GEOLOGICAL TECHNICAL STUDY
CENTRAL ESTUARY
OAKLAND, CALIFORNIA

PREPARED FOR:
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April 17, 2009
Project No. 401525002

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Mr. John Cook
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Subject: Geological Technical Study
Central Estuary
Oakland, California

Dear Mr. Cook:

In accordance with your authorization, we are pleased to present the results of our Geological Technical Study to assist in the preparation of the Central Estuary Specific Plan and supporting Environmental Impact Report. This report provides a summary of our findings and conclusions regarding geologic and soils conditions relative to the study area.

We appreciate the opportunity to be of service.

Respectfully submitted,
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1. INTRODUCTION

In accordance with your request, Ninyo & Moore has performed a Geological Technical Study for the Central Estuary project located in Oakland, California. The purpose of this study was to evaluate the geologic and soils conditions related to the project site using available data to assist with the preparation of the Central Estuary Specific Plan and supporting Environmental Impact Report. The objective of the Specific Plan is to establish a framework for development of the project area into a mixed use district and regional destination while preserving the industrial land base and maintaining the waterfront as a place of employment. Subsurface exploration and laboratory testing were not included in the scope of this reconnaissance-level evaluation.

2. SCOPE OF SERVICES

Ninyo & Moore's scope of services for this evaluation included the following:

- Review of readily available geologic maps, geologic hazard maps, historic topographic maps, published geologic literature, soil survey data, aerial photographs, in-house geotechnical information, and relevant available geotechnical reports from the City of Oakland and the County of Alameda. Documents pertaining to our evaluation are listed in the References section of this report.

- Research and assessment of project area seismicity, including a review of historic earthquakes that have impacted the project area, an evaluation of known active faults within an approximately 100-kilometer radius of the project, and a probabilistic seismic hazard analysis to estimate anticipated ground accelerations at the project area.

- Performing a site reconnaissance of the project site by our geologist.

- Compilation and analysis of data obtained, with particular emphasis on potential geologic considerations relative to the project.

- Preparation of this report presenting our findings and conclusions pertaining to the existing geologic and soils conditions.

3. SITE DESCRIPTION AND TOPOGRAPHY

The Central Estuary study area is an irregularly shaped, 428-acre parcel that is located at the western perimeter of the City of Oakland. The project area is bounded by the alignment of

19th Avenue to the northwest; Interstate-880 (I-880) to the northeast; an East Bay Municipal Utility District (EBMUD) facility, located at 5597 Oakport Street, and San Leandro Bay to the southeast; and Brooklyn Basin and a tidal canal to the southwest (Figure 1). The tidal canal is a man-made feature. Prior to dredging of the tidal canal in 1902, Oakland and Alameda were connected between the alignment of 27th Avenue to the northwest and High Street to the southeast (San Francisco Estuary Institute, 1998; Sowers, 2000).

The Oakland Estuary area has historically been a heavy industrial use waterfront, but more recently has evolved into a mixed use district. The northern and central portion of the Central Estuary area includes a mix of well-established heavy industrial uses, more recent commercial activities, and a residential neighborhood. The southern portion of the Central Estuary area contains a number of businesses in the manufacturing and construction sectors.

As shown in Figure 2, the project site is relatively flat with a gentle slope to the west, south, and southwest toward the bay. Elevations within the project area range from about 20 feet above Mean Sea Level (MSL) adjacent to I-880 in the east central portion of the site to about 5 feet above MSL at the southern extent of the project area (United States Geological Survey [USGS], 1997). During our site reconnaissance, we noted that slopes are present at the waterfront in the study area along Brooklyn Basin, the tidal canal, and San Leandro Bay. These slopes are generally on the order of 10 feet in height and range from approximately 2:1 (horizontal to vertical) to nearly vertical. At some locations the slopes are protected with rip-rap, asphalt concrete, or Portland cement concrete, while at other areas the slopes consist of unprotected soil. Portions of the waterfront slopes are partially supported by retaining walls. Slopes are also present in the study area where up to approximately 15 feet of fill has been placed at the approach embankments for the 23rd and 29th Avenue overcrossing bridge abutments at I-880. Side slopes of these embankments are generally on the order of 1½:1 (horizontal to vertical) to 2½:1 (horizontal to vertical). Retaining walls support portions of the approach embankments.

4. HISTORICAL MAP REVIEW

A creek and watershed map showing historical water features (Sowers, 2000), a map of former shoreline features along the east side of the San Francisco Bay (Radbruch, 1959), and historical topographic maps from Environmental Data Resources, Inc. (EDR) for the years 1915, 1948, 1949, 1959, 1968, 1973, and 1980 were reviewed (EDR, 2009a). These maps indicate that there have been significant alterations to the shoreline and tidal marsh areas in the study area.

The Creek and Watershed map prepared by Sowers (2000) indicates that the tidal canal marking the western boundary of the central portion of the study area is an artificial body of water, and that, circa 1850, the shoreline in the vicinity of the study area was significantly different (Figure 3). The map also indicates that around 1850 the southeastern and northwestern portions of the study area were tidal marshes and that there are several creeks in the study area that have been buried or drained, or diverted into underground culverts and storm drains. The largest of these is Sausal Creek which is shown to pass through the study area along Fruitvale Avenue in an underground culvert or storm drain and drain into the tidal canal.

The map of former shoreline features prepared by Radbruch (1959) is based upon unpublished data from 1856, and shows little change to the shoreline and tidal marshes depicted by Sowers (2000) for 1850.

The historic topographic map from 1915 shows that the shoreline at the northwest portion of the study area had been expanded to the west toward Oakland Harbor since 1856 and areas that were formerly indicated as tidal marshes were developed, suggesting this area had been filled and re-claimed. In the central portion of the study area, the tidal canal marking the western boundary was present. The southeastern portion of the study area, however, was still mapped as a wet-land/tidal marsh.

The historic topographic map from 1948 shows that the shoreline at the northwest portion of the study area had roughly reached its current configuration. The southeastern portion of the study area was no longer mapped as a wetland/tidal marsh and was developed, indicating the area had been filled and reclaimed. The historic topographic map from 1949 showed little change from 1948.

The historic topographic map from 1959 showed that I-880 had been constructed through the study area since 1949, and that fill had been placed across the creek/slough (East Creek Slough) near the southern boundary of the project area to construct the Interstate. The historic topographic map from 1968 showed that East Creek Slough had been diverted into an engineered channel southwest of I-880, but that remnants of the former channel remained parallel to and just northwest of the engineered channel. The portions of the former channel that were visible in 1968 were no longer present in the historic topographic map from 1973, indicating that the area had been filled. Topographic maps from 1980 and 1997 (USGS, 1997) showed little change from 1973.

5. HISTORIC AERIAL PHOTOGRAPH REVIEW

Aerial photographs from EDR for the years 1939, 1946, 1958, 1965, 1982, 1993, 1998, and 2005 were reviewed for the study area (EDR, 2009b). The photographs reviewed varied in scale and clarity, and were taken from various altitudes.

Aerial photograph from 1939 showed that the area was extensively developed. As indicated by the historic topographic maps, the tidal channel along the southwestern boundary of the study area was present. The shoreline along the northwestern portion of the study area had roughly the same configuration as it does presently. The southeastern portion of the study area had also been reclaimed from the tidal flats and was partially developed with industrial facilities. The central portion of the site was dominated by residential structures, while the northern portion of the study area was predominantly industrial. The 29th Avenue and Fruitvale Avenue bridges to Alameda were complete, and the High Street bridge to Alameda was under construction. Photographs from 1946 showed further industrial development at the southeastern portion of the site and the completion of the High Street bridge.

Aerial photographs from 1958 showed that I-880 had been constructed along the northeastern boundary of the study area. Fill had been placed across East Creek Slough along the alignment of I-880, and the tidal marsh area to the southeast of East Creek Slough had been developed. To the northeast of I-880 East Creek Slough had been diverted into engineered channels, while to the

southwest of I-880 East Creek Slough had not been diverted. Photographs from 1965 showed further development at the reclaimed tidal flat area southeast of East Creek Slough.

Aerial photographs from 1982 showed that, to the southwest of I-880, East Creek Slough had been diverted into an engineered channel. Photographs from 1993, 1998, and 2005 showed little change from 1982.

6. GEOLOGY

The following sections present our findings relative to the regional and study area geology.

6.1. Regional Geologic Setting

The study area is located at the western margin of a broad, alluvial plain that slopes gently west from the Oakland Hills to the San Francisco Bay in the Coast Ranges geomorphic province of California. The Coast Ranges are comprised of several mountain ranges and structural valleys formed by tectonic processes commonly found around the Circum-Pacific belt. Basement rocks have been sheared, faulted, metamorphosed, and uplifted, and are separated by thick blankets of Cretaceous and Cenozoic sediments that fill structural valleys and line continental margins. The San Francisco Bay area has several ranges that trend northwest-southeast, parallel to major strike-slip faults such as the San Andreas, Hayward, and Calaveras faults. Major tectonic activity associated with these and other faults within this regional tectonic framework consists primarily of right-lateral, strike-slip movement. Further discussion of faulting relative to the site is provided in Section 8.2 of this report.

6.2. Study Area Geology

A review of published geologic maps indicates that, in general, the central portion of the study area is underlain by Quaternary alluvium, while the northwestern and southeastern portions of the study area are underlain by recent artificial fill (Dibblee, 2005; California Geological Survey [CGS], 2003; Graymer, 2000; Knudsen et al., 2000; Helley et al., 1979;

Radbruch and Case, 1967). A portion of the map prepared by Graymer (2000) is provided as a Regional Geologic Map (Figure 4).

Each of the above referenced authors has a slightly different interpretation of the geology of the central portion of the study area. Dibblee (2005) indicates that the central portion of the project study area is underlain by undifferentiated Holocene alluvial gravel, sand, and clay; while CGS (2003) indicates it is underlain by Holocene alluvial fan deposits, but that the area along the former path of Sausal Creek through the study area (roughly along the alignment of Fruitvale Avenue) is underlain by artificial fill. Graymer (2000) indicates that the central portion of the study area is underlain by Holocene alluvial fan and fluvial deposits, but differentiates areas that are underlain by younger alluvial fan deposits. Graymer indicates that these areas are the modern location of deposition for the Holocene alluvial fan and fluvial deposits. Knudsen et al. (2000) indicate the central portion of the area is underlain by Holocene alluvial fan deposits. Helley et al. (1979), however, indicate the central portion is underlain by Pleistocene Merritt Sand, which consists of beach and sand dune deposits. Radbruch and Case (1967) indicates that the central portion is underlain by undifferentiated Quaternary alluvium with a small pocket of Bay Mud adjacent to the tidal canal between Derby Avenue and Peterson Street

Dibblee (2005), CGS (2003), Graymer (2000), Knudsen et al. (2000), and Radbruch and Case (1967) show that the northwestern and southeastern portions of the study area are underlain by artificial fill. CGS (2003) and Knudsen (2000) indicate that the artificial fill overlies Bay Mud. Helley et al. (1979) indicate that the northwestern and southeastern portions of the study area are underlain by Holocene Bay Mud. Rogers and Figuers (1991) indicate that the bottom of the Bay Mud in the project area is generally less than 25 feet below MSL, except at the northwestern portion of the project site where the bottom of the Bay Mud is 25 feet or more below MSL. California Division of Mines and Geology (CDMG, 1969) indicate that Bay Mud is present at the southern portion of site (roughly southeast of Fruitvale Avenue) and that the thickness is less than 20 feet. Rogers and Figuers (1991) also indicate that the top of Franciscan bedrock is about 700 to 900 feet below MSL in the study area.

Our review of available geotechnical reports for the study area generally supports the interpretation of the above referenced authors that the central portion of the study area is underlain by Quaternary alluvium, while the northwestern and southeastern portions of the study area are underlain by recent artificial fill that overlies Bay Mud. However, the review also indicated that fill materials are present at the surface at some locations in the central portion of the site which is mapped as being underlain by Quaternary alluvium.

At the northwestern portion of the study area, Bay Soils (1981, 1983) encountered approximately 3 to 12 feet of fill overlying Bay Mud at the northeast corner of Livingston Street and Embarcadero. The Bay Mud was approximately 6 to 15 feet in thickness and was underlain by older native soils. Harding-Lawson Associates (1979) also encountered approximately 5 to 6 feet of fill overlying approximately 8 to 10 feet of Bay Mud at the northeast corner of Embarcadero and Dennison Street. The Bay Mud was underlain by older bay deposits.

At the central portion of the study area, Kaldveer Associates (1988) encountered approximately 5½ to 8½ feet of fill overlying native soils at 3675 Alameda Avenue (between Alameda Avenue and the tidal canal). Krazan & Associates (1994) encountered approximately 1 to 9 feet of fill overlying native surface soils at the northwest corner of Alameda Avenue and East 8th Street. Log of test boring sheets from the 23rd Avenue overcrossings and the Fruitvale Avenue Overhead indicate that alluvium was encountered during subsurface exploration (AGS, 1994a; AGS, 1994b). Cone penetration test (CPT) soundings in the vicinity of the 23rd and 29th Avenue overcrossings at I-880 by Ninyo & Moore (2008) indicated materials consistent with alluvium.

At the southeastern portion of the study area, R.C. Harlan and Associates (1982) encountered approximately 4 to 5 feet of fill overlying about 8 feet of Bay Mud at 4601 Malat Street (between Malat Street and Tidewater Avenue). The Bay Mud was underlain by older native soils. Nearby at 4611 Malat Street, J. Yang and Associates (1998) encountered approximately 8 feet of fill overlying Bay Mud.

Natural Resources Conservation Service (NRCS) soil maps of the study area (NRCS, 2009) indicate the north-central portion of the area is underlain by the Urban Land-Clear Lake complex, which generally consists of clay in the upper approximately 60 inches, and that remainder of the study area is underlain by Urban Land. The representative plasticity index of these soils was not evaluated.

During the geologic reconnaissance, Ninyo & Moore did not observe exposures of rock or soil to contradict the published interpretations of the site geology.

6.3. Subsurface Conditions

The following unit descriptions are based on our literature review and field observations.

6.3.1. Artificial Fill

Areas of man-made artificial fill are present in the study area in locations between the present and former shorelines or at former tidal flats (Radbruch, 1959). Graymer (2000) indicates that the artificial fill consists of various materials and ages, and that some are compacted and quite firm, but that fills made before 1965 are nearly everywhere not compacted and consist simply of dumped materials. Radbruch (1959) indicates that the majority of fill along the east shore of the San Francisco Bay consists of Merritt sand that has been dredged or pumped from offshore underwater borrow areas, but that in some areas it may consists of bay mud, material from the Temescal Formation, broken rock, or miscellaneous refuse.

At the northwestern portion of the study area, Bay Soils (1981; 1983) describes the fill encountered at the northeast corner of Livingston Street and Embarcadero as sand and gravel, sand, clay and sand, and silty clay with concrete rubble. Harding-Lawson Associates (1979) describes the fill encountered at the northeast corner of Embarcadero and Dennison Street as a homogenous mix of silts and clays with occasional sand and gravel layers.

At the central portion of the study area, Kaldveer Associates (1988) described the fill encountered at 3675 Alameda Avenue (between Alameda Avenue and the tidal canal) as sandy, clayey gravels, gravelly sands, silty clays, and sandy silts with metal, glass, and wood fragments. Krazan & Associates (1994) described the fill encountered at the northeast corner of Alameda Avenue and East 8th Street as silty sand with gravel, clayey sand with gravel, and sandy clay.

At the southeastern portion of the study area, R.C. Harlan and Associates (1982) describes the fill encountered at 4601 Malat Street (between Malat Street and Tidewater Avenue) as sandy, clayey gravel. J. Yang and Associates (1998) describes the fill encountered at 4611 Malat Street as sandy clay, silty sand, clay, sandy clay gravel, and sandy gravel.

6.3.2. Bay Mud

Graymer (2000) indicates that the Bay Mud is Holocene-age and consists of water saturated estuarine mud that consists of grey, green, and blue clay and silty clay with lenses of well-sorted fine sand and silt, a few shelly layers, and peat. Helley et al. (1979) describe the Bay Mud as Holocene-age, unconsolidated, water-saturated, dark, plastic clay and silty clay rich in organic material with lenses and stringers of well-sorted silt and sand as well as beds of peat. Radbruch (1959) describes the Bay Mud as predominantly homogenous, plastic, olive-gray, sandy, silty clay with a few small sand lenses, shells, and organic-material that is too soft to be a suitable foundation material.

At the northwestern portion of the study area, Bay Soils (1981; 1983) describes the Bay Mud encountered at the northeast corner of Livingston Street and Embarcadero as silty clay and clay with some sand lenses and organic material. Harding-Lawson Associates (1979) describe the Bay Mud encountered at the northeast corner of Embarcadero and Dennison Street as clayey silt.

At the southeastern portion of the site, R.C. Harlan and Associates (1982) describes the Bay Mud encountered at 4601 Malat Street (between Malat Street and Tidewater Avenue) as silty clay.

6.3.3. Younger Alluvial Fan Deposits

Graymer (2000) identifies this unit as Holocene-age, brown, poorly-sorted, dense, sandy or gravelly clay that represents the modern loci of deposition for Holocene alluvial fan and fluvial deposits

6.3.4. Alluvium

Dibblee (2005) describes the alluvium as Holocene-age alluvial gravel, sand, and clay. Graymer (2000) describes this unit as Holocene alluvial fan and fluvial deposits. Graymer (2000) describes the alluvial fan deposits as brown or tan, medium dense to dense, gravely sand or sandy gravel that generally grades upward to sandy or silty clay; and describes the fluvial deposits as brown, not reddish, medium dense sand that fines upward to sand or silty clay. Helley et al. (1979) indicate that the area is underlain by Pleistocene Merritt Sand, which is described as beach and sand dune deposits consisting of loose, well-sorted, fine- to medium-grained sand with subordinate silt.

At the central portion of the study area, Kaldveer Associates (1988) describe the native soils at 3675 Alameda Avenue (between Alameda Avenue and the tidal canal) as silty clay, clayey silt, clayey sand, and sandy gravel. Krazan & Associates (1994) describes the native surface soils at the northwest corner of Alameda Avenue and East 8th Street as clay interlayered with clayey sand and silty sand. Log of test boring sheets from the 23rd Avenue overcrossings and the Fruitvale Avenue Overhead indicate that alluvium consisted of alternating layers of gravel, sand, sandy and silty clay, clayey and silty sand, and sandy silt (AGS, 1994a; AGS, 1994b). Soil Behavior Type correlations with the CPT data acquired by Ninyo & Moore (2008) indicate that the subsurface materials in the vicinity of the 23rd and 29th Avenue overcrossings generally consist of clay with some layers of silty clay, clayey silt, silty sand, and sand.

7. GROUNDWATER

The groundwater table is expected to occur at relatively shallow depths. The map of historic high groundwater levels presented within the Seismic Hazard Zone report for the Oakland East and part of the Las Trampas Ridge Quadrangle (CGS, 2003) indicates that the depth to historic high groundwater within the project study area is between less than 5 and less than 10 feet below ground surface (Figure 5).

At the northwestern portion of the study area, Bay Soils (1981, 1983) encountered groundwater at depths of approximately 6 to 7 feet below ground surface at the northeast corner of Livingston Street and Embarcadero.

At the central portion of the study area, Kaldveer Associates (1988) encountered groundwater at depths of approximately 9 to 12 feet below ground surface at 3675 Alameda Avenue. Krazan & Associates (1994) encountered groundwater at approximately 7 to 19 feet below ground surface at the northwest corner of Alameda Avenue and East 8th Street. Log of test boring sheets from the 23rd Avenue and 29th Avenue overcrossings indicate that groundwater was encountered at about 11½ feet below ground surface in the vicinity of the 23rd Avenue overcrossing (AGS, 1994a) and at about 9 to 30 feet below ground surface in the vicinity of the Fruitvale Avenue overhead (AGS, 1994b).

At the southeastern portion of the study area, R.C. Harlan and Associates (1982) encountered groundwater at depths of approximately 3 to 4 feet below ground surface at 4601 Malat Street (between Malat Street and Tidewater Avenue). Fluctuations in the groundwater level may occur, however, due to variations in ground surface topography, subsurface geologic conditions and structure, rainfall, irrigation, and other factors.

8. SEISMIC HAZARDS

The seismic hazards considered in this study include the potential for ground surface rupture and ground shaking due to seismic activity, seismically induced liquefaction, dynamic settlement,

seismic slope stability, and tsunamis and seiches. These potential hazards are discussed in the following subsections.

8.1. Historical Seismicity and Ground Failure

The site is located in a seismically active region, as is the majority of northern California. Table 1 summarizes the significant historic earthquakes that have occurred within a radius of approximately 100 kilometers (62 miles) of the site with a magnitude of 6.0 or more since 1800.

Table 1 – Historic Earthquakes

Date	Magnitude[1] (M)
June 21, 1808	6.0
June 10, 1836	6.8
June 1838	7.0
November 26, 1858	6.1
October 8, 1865	6.3
October 21, 1868	6.8
May 19, 1889	6.0
April 19, 1892	6.4
April 21, 1892	6.2
March 31, 1898	6.2
April 18, 1906	7.8
July 1, 1911	6.6
April 24, 1984	6.1
October 18, 1989	7.1

Note:
[1]USGS http://neic.usgs.gov/neis/epic/epic_circ.html

We also reviewed a map of historic ground failures in the study area that were triggered by earthquakes (Youd and Hoose, 1978), a map showing locations of liquefaction and related ground-failure effects related to the Loma Prieta earthquake (1989) (Holzer, 1998), and a map of damage in Alameda and Contra Costa counties in the 1906 earthquake (Nason, 1982).

Youd and Hoose (1978) indicated an occurrence of lateral spread near the northwest portion of the study area associated with the 1868 earthquake and a miscellaneous effect at the central portion of the study area associated with the 1906 earthquake. Holzer (1998) did not

indicate occurrences of liquefaction or related ground-failure effects related to the Loma Prieta earthquake within the study area. Nason (1982) indicates that damage in the vicinity of the study area in the 1906 earthquake included falling of several chimneys in houses along High Street and that plastering in the houses was severely cracked.

8.2. Faulting and Ground Surface Rupture

The numerous faults in northern California include active, potentially active, and inactive faults. As defined by the CGS, active faults are faults that have ruptured within Holocene time, or within approximately the last 11,000 years. Potentially active faults are those that show evidence of movement during Quaternary time (approximately the last 1.6 million years) but for which evidence of Holocene movement has not been established. Inactive faults do not show evidence of movement within Quaternary time.

The site is not located within an Alquist-Priolo Fault Rupture Hazard Zone established by the state geologist (CDMG, 1982) to delineate regions of potential ground surface rupture adjacent to active faults (Figure 6). The closest known active fault is the Hayward fault located approximately 4.3 to 5.0 kilometers northeast of the study area. Major known active faults in the region consist generally of en-echelon, northwest-striking, right-lateral, strike-slip faults. These include the Calaveras, Hayward, and Concord/Green Valley faults, located east of the site, and the San Andreas fault, located west of the site. The approximate locations of major faults in the region and their geographic relationship to the project vicinity are shown on Figure 7. Table 2 lists the seismic parameters for the principal active faults in the project vicinity. The values of fault to site distance, moment magnitude, and slip rate listed in the table were evaluated using FRISKSP (Blake, 2001) which is based upon the seismic data published by the USGS and the CGS (Cao et al., 2003) with consideration for multi-segment events where noted.

Table 2 – Principal Active Faults

Fault	Approximate Fault to Site Distance [1] (km)	Moment Magnitude [1] (M_{max})	Slip Rate [1] SR (mm/year)	Fault Type [2]
Hayward[3]	4.3-5.0	7.26	9.0	Strike Slip
Calaveras[4]	19.1-20.8	6.93	11.0	Strike Slip
Mount Diablo Thrust	20.0-21.0	6.65	2.0	Reverse
San Andreas[5]	23.8-24.8	7.90	20.0	Strike Slip
Concord/Green Valley[6]	25.0-26.1	6.71	4.7	Strike Slip
San Gregorio[7]	31.3-32.9	7.44	6.0	Strike-Slip
Monte Vista – Shannon	35.8-38.6	6.70	0.4	Reverse
Greenville North	36.3-37.8	6.66	2.0	Strike-Slip
West Napa	42.2-45.2	6.50	1.0	Strike-Slip
Great Valley 5	54.1-55.0	6.50	1.5	Reverse
Point Reyes	54.9-58.1	7.00	0.3	Reverse
Great Valley 7	60.8-63.4	6.70	1.5	Reverse
Great Valley 4	64.6-66.4	6.60	1.5	Reverse
Hunting Creek-Berryessa	74.4-77.2	7.10	6.0	Strike-Slip
Zayante-Vergeles	77.6-80.9	7.00	0.1	Reverse
Monterey Bay-Tularcitos	93.5-96.6	7.30	0.5	Reverse
Maacama-Gerberville	96.4-99.8	7.50	9.0	Strike-Slip
Ortigalita	98.6-102.1	7.10	1.0	Strike-Slip
Great Valley 8	99.8-103.0	6.60	1.5	Reverse

Notes:
[1] Blake, 2001
[2] Cao et. al., 2003
[3] Includes Southern, Northern, and Rodgers Creek segments
[4] Includes Southern, Central, and Northern segments
[5] Includes Southern, Peninsula, Northern, and Offshore segments
[6] Includes Concord, Green Valley South, and Green Valley North segments
[7] Includes Southern and Northern segments

8.3. Strong Ground Motion

The site will experience a relatively large degree of ground shaking during a significant earthquake on a nearby fault. Based on a probabilistic seismic hazard model for California (USGS/CGS, 2002) peak horizontal ground accelerations having a 10 percent probability of exceedance in 50 years can be estimated to be between about 0.65g to 0.68g in the study area.

8.4. Liquefaction and Strain Softening

The strong vibratory motions generated by earthquakes can trigger a rapid loss of shear strength in saturated, loose, granular soils of low plasticity (liquefaction) or in wet, sensitive, cohesive soils (strain softening). Liquefaction and strain softening can result in a loss of

foundation bearing capacity or lateral spreading of sloping or unconfined ground. Liquefaction can also generate sand boils leading to subsidence at the ground surface.

The study area is located within a liquefaction hazard zone on the Map of Seismic Hazard Zones (Figure 8) prepared by the CGS (CGS, 2003b). The City of Oakland General Plan, Safety Element (2004) also indicates that the area is in an area susceptible to liquefaction. The Association of Bay Area Governments (ABAG, 2004) indicates that the liquefaction susceptibility at the central portion of the area is moderate, but that the liquefaction susceptibility at the northwestern and southern portion of the site is very high (Figure 9). Knudsen et al. (2000) show the similar liquefaction susceptibility as ABAG in the central and southeastern portions of the study area, but the zone of very high liquefaction susceptibility at the northwest portion of the site extends farther east. Holzer et al. (2002) indicates that the approximate percent of the area predicted to liquefy during a Magnitude 7.1 earthquake on the Hayward fault is 3 percent in the central portion of the area and 73 percent at the northwest and southern portions of the area. .

As noted previously, relatively shallow groundwater conditions exist at the project site. Due to the relatively young age of the on-site soils, there may be loose sandy intervals in the unit that have a potential for liquefaction. Typically, materials at depths of more than 50 feet, due to the overburden, do not have a potential for liquefaction.

8.5. Dynamic Settlement

The strong vibratory motion associated with earthquakes can also dynamically compact loose granular soil leading to surficial settlements. Dynamic settlement is not limited to the near-surface environment and may occur in both dry and saturated sand and silt. Cohesive soils are not typically susceptible to dynamic settlement.

Seismically induced dynamic settlement may occur within the study area following a significant seismic event, particularly in the areas where the liquefaction susceptibility is mapped as moderate to very high.

8.6. Lateral Spread

In addition to vertical displacements, seismic ground shaking can induce horizontal displacements as surficial soil deposits spread laterally by floating atop liquefied subsurface layers. Lateral spread can occur on sloping ground or on flat ground adjacent to an exposed face. Lateral spreading has generally been observed to take place in the direction of a free-face (e.g., a retaining wall or slope).

In the study area, free-facing slopes and exposed faces that are underlain by potentially liquefiable soils are present along the waterfront. Therefore, there is a potential for lateral spreading in the study area.

8.7. Seismic Slope Stability

As discussed previously, slopes are present in the study area along the waterfront and at the 23rd and 29th Avenue overcrossings at I-880. Slopes at the waterfront are located along Brooklyn Basin, the tidal canal, and San Leandro Bay and are generally on the order of 10 feet in height and range from approximately 2:1 (horizontal:vertical) to nearly vertical. Slopes at the 23rd and 29th Avenue overcrossing bridge abutments at I-880 are present where up to approximately 15 feet of fill has been placed for the approach embankments. Side slopes of these embankments are generally on the order of 1½:1 (horizontal to vertical) to 2½:1 (horizontal to vertical).

The study area is not located within a landslide hazard zone on the map of Seismic Hazard Zones (Figure 8) prepared by the CGS (CGS, 2003b). A seismic landslide hazard map prepared by Miles and Keefer (2001) indicates that the majority of the study area was not evaluated due to the slope (less than 6 degrees). However, the approach embankments for the 23rd Avenue and 29th Avenue overcrossings are shown to have a moderately low to moderately high seismic landslide hazard. Miles and Keefer (2001) also indicate a moderately low seismic landslide hazard along the tidal canal between Peterson Street and Lancaster Street, and a moderately low to moderate seismic landslide hazard south of the

bend in Alameda Avenue. Seismic slope stability in the study area may be an issue of concern along the waterfront and at the approach embankments.

8.8. Tsunamis and Seiches

Tsunamis are long wavelength seismic sea waves (long compared to ocean depth) generated by the sudden movements of the ocean floor during submarine earthquakes, landslides, or volcanic activity. The City of Oakland General Plan, Safety Element (2004) indicates that the southeastern portion of the study area is in a tsunami run-up zone (Figure 10). Seiches are waves generated in a large enclosed body of water. Considering that there are no large enclosed bodies of water nearby, the potential for damage due to seiches is not significant.

9. LANDSLIDING

As discussed previously, slopes are present in the study area along the waterfront and at the 23rd and 29th Avenue overcrossings at I-880.

The City of Oakland General Plan, Safety Element (2004) indicates that the study area is not in an area susceptible to landsliding. Pike et al. (2001) indicate that the study area generally has the bottom rating for susceptibility to slope failure, except in the vicinity of the 23rd Avenue and 29th Avenue overcrossings, where the approach embankments have the near-bottom rating for susceptibility to slope failure. Roberts et al. (1999) do not indicate landslides within the study area. Wentworth et al. (1997) indicate that the study area is an area with little or no potential for slope instability except along stream banks or terrace margins.

We did not observe indications of landslides on the approach embankment slopes during our site reconnaissance. However, we did observe indications of slope instability at near-vertical, unprotected slopes along the waterfront in the study area. The waterfront area in the study area is susceptible to slope instability.

10. FLOOD HAZARDS

Our review of FEMA Flood Insurance Rate Maps (FEMA, 1982) found that there are portions of the study area bordering Brooklyn Basin, the tidal canal, and the engineered channel at the southern portion of the site considered to be within the 100-year floodplain and areas along Fruitvale Avenue/Sausal Creek and the southernmost portion of the site considered to be between the limits of the 100-year floodplain and the 500-year floodplain. A portion of this map is shown on Figure 11. The ABAG map of FEMA flood hazard areas (ABAG, 2009) shows similar relationships. The City of Oakland General Plan, Safety Element (2004) indicates that the former alignment of Sausal Creek along Fruitvale Avenue is within a 500-year floodplain and that the engineered channel at the southeastern portion of the study area is within a 100-year floodplain (Figure 10). Based on a review of the Dam Failure Inundation Areas prepared by the Association of Bay Area Governments (ABAG, 1995) and the City of Oakland General Plan, Safety Element (2004), the central portion of the study area is located within an inundation area following a conjectured catastrophic dam failure for the Central Reservoir (Figure 10).

11. EXPANSIVE SOILS

Some clay minerals undergo volume changes upon wetting or drying. Unsaturated soils containing those minerals will shrink/swell with the removal/addition of water. The heaving pressures associated with this expansion can damage structures and flatwork.

Soils in the study area that have relatively high clay contents may be expansive. Kaldveer Associates (1988) indicated that the clayey fill materials encountered at 3675 Alameda Avenue had a moderate to high expansion potential.

12. COMPRESSIBLE SOILS

Bay Mud is recognized as a compressible soil (Bay Soils, 1981; Harding-Lawson Associates, 1979; CDMG, 1969; Radbruch, 1959). Compressible soils may also be found in the study area in the form of loose, poorly compacted fill. Compressible soils can be susceptible to settlement when additional loads are placed on them.

13. CORROSIVE SOILS

There is a potential for corrosive soils to be encountered in the study area. Natural Resources Conservation Service (NRCS) soil maps of the study area (NRCS, 2009) did not evaluate the corrosivity of the soils at the study area, and data pertaining to the sulfate content and corrosivity of the on-site soils was not available in our review of geotechnical reports in the study area. However, Caltrans also defines a corrosive environment as an area within 1,000 feet of brackish water (Caltrans, 2003). A large portion of the study area falls within 1,000 feet of brackish water.

14. CONCLUSIONS

Based on the results of our study, it is our opinion that the project is feasible from a geotechnical perspective. Further, it is our opinion that the project will not have significant impacts on the geologic or geotechnical conditions as long as the project is conducted through proper design, including geotechnical design, and construction techniques. The following sections discuss site-specific geologic and geotechnical issues.

14.1. Geologic and Geotechnical Issues

- The northwestern and southeastern portions of the study area were formerly tidal marshes or bodies of water. These areas have fill materials present at the surface overlying soft Bay Mud.
- Fill is present at the surface overlying Quaternary alluvium in some locations at the central portion of the study area.
- There are several creeks, including 23rd Avenue Creek, Sausal Creek, and East Creek Slough, that have been buried or drained, or diverted underground in culverts and storm drains passing through the study area.
- The groundwater table is expected to occur at relatively shallow depths in the study area.
- There are several active faults in the region. Accordingly, the study area is subject to a relatively large degree of ground shaking due to earthquakes. Historically, the study area has experienced a high level of seismicity.
- Liquefiable soil are likely present within the study area.

- Seismically induced dynamic settlement may occur within the study area following a significant seismic event.
- There is a potential for lateral spreading in the study area, particularly at the slopes along the waterfront.
- Seismic slope stability in the study area may be an issue of concern along the waterfront and at the approach embankments.
- The southeastern portion of the study area is in a tsunami run-up zone.
- The waterfront slopes within the study area are susceptible to static slope instability.
- Portions of the study area are located within 100- and 500-year floodplains.
- The central portion of the study area is located within an inundation area following a conjectured catastrophic dam failure for the Central Reservoir,
- Expansive soils may be present in the study area. Treatment of expansive soils, if present at or near grade of new surface improvements sensitive to the action of expansive soils, could include removal and replacement with non-expansive soils, lime treatment, moisture conditioning, or utilization of special foundations.
- Compressible soils (Bay Mud and loose, uncompacted fill) are present in the study area. Loads imposed by surface improvements may cause compressible soils to settle. Means to remedy compressible soils include removal and recompaction (to improve their density), surcharging, compaction grouting, deep soil compaction, deep foundations, or foundations specially designed to tolerate the anticipated settlement.
- A large portion of the study area is located within 1,000 feet of brackish water, which is considered to be a corrosive environment. There is a potential for corrosive soils to be encountered in the study area.

15. LIMITATIONS

The field evaluation and geotechnical analyses presented in this report have been conducted in accordance with current engineering practice and the standard of care exercised by reputable geotechnical consultants performing similar tasks in this area. No warranty, implied or expressed, is made regarding the conclusions, recommendations, and professional opinions expressed in this report. Variations may exist and conditions not observed or described in this

report may be encountered. Our preliminary conclusions are based on an analysis of the observed conditions and the referenced background information.

The purpose of this study was to evaluate geologic and geotechnical conditions within the project site and to provide a geotechnical reconnaissance report to assist in the preparation of environmental impact documents for the project. The report is not intended for design or construction purposes.

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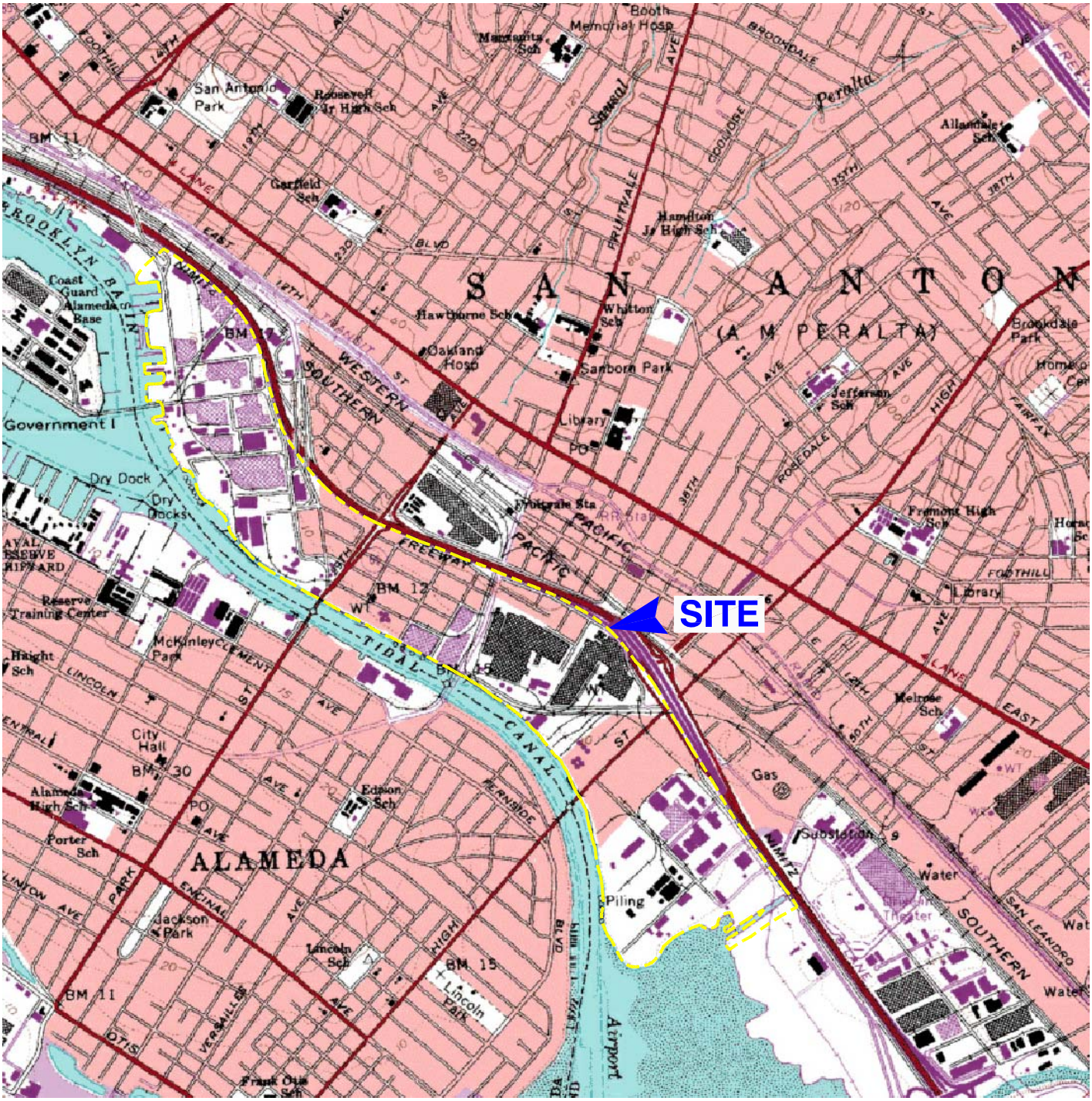
N

APPROXIMATE SCALE IN FEET

0 1900 3800

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Ninyo & Moore	SITE LOCATION MAP	FIGURE
PROJECT NUMBER: 401525002 / DATE: 4/09	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	1



REFERENCE: UNITED STATES GEOLOGICAL SURVEY, 1980, OAKLAND EAST 7.5 MINUTE QUADRANGLE TOPOGRAPHIC MAP: SCALE 1:24,000.

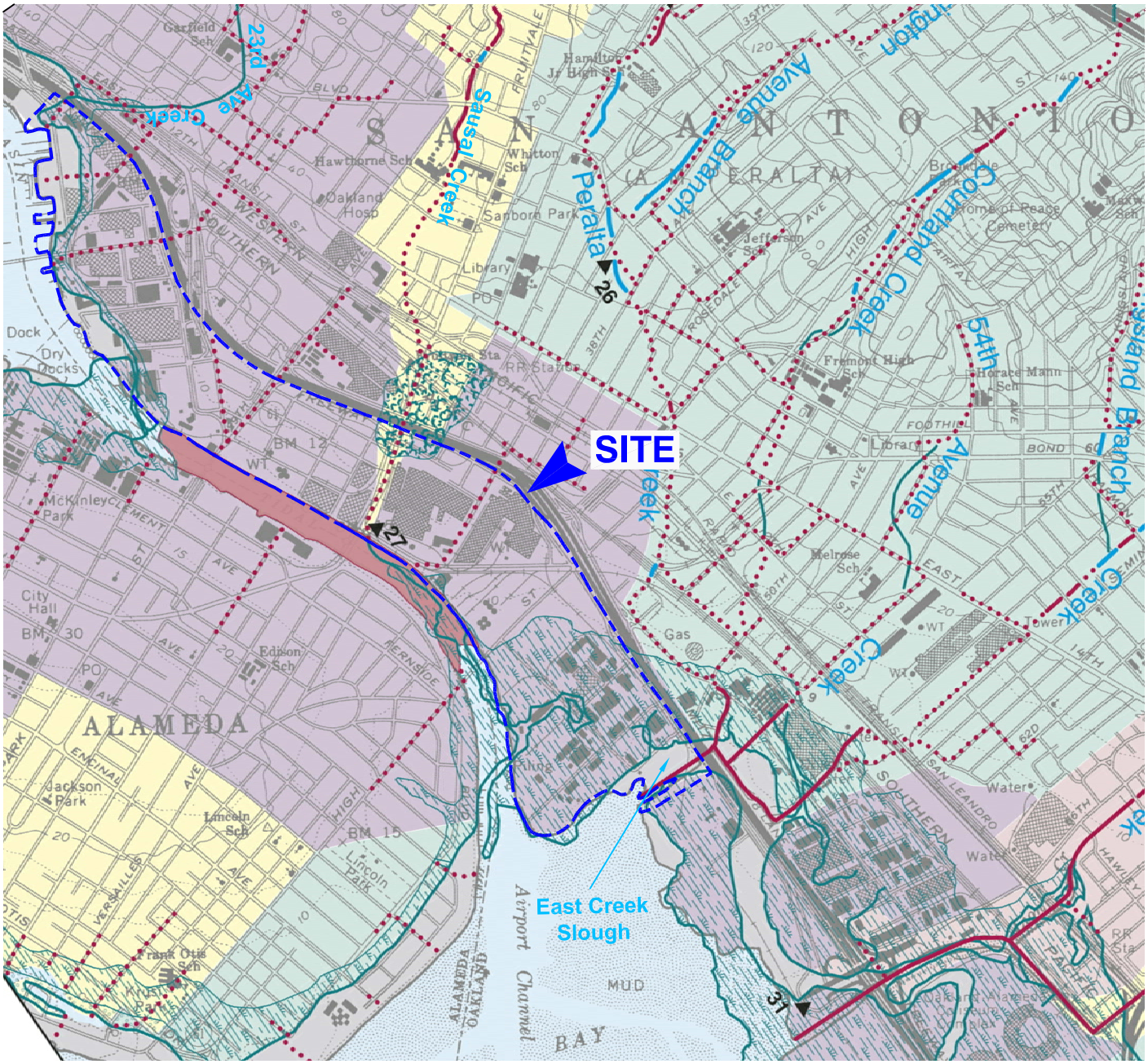
N

APPROXIMATE SCALE IN FEET

0 2000 4000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Ninyo & Moore		TOPOGRAPHIC MAP	FIGURE
PROJECT NO.	DATE	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	2
401525002	4/09		



REFERENCE: SOWERS, J.M., 2000, CREEK AND WATERSHED MAP OF OAKLAND AND BERKELEY, THE OAKLAND MUSEUM OF CALIFORNIA.

N

APPROXIMATE SCALE IN FEET

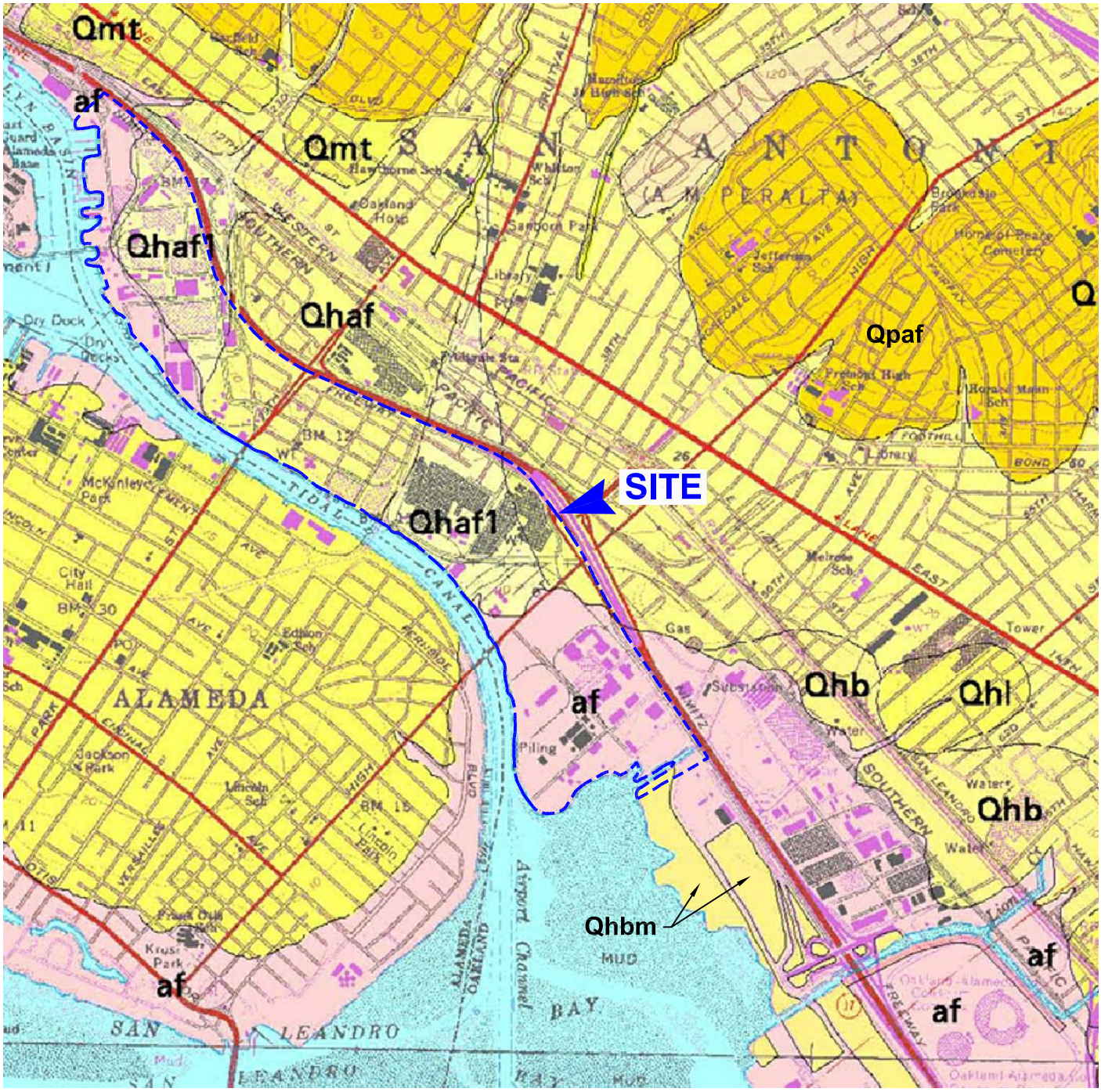
0 2000 4000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

- Creeks
- Former creeks, buried or drained, and Bay shoreline, circa 1850
- Underground culverts and storm drains
- Engineered channels
- now water
- now fill land
- Tidal marsh, circa 1850
- Willow groves, circa 1850
- Beach, circa 1850
- Bay
- Bay, circa 1850, now fill land
- Present watersheds
- Artificial bodies of water
- ▲10 Points of interest

Ninyo & Moore	CREEK & WATERSHED MAP	FIGURE
PROJECT NO. 401525002 / DATE 4/09	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	3



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N

APPROXIMATE SCALE IN FEET

0 2000 4000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

af	Artificial fill (Historic)	Qhb	Basin deposits (Holocene)
Qhaf1	Younger alluvial fan deposits (Holocene)	Qhaf	Alluvial fan and fluvial deposits (Holocene)
Qhl	Natural levee deposits (Holocene)	Qhbm	Bay Mud (Holocene)
Qmt	Marine terrace deposits (Pleistocene)	Qpaf	Alluvial fan and fluvial deposits (Pleistocene)
			Geologic Contact

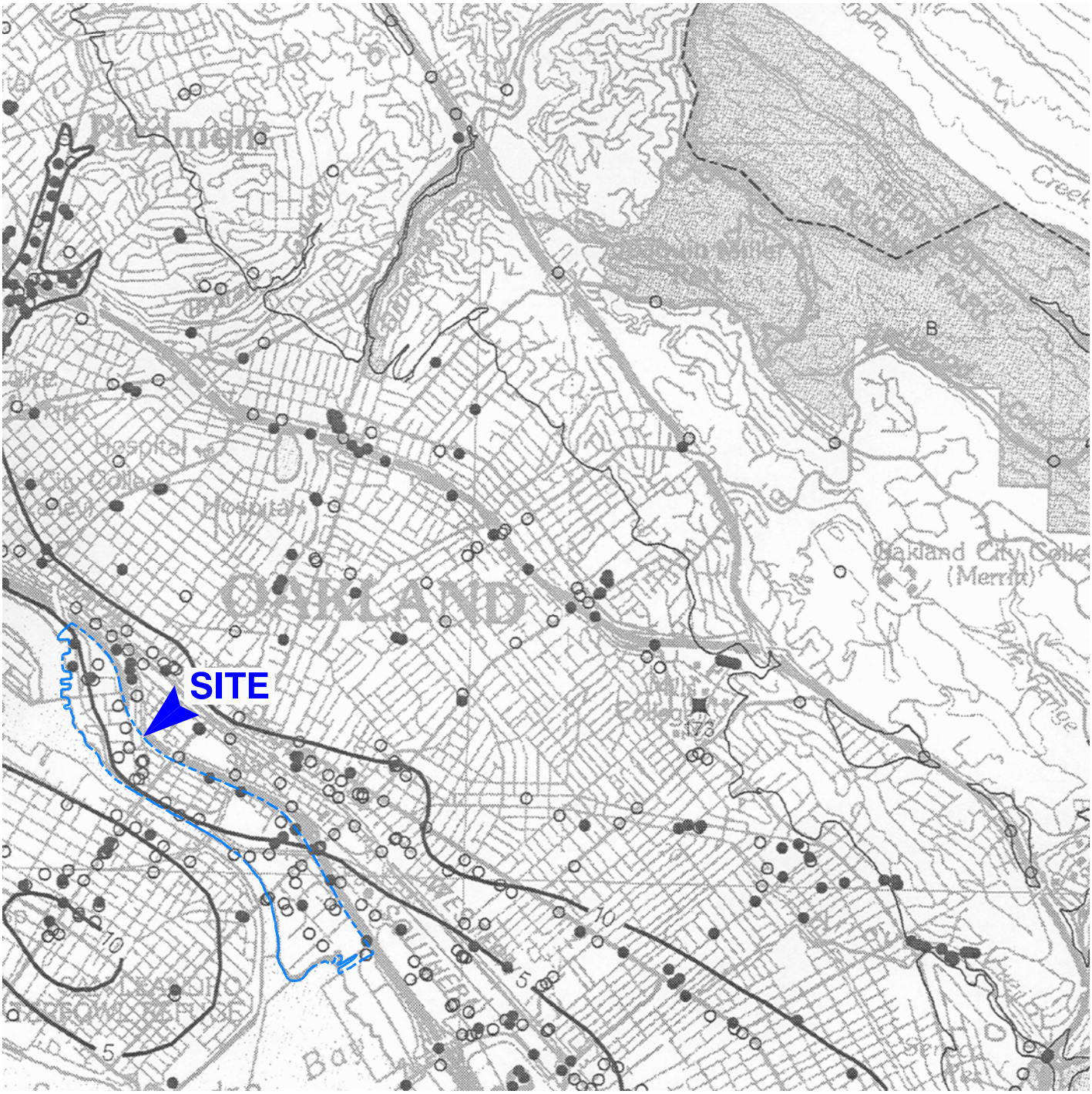
Ninyo & Moore

REGIONAL GEOLOGIC MAP

FIGURE 4

PROJECT NO.	DATE
401525002	4/09

GEOLOGICAL TECHNICAL STUDY
CENTRAL ESTUARY
OAKLAND, CALIFORNIA



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N

APPROXIMATE SCALE IN FEET

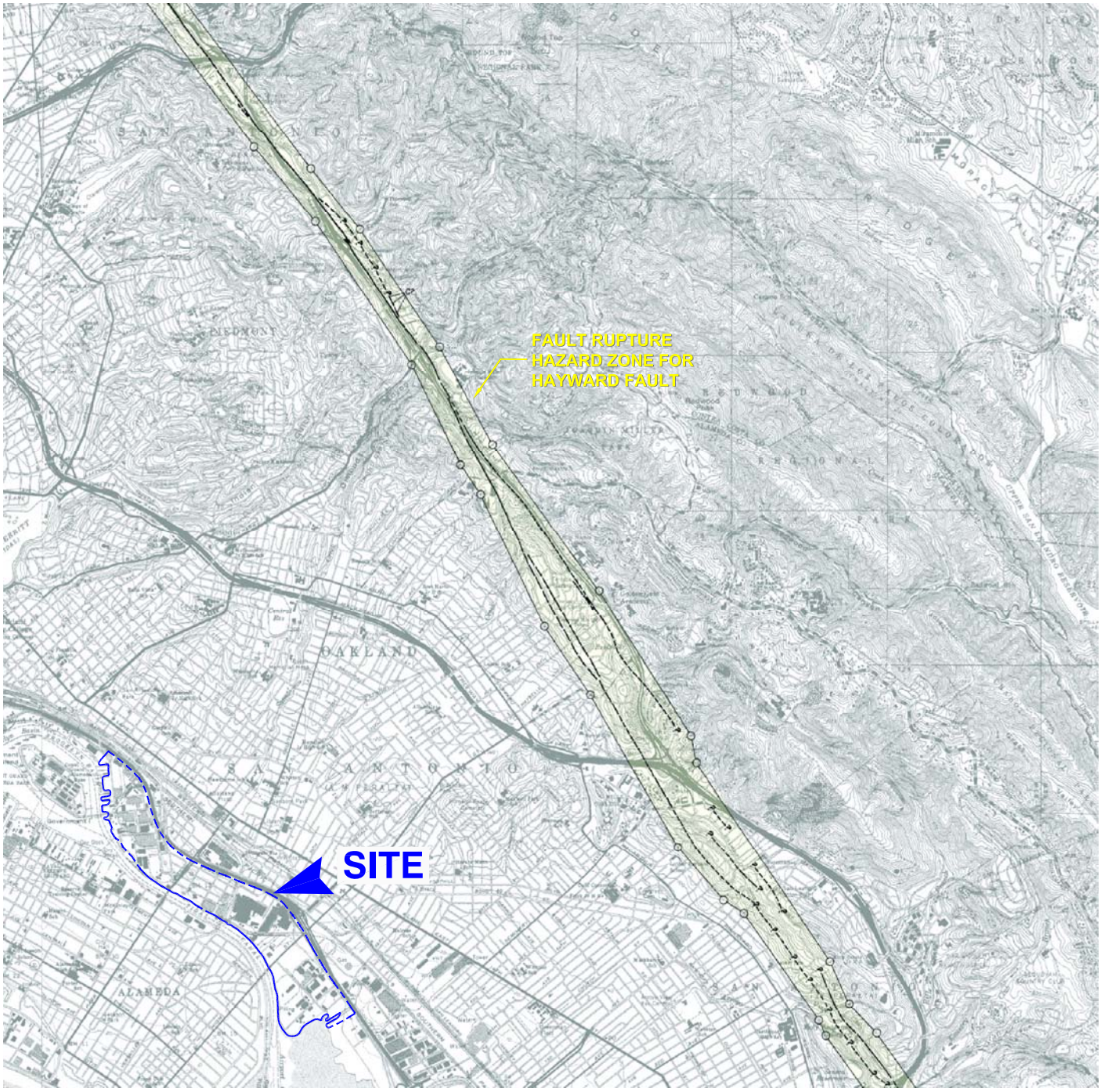
0 4000 8000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

●	GEOTECHNICAL BORINGS USED FOR LIQUEFACTION EVALUATION BY C.G.S
○	GROUND-WATER LEVEL DATA PROVIDED BY THE CALIFORNIA STATE WATER RESOURCES CONTROL BOARD
10	DEPTH TO GROUND WATER, IN FEET

Ninyo & Moore	DEPTH TO HISTORICALLY HIGH GROUND WATER	FIGURE
PROJECT NO. / DATE	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	5
401525002 / 4/09		



REFERENCE: CALIFORNIA DIVISION OF MINES AND GEOLOGY, OAKLAND EAST, SPECIAL STUDIES ZONES, SCALE 1:24000, DATED JANUARY 1, 1982.

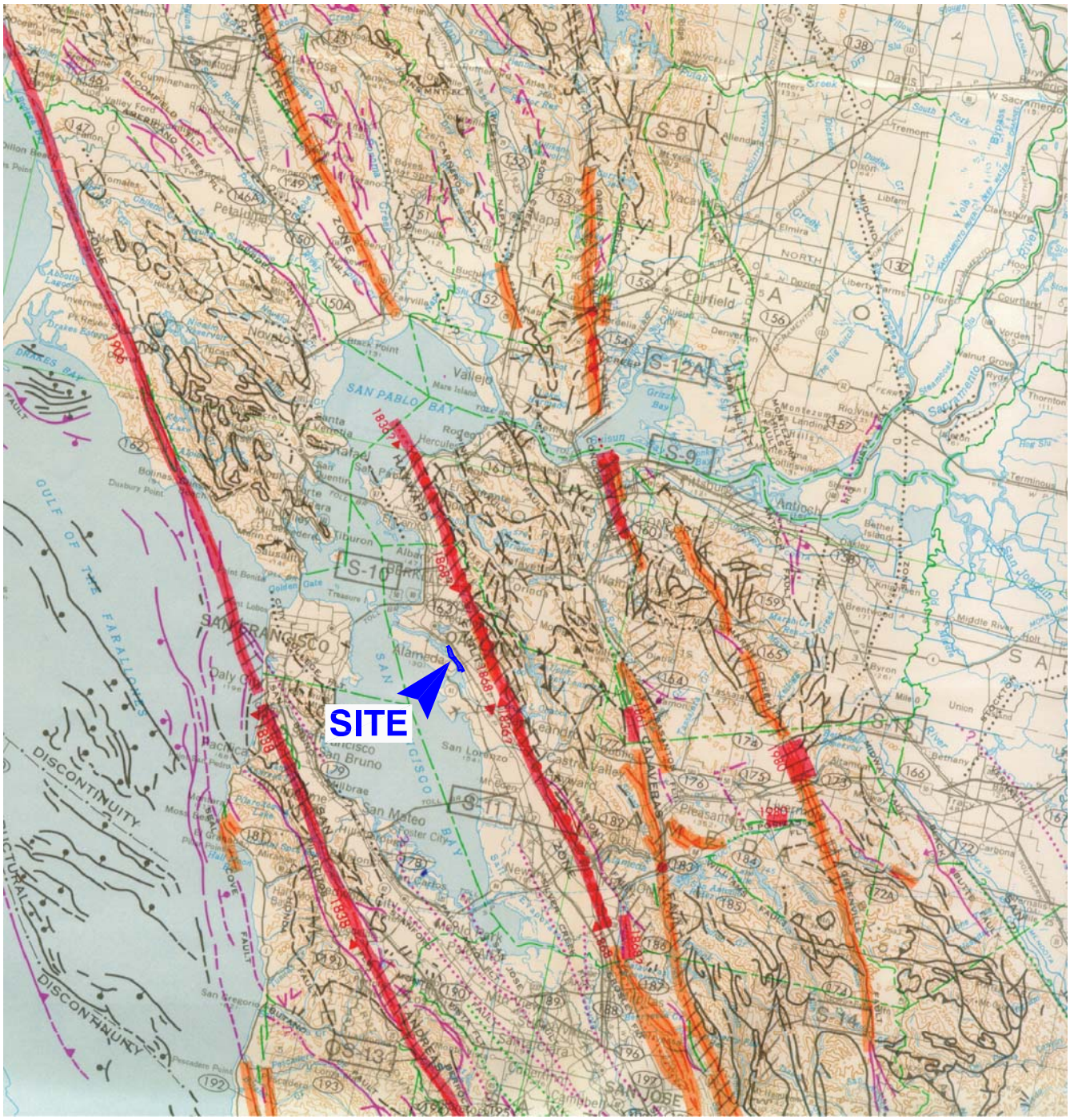
N

APPROXIMATE SCALE IN FEET

0 5000 10000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Ninyo & Moore		FAULT RUPTURE HAZARD ZONES MAP	FIGURE
PROJECT NO.	DATE	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	6
401525002	4/09		



REFERENCE: JENNINGS, C.W., 1994, FAULT ACTIVITY MAP OF CALIFORNIA AND ADJACENT AREAS, CALIFORNIA DIVISION OF MINES AND GEOLOGY, CALIFORNIA GEOLOGIC DATA MAP SERIES, MAP NO.6, SCALE 1:750,000.

N

APPROXIMATE SCALE IN MILES

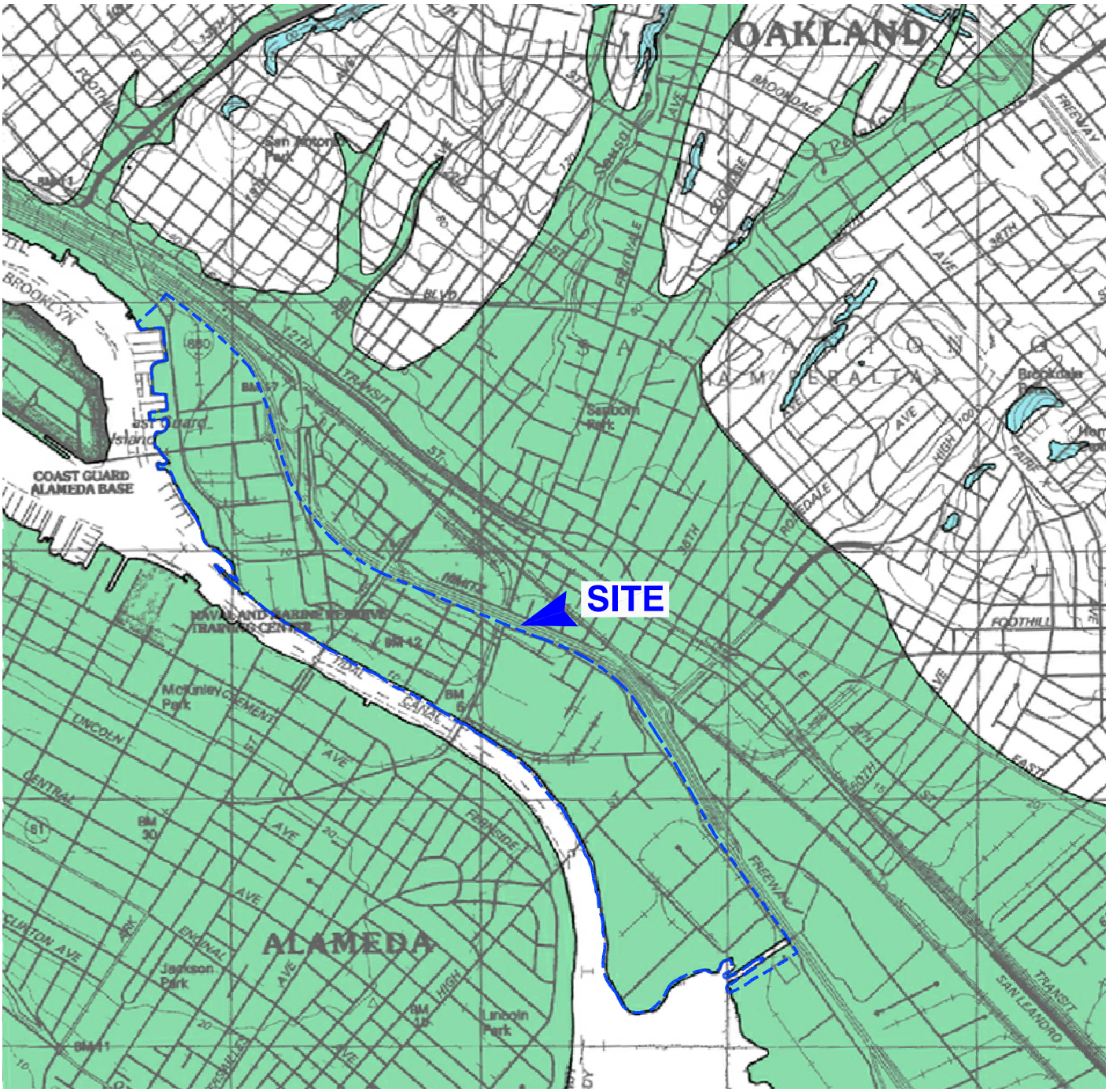
0 12 24

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

EXPLANATION

- Historic Fault Displacement (Last 200 Years)
- Holocene Fault Displacement (During Past 11,000 Years)

Ninyo & Moore	FAULT LOCATION MAP	FIGURE
PROJECT NO. / DATE	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	7
401525002 / 4/09		



REFERENCE: CALIFORNIA GEOLOGICAL SURVEY, 2003, SIESMIC HAZARD ZONES,OAKLAND EAST AND PART OF THE LAS TRAMPAS RIDGE: QUADRANGLES,SCALE 1:24000.

N

APPROXIMATE SCALE IN FEET

0 2000 4000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

SEISMIC HAZARDS

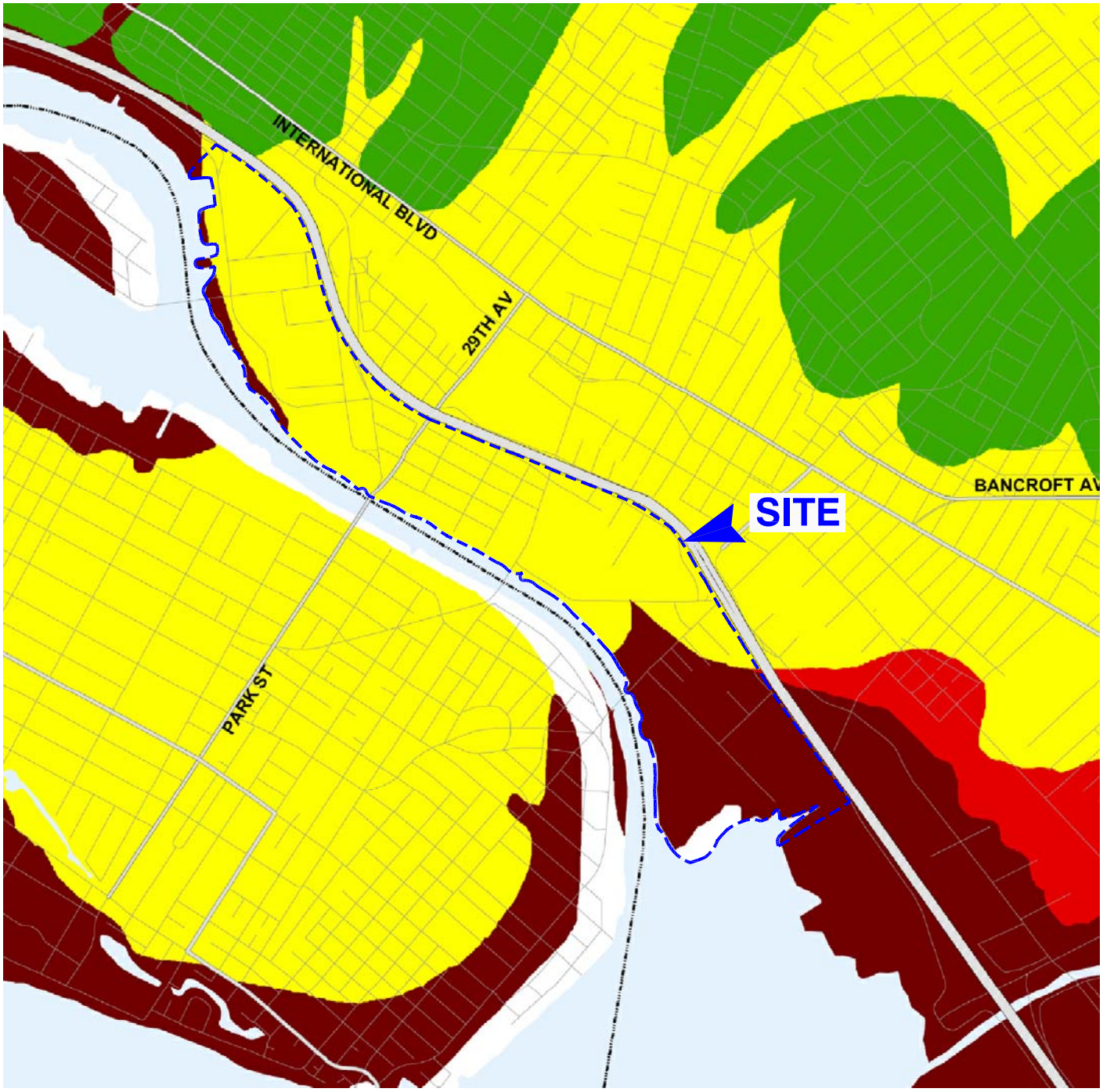
LIQUEFACTION

AREAS WHERE HISTORICAL OCCURRENCE OF LIQUEFACTION, OR LOCAL GEOLOGICAL, GEOTECHNICAL AND GROUNDWATER CONDITIONS INDICATE A POTENTIAL FOR PERMANENT GROUND DISPLACEMENTS SUCH THAT MITIGATION AS DEFINED IN PUBLIC RESOURCES CODE SECTION 2693(c) WOULD BE REQUIRED.

EARTHQUAKE-INDUCED LANDSLIDES

AREAS WHERE PREVIOUS OCCURRENCE OF LANDSLIDE MOVEMENT, OR LOCAL TOPOGRAPHIC, GEOLOGICAL, GEOTECHNICAL AND SUBSURFACE WATER CONDITIONS INDICATE A POTENTIAL FOR PERMANENT GROUND DISPLACEMENTS SUCH THAT MITIGATION AS DEFINED IN PUBLIC RESOURCES CODE SECTION 2696(c) WOULD BE REQUIRED.

Ninyo & Moore	SEISMIC HAZARD ZONES MAP	FIGURE
PROJECT NUMBER: 401525002 / DATE: 4/09	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	8



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N

APPROXIMATE SCALE IN FEET

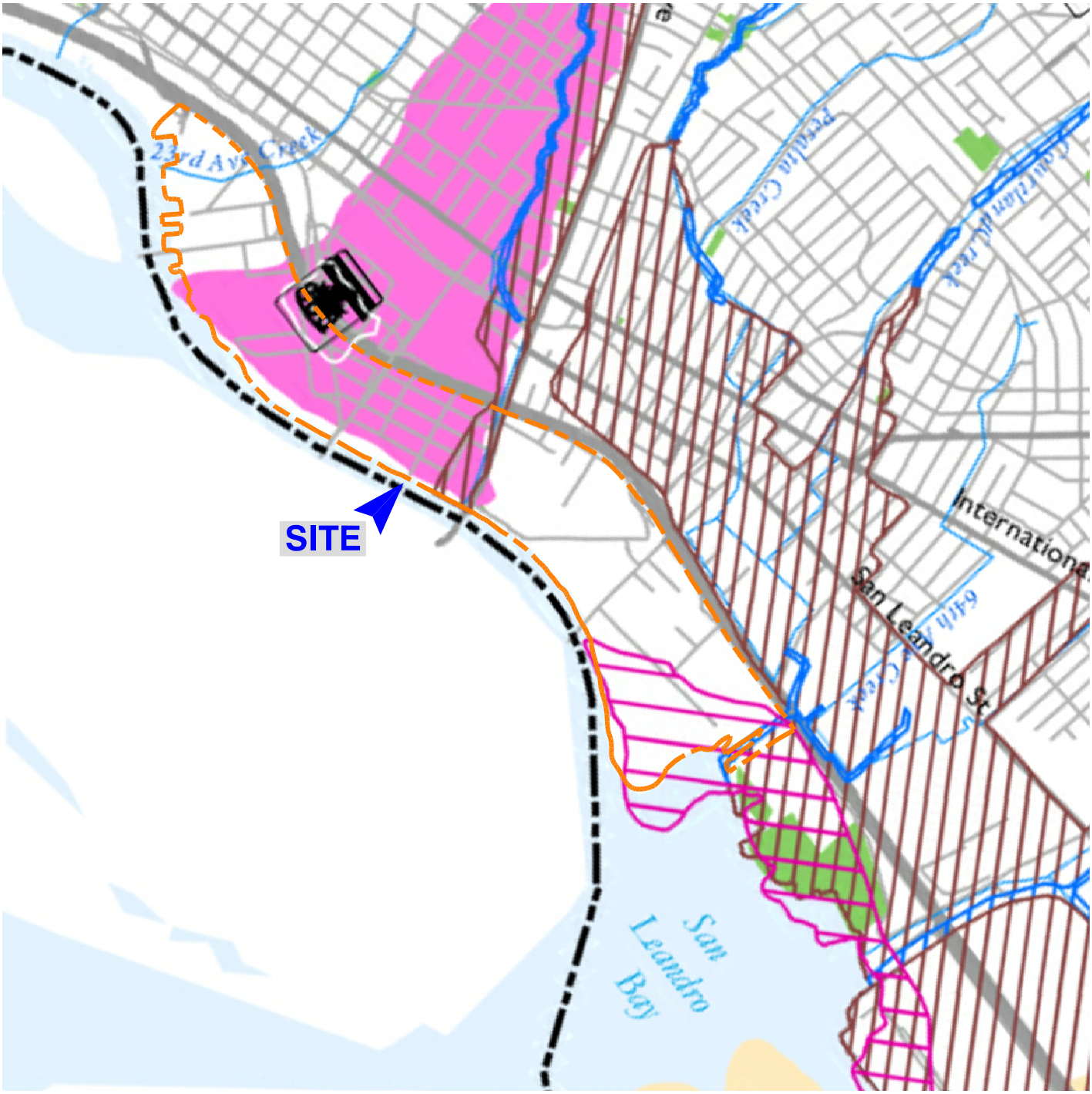
0 2000 4000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

SUSCEPTIBILITY LEVEL

- Very High
- High
- Moderate
- Low
- Very Low
- Major Roads
- Local Roads

Ninyo & Moore	LIQUEFACTION SUSCEPTIBILITY MAP	FIGURE
PROJECT NO. / DATE	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	9
401525002 / 4/09		



REFERENCE: CITY OF OAKLAND, 2004, GENERAL PLAN, SAFETY ELEMENT; DATED NOVEMBER.

N

APPROXIMATE SCALE IN FEET

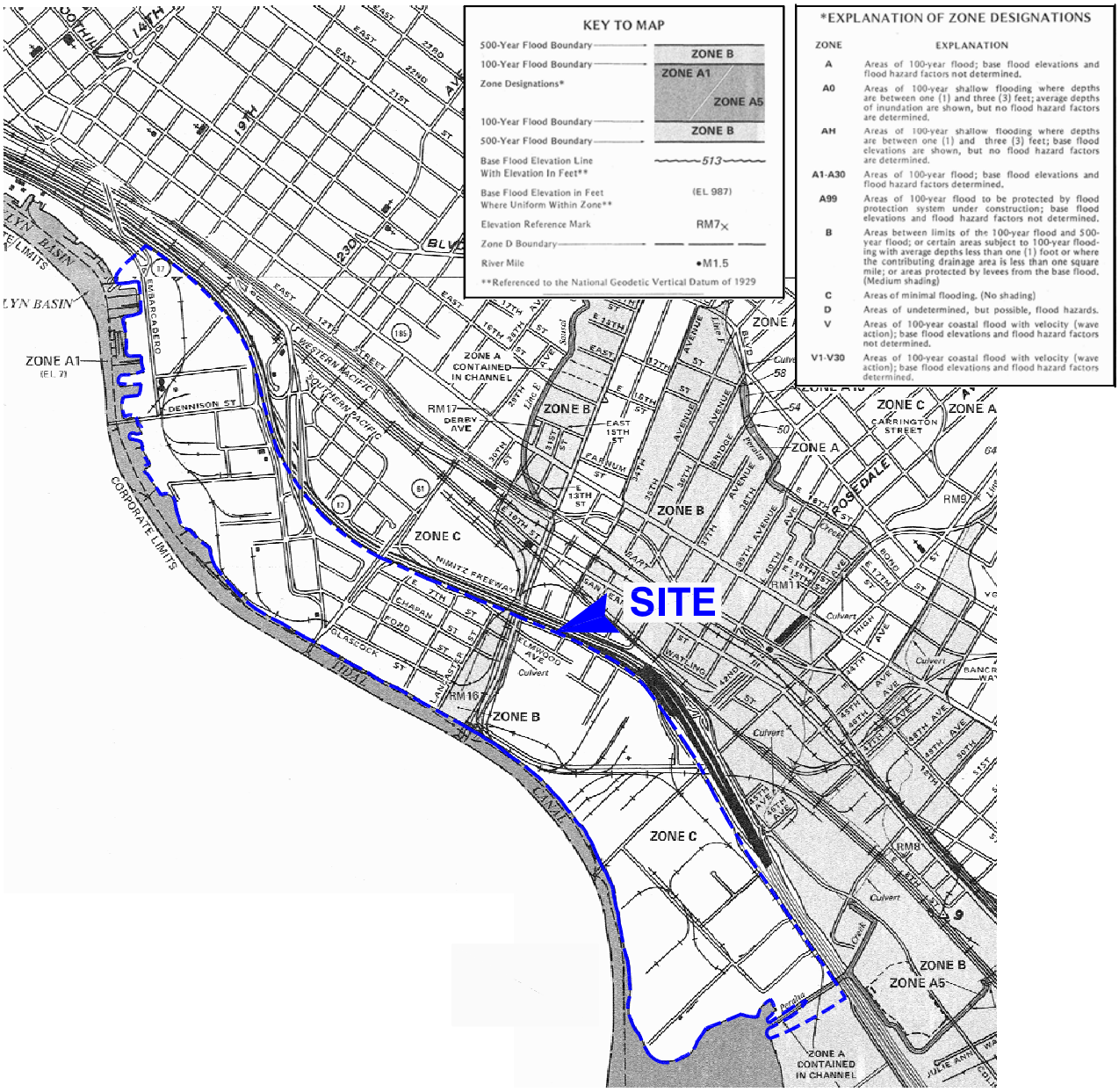
0 2000 4000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

- Central Reservoir Dam Failure Inundation Area
- 100-year floodplain
- 500-year floodplain
- Tsunami run-up zone
- streams

Ninyo & Moore		SAFETY ELEMENT OF THE OAKLAND GENERAL PLAN FLOODING HAZARDS	FIGURE
PROJECT NO.	DATE	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	10
401525002	4/09		



REFERENCE: FEDERAL EMERGENCY MANAGEMENT AGENCY, COMMUNITY–PANEL NUMBER 065048 0025B AND 065048 0020B, SEPTEMBER 1982.

N

APPROXIMATE SCALE IN FEET

0 2000 4000

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

Ninyo & Moore	FEMA FLOOD INSURANCE RATE MAP	FIGURE
PROJECT NO. / DATE	GEOLOGICAL TECHNICAL STUDY CENTRAL ESTUARY OAKLAND, CALIFORNIA	11
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APPENDIX A

SIGNIFICANCE CRITERIA AND IMPACT ANALYSIS

The following significance criteria are adapted from and are consistent with the California Environmental Quality Act (CEQA) Guidelines, Appendix G, Environmental Checklist. In accordance with the CEQA guidelines, the proposed project would result in a significant impact to geology, soils, seismicity, and mineral resources if it would:

a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

   i. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (Refer to Division of Mines and Geology Special Publication 42.)

   ii. Strong seismic ground shaking

   iii. Seismic-related ground failure, including liquefaction

   iv. Landslides

b) Result in substantial soil erosion or the loss of topsoil

c) Be located on geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse

d) Be located on expansive soil, as evaluated by American Society for Testing and Materials (ASTM) test method D 4829,creating substantial risks to life or property

e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater

f) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state

g) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (Refer to Division of Mines and Geology Special Publication 42.)

There are no known active faults crossing the study area and there are no State of California Alquist-Priolo Earthquake Fault Zones on, or adjacent to, the project site. Accordingly, there are no impacts associated with the potential for ground surface rupture due to the on-site presence of earthquake faults.

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ii) Strong seismic ground shaking.

There is a high likelihood that the project will be subjected to strong ground shaking due to earthquakes during the lifetime of the project. When the structures are properly designed and constructed in accordance with the applicable building codes (e.g., the California Building Code) and modern standards, there should be a less than significant impact due to ground shaking.

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iii) Seismic-related ground failure, including liquefaction.

A comprehensive geotechnical design evaluation will need to be performed for the project. During that evaluation the presence and extent of potentially liquefiable soils, soils subject to dynamic settlement, areas of lateral spreading, and areas of concern for seismic slope stability should be explored.

A typical remedy for liquefiable soils is the use of deepened building foundations that extend through the liquefiable soils to competent underlying materials. Mitigation measures for dynamic settlement include supporting structures on deep foundations, such as driven piles or drilled piers, or ground improvement by compaction grouting, deep soil mixing, stone columns, vibroflotation, or remedial grading. Mitigation measures for lateral spreading include ground improvement by compaction grouting, deep soil mixing, stone columns, or vibroflotation. Appropriate design of slopes in the study area should mitigate seismic slope stability issues. With a proper geotechnical design evaluation and appropriate foundation design, seismic-related ground failure would have a less than significant impact.

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iv) Landslides.

The waterfront in the study area is susceptible to landsliding. Appropriate design of these slopes in the study area should mitigate slope stability issues.

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b) Result in substantial soil erosion or the loss of topsoil.

Proper engineering design of proposed improvements would have drainage provisions to control erosion. If the loss of topsoil during construction of the site is considered significant it can be separated from the other earth materials and stockpiled for use elsewhere. A less than significant impact is anticipated.

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c) Be located on geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

Issues of collapsible or compressible soils, and liquefaction, lateral spreading, and landsliding can be addressed through the proper geotechnical design of the project, particularly with respect to foundations and earthwork. A less than significant impact is anticipated.

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d) Be located on expansive soil, as evaluated by American Society for Testing and Materials (ASTM) test method D 4829, creating substantial risks to life or property.

Expansive soils may be present on the project site. A geotechnical design evaluation will need to be conducted to facilitate the civil design and construction of new structures. Subsurface exploration (e.g., borings) and laboratory soil testing can indicate the presence and extent of these soils. A typical remedial earthwork that can be performed to treat the presence of expansive soils is their removal to prescribed depth below structural elements and their replacement with soils that are not expansive. Following proper geotechnical design for the project, expansive soil will have a less than significant impact.

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e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

We do not anticipate that the project will involve the construction of on-site wastewater disposal systems. Accordingly, there is no impact with respect to soils that cannot support such systems.

f) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state.

The project does not involve the extraction of mineral resources.

g) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

No mineral resource recovery sites were delineated in the study area in the Oakland general plan. The project will not result in the loss of a locally important mineral resource recovery site.