHGA Estimate			PVGA Estimate		
Fault	**M_w**	**Type**	**r_{jb}[1]**	**r_{seis}[2]**	**r_{rup}[3]**	**BJF[4]**	**Campbell[5]**	**A & S[6]**	**Average**	**Campbell**	**A & S**	**Average**
Strike-Slip												
Newport-Inglewood	6.9	SS	5.1	6.0	5.1	0.41	0.45	0.45	0.44	0.41	0.44	0.43
Palos Verdes	7.1	SS	9.7	10.1	9.7	0.34	0.40	0.31	0.35	0.34	0.32	0.33
San Andreas (Mojave Segment)	7.5	SS	72.4	72.5	72.4	0.10	0.09	0.08	0.09	0.06	0.05	0.06
San Andreas (Coachello to Carrizo Segment)[7]	7.9	SS	72.4	72.5	72.4	0.12	0.12	0.10	0.11	0.09	0.06	0.08
San Clemente	8	SS		70.9	70.8	0.13	0.13	0.10	0.12	0.10	0.06	0.08
San Gabriel	7.0	SS	38.6	38.7	38.6	0.12	0.12	0.11	0.12	0.09	0.08	0.09
Whittier-Elsinore	6.8	SS	37.3	37.5	37.3	0.12	0.11	0.10	0.11	0.07	0.07	0.07
Dip-Slip												
Anacapa-Dume	7.3	RO	30.3	32.5	30.3	0.21	0.19	0.16	0.19	0.13	0.11	0.12
Hollywood	6.4	RO	15.8	17.7	15.8	0.21	0.22	0.21	0.21	0.14	0.15	0.15
Hollywood-Santa Monica-Malibu Coast[7]	7.3	RO	12.6	13.7	12.6	0.39	0.42	0.31	0.37	0.32	0.27	0.30
Malibu Coast	6.7	RO	17.7	18.9	17.7	0.22	0.24	0.21	0.22	0.16	0.15	0.16
Raymond	6.5	RO	28.0	29.2	28.0	0.15	0.13	0.13	0.14	0.08	0.09	0.09
Santa Monica	6.6	RO	12.6	13.7	12.6	0.27	0.32	0.26	0.28	0.21	0.20	0.21
Santa Susana	6.6	RS	41.5	44.1	41.5	0.12	0.08	0.11	0.10	0.05	0.06	0.06
Sierra Madre	6.7	RS	36.0	39.2	36.0	0.13	0.10	0.13	0.12	0.06	0.07	0.07
Sierra Madre-San Fernando[7]	7.0	RS	36.0	38.3	36.0	0.16	0.13	0.14	0.14	0.08	0.08	0.08
Simi-Santa Rosa	6.7	RS	49.6	51.6	49.6	0.11	0.07	0.10	0.09	0.04	0.05	0.05
Verdugo	6.7	RS	29.6	32.9	29.6	0.16	0.14	0.15	0.15	0.09	0.09	0.09
Blind Faults												
Channel Islands Thrust	7.4	RS	64.4	64.9	64.9	0.13	0.09	0.10	0.11	0.06	0.05	0.06
Compton	6.8	RS	0.0	8.6	8.6	0.60	0.49	0.52	0.54	0.37	0.51	0.44
Elysian Park	6.9	RS	13.2	16.6	16.6	0.30	0.31	0.34	0.32	0.21	0.31	0.26
Compton-Elysian Park[7]	7.3	RS	0.0	8.6	8.6	0.78	0.53	0.57	0.63	0.44	0.61	0.53
Oak Ridge	6.9	RS	29.0	37.9	37.9	0.17	0.12	0.13	0.14	0.08	0.07	0.08
Santa Monica Mountains	7.3	RS	17.7	22.6	22.6	0.31	0.28	0.25	0.28	0.19	0.18	0.19
Puente Hills Thrust												
L.A. Segment	6.5	RS	21.6	22.2	22.2	0.17	0.18	0.18	0.18	0.11	0.11	0.11
S.F. Springs	6.5	RS	23.0	23.6	23.6	0.17	0.18	0.17	0.17	0.10	0.10	0.10
Coyote Hills	6.5	RS	28.9	29.4	29.4	0.14	0.13	0.14	0.14	0.08	0.08	0.08

1 r_{jb}: The closest horizontal distance to the vertical projection of the rupture (the "Joyne-Boone distance").
2 r_{seis}: The closest distance to the seismogenic rupture surface (assumes that near-surface rupture in sediments is non-seismogenic (Marone and Sholz, 1998).
3 r_{rup}: The closest distance to the rupture surface.
4 Site Class B (Avg. Vs= 390 m/s) & r_{jb}: PHGA corresponds to geometric mean of PGA from the two orthogonal horizontal components.
5 Soil Site & r_{seis}: PHGA corresponds to geometric mean of PGA from the two orthogonal horizontal components.
6 Deep Soil Site & r_{rup}: PHGA corresponds to arithmetic mean of PGA from the two orthogonal horizontal components.
7 Multiple rupture scenarios.

Source: Independent analysis by Bing Yen & Associates, Inc., 1998.

Table 8

Deterministic Ground Motion Estimates for Site C

Fault	M_w	Fault Type	Closest Distance (km)				PHGA Estimate			PVGA Estimate		
			r_{jb}[1]	r_{seis}[2]	r_{rup}[3]	BJF[4]	Campbell[5]	A & S[6]	Average	Campbell	A & S	Average
Strike-Slip												
Newport-Inglewood	6.9	SS	3.9	4.9	3.9	0.42	0.47	0.45	0.45	0.45	0.48	0.47
Palos Verdes	7.1	SS	11.3	11.7	11.3	0.29	0.37	0.29	0.32	0.31	0.28	0.30
San Andreas (Mojave Segment)	7.5	SS	72.1	72.2	72.1	0.09	0.09	0.08	0.09	0.06	0.04	0.05
San Andreas (Coachello to Carrizo Segment)[7]	7.9	SS	72.1	72.2	72.1	0.11	0.12	0.10	0.11	0.09	0.06	0.08
San Clemente	8	SS	70.8	70.9	70.8	0.12	0.13	0.10	0.12	0.10	0.06	0.08
San Gabriel	7.0	SS	37.0	37.1	37.0	0.07	0.13	0.11	0.10	0.09	0.08	0.09
Whittier-Elsinore	6.8	SS	34.1	34.2	34.1	0.11	0.12	0.11	0.11	0.08	0.08	0.08
Dip-Slip												
Anacapa-Dume	7.3	RO	34.1	36.4	34.1	0.18	0.17	0.15	0.17	0.11	0.10	0.11
Hollywood	6.4	RO	18.0	19.9	18.0	0.18	0.19	0.19	0.19	0.12	0.13	0.13
Hollywood-Santa Monica-Malibu Coast[7]	7.3	RO	13.2	14.3	13.2	0.36	0.41	0.30	0.36	0.30	0.26	0.28
Malibu Coast	6.7	RO	20.9	22.1	20.9	0.19	0.20	0.18	0.19	0.13	0.13	0.13
Raymond	6.5	RO	26.4	27.6	26.4	0.14	0.14	0.14	0.14	0.08	0.09	0.09
Santa Monica	6.6	RO	13.2	14.3	13.2	0.25	0.30	0.25	0.27	0.20	0.20	0.20
Santa Susana	6.6	RS	42.5	45.1	42.5	0.11	0.08	0.11	0.10	0.05	0.05	0.05
Sierra Madre	6.7	RS	36.7	39.9	36.7	0.12	0.10	0.12	0.11	0.06	0.07	0.07
Sierra Madre-San Fernando[7]	7.0	RS	36.7	38.9	36.7	0.15	0.12	0.14	0.14	0.08	0.08	0.08
Simi-Santa Rosa	6.7	RS	52.8	54.8	52.8	0.09	0.06	0.09	0.08	0.04	0.04	0.04
Verdugo	6.7	RS	29.0	32.2	29.0	0.15	0.13	0.15	0.14	0.08	0.09	0.09
Blind Faults												
Channel Islands Thrust	7.4	RS	67.6	68.1	68.1	0.11	0.08	0.10	0.10	0.05	0.05	0.05
Compton	6.8	RS	0.0	7.9	7.9	0.57	0.51	0.54	0.54	0.39	0.54	0.47
Elysian Park	6.9	RS	12.6	16.0	16.0	0.30	0.32	0.35	0.32	0.22	0.32	0.27
Compton-Elysian Park[7]	7.3	RS	0.0	8.6	8.6	0.74	0.55	0.60	0.63	0.46	0.64	0.55
Oak Ridge	6.9	RS	30.6	39.3	39.3	0.16	0.11	0.13	0.13	0.07	0.07	0.07
Santa Monica Mountains	7.3	RS	20.9	25.2	25.2	0.26	0.25	0.21	0.24	0.17	0.13	0.15
Puente Hills Thrust												
L.A. Segment	6.5	RS	19.5	20.2	20.2	0.19	0.20	0.19	0.19	0.12	0.12	0.12
S.F. Springs	6.5	RS	20.1	20.8	20.8	0.19	0.19	0.19	0.19	0.12	0.12	0.12
Coyote Hills	6.5	RS	27.3	27.8	27.8	0.15	0.14	0.15	0.15	0.08	0.08	0.08

1 r_{jb}: The closest horizontal distance to the vertical projection of the rupture (the "Joyne-Boone distance").
2 r_{seis}: The closest distance to the seismogenic rupture surface (assumes that near-surface rupture in sediments is non-seismogenic (Marone and Sholz, 1998).
3 r_{rup}: The closest distance to the rupture surface.
4 Site Class B (Avg. Vs= 390 m/s) & r_{jb}; PHGA corresponds to geometric mean of PGA from the two orthogonal horizontal components.
5 Soil Site & r_{seis}; PHGA corresponds to geometric mean of PGA from the two orthogonal horizontal components.
6 Deep Soil Site & r_{rup}; PHGA corresponds to arithmetic mean of PGA from the two orthogonal horizontal components.
7 Multiple rupture scenarios.

Source: Independent analysis by Bing Yen & Associates, Inc., 1998.

3.3 Liquefaction Evaluation

The potential for soils inundated by perched water to liquefy was evaluated using empirical methods based on standard penetration test (SPT) blow counts developed by Seed et al.[26] For this study, SPT data from Borings B-1, B-5, B-8, B-10, and B-14 made by Dames and Moore in 1991 were assessed to be of sufficient quality and representative of the specific location and were used for the analysis. The intent of this evaluation was not to determine which areas within the LAX Master Plan boundaries were subject to liquefaction, but to provide an indication of whether some materials in the LAX area could be susceptible.

As indicated above, the Seismic Hazard Mapping Act of 1990 was enacted, in part, to address seismic hazards not included in the Alquist-Priolo Act, including liquefaction and other ground failures induced by seismic activity. Currently, the CDMG has begun mapping the seismic hazard zones associated with the LAX area, and preliminary seismic hazard maps identifying areas potentially subject to liquefaction were recently published for the LAX area. This map indicates that the LAX area, including the Scattergood and oil refinery fuel farm sites and LAX Expressway, are not zoned by the state for liquefaction hazard potential. However, for the purposes of the Draft EIS/EIR, it is concluded that liquefaction could potentially occur in very localized areas of Quarternary-age sands saturated by perched water (see Section 3, *Methodology*). Therefore, generally low susceptibility to liquefaction may be present in the LAX area, including the Scattergood Fuel Farm site, the oil refinery fuel farm site, and the LAX Expressway alignments.

3.4 Seismic Settlement Evaluation

As discussed above, strong ground shaking can densify loose to medium dense deposits of sand, which could result in seismic settlement of foundations and the ground surface. At LAX, the subsurface soils are typically medium dense to dense sand. For the purposes of the Draft EIS/EIR, an evaluation was made of the potential for seismic settlement of sand using boring data from an investigation performed in the vicinity of LAXFUEL Fuel Farm. Empirical procedures developed by Tokimatsu and Seed[27] were used to evaluate the potential for seismic settlement. This procedure involves using SPT blow count data from borings at the site. For this study, SPT data from Borings B-1, B-5, B-8, B-10, and B-14 made by Dames and Moore[28] were assessed to be of sufficient quality and representative of the specific location and were used for the analysis. Based on an assumed earthquake on the combined Compton and Elysian Park faults, the estimated maximum seismic settlement in this area is less than ½ at the location of the above referenced borings.

It is likely that the potential for seismic settlements would tend to vary considerably across the site, generally between negligible levels and ½ inch. Because of variations in the level of detail and quality of data included in various documents reviewed for the Draft EIS/EIR, it is difficult to estimate the potential for seismic settlement in different areas of LAX. The intent of this evaluation was not to determine which areas within the Master Plan boundaries were subject to seismic settlement, but to provide a qualitative indication of whether some materials in the LAX area may be susceptible.

3.5 Aerial Photograph Review

In order to evaluate geologic processes that may have effected the landforms in and around the LAX study area, historic topographic maps and aerial photographs were researched, reviewed and documented. In this review, topographic features were looked for that could be related to active faulting or shaking-induced ground deformation. Such features include linear valleys, scarps, elongated drainages, or tonal lineaments due to material or moisture variation across a fault. Topographic maps covering the study area were acquired for the Redondo 15 minute quadrangle (scale 1 inch = 1 mile), dated 1896, and for the Venice and Inglewood 7-1/2 minute quadrangles (scale 1 inch = 2,000 feet) dated 1924.

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[26] Seed, H.B. et al., "Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations," Journal, Geotechnical Engineering Division, December 1985.

[27] Seed, H.B. et al., "Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations," Journal, Geotechnical Engineering Division, December 1985.

[28] Dames and Moore: Geotechnical Investigation, Proposed Fuel Facilities Expansion, Los Angeles International Airport, Los Angeles, California, February 8, 1991.

An air photo search was performed at the Fairchild Aerial Photography Collection housed at Whittier College to identify historic aerial photographs covering the site. Nineteen flights of stereographic vertical aerial photographs were identified covering or partially covering the LAX site. The methodology employed to view and interpret was first to lay out the individual photos from a flight into an overlapping mosaic. The photos were then compared to a topographic base map and, based on the landforms and geographic landmarks visible, the study area was located. Stereo pairs were then viewed with either a Sokkia MS27 Mirror Stereoscope or Abrams Scientific 2-4x stereoscope in order to observe the topographic features of the area. Photos were documented by placing a clear mylar sheet over a photo and drawing an overlay of the features observed. **Figure 6** presents a summary of some of the features observed. A table summarizing each flight, photos reviewed, and descriptions was also developed (**Table 9**, Summary of Aerial Photographs Reviewed).

Table 9

Summary of Aerial Photographs Reviewed

Date	Flight Number[1]	Photo Number[2]	Description
1927	C-113 (Fairchild)	134-139 136, 138	Approx. Scale 1 in.=1,600 ft. Moderate contrast, weak vertical exaggeration. Fight line covers a swath generally centered along the A.T.S.F. Railroad. The area of future LAX is utilized for agricultural purposes. The primary geomorphic features observed are a series of circular and elongate depressions in the fields, which appear to be possible soil collapse features. A dendritic, ephemeral stream course trending east-to-southeast is present in the southeast portion of the site. A faint lineament (F1) delineated by slight topographic relief aligns with several of the depressions east of the railroad. A second lineament (F2), trending northwest and located southeast of LAX, was observed as a vegetation contrast with more vigorous growth southwest of the lineament. Further to the southeast, a faint tonal lineament (F3) was observed crossing the Pacific Electric railroad alignment. No surface expression of the Charnock fault was observed on the terrace surface south of Ballona Gap.
1928	C-300 (Fairchild)	J:290-292; K:29-31,56-58, 83-85; M:1-2, 13-15 J-292, K-30, K-57, M-2	Approx. Scale 1 in.=1,500 ft. Moderate contrast, moderate vertical exaggeration. Photos cover area from beach eastward to Inglewood. Similar features to those on C-135 were observed. Additional closed depressions were observed in the west-central part of the future LAX site. Several prominent northwest-trending drainages were observed west of Sepulveda Boulevard. Hummocky sand dune morphology was observed in the western portion of the site. A faint topographic lineament (F4) was observed trending northwest just west of Sepulveda Boulevard.
4/5/1940	C-6830 (Fairchild)	0 – 1	Approx. Scale 1 in.=2,000 ft. Strong contrast (dark) due to moist soil conditions. Many of the closed depressions are holding water. No evidence of any of the previously described lineaments. Air field beginning to be constructed.
8/1947	C-11351 (Fairchild)	10:31-34, 44-47	Approx. Scale 1 in.=3,000 ft. Good contrast. Flight line oriented east-west. Sepulveda Boulevard has been re-routed towards the west to accommodate airport expansion. Housing developments have been constructed north of airport to Ballona Gap. Fields east and west of airport remain undeveloped. No lineaments observed.

1 Photos reviewed from the Fairchild Collection at Whittier College.
2 Photo numbers shown in bold indicate that overlays were prepared to document the site conditions observed on the specified photo.

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