SECTION III.L GEOLOGY AND SOILS

III.L.1 Introduction

This section describes the geologic and seismic setting of the Project site, including regional and local geology, soils and groundwater, and the regulatory framework relevant to the Project. The potential environmental effects of the Project related to geology, soils, and seismicity are described. The impacts examined include risks related to geologic hazards such as earthquakes, landslides, liquefaction, expansive soils, and impacts on the environment related to soil erosion and sedimentation. This section identifies Project level and cumulative environmental impacts and explains how compliance with the applicable regulations, which are also identified as the mitigation measures, would reduce or avoid the identified impacts.

The Setting describes the local geologic setting and soils information for Candlestick Point (including the proposed Yosemite Slough bridge area) and for HPS Phase II. The EIR glossary, in Chapter VIII, defines unique terms used in the text below.

A preliminary geotechnical assessment of the Project site has been completed by ENGEO for Lennar Urban (refer to Appendix L [Geotechnical Report]).[342] The assessment is based on previous site-specific geotechnical and hazardous material investigations, some of which include subsurface borings, and review of published geologic reports and maps. This preliminary geotechnical assessment describes and evaluates geologic and geotechnical conditions at the Project site to support preliminary planning and conceptual-level design during initial phases of project planning. A design investigation to support preliminary infrastructure design efforts is underway at the time this EIR is being prepared. Design-level geotechnical studies would be completed on a parcel-by-parcel basis during development of construction plans.[343] Once infrastructure development is complete, foundation recommendations, which may or may not involve further exploration, would be required for each block. For high-rise structures, a unique foundation recommendation report would be required for each such building. The preliminary geotechnical assessment provides a summary and compilation of available geotechnical information that was used as part of the analysis of geologic, seismic, and geotechnical issues for this EIR.

III.L.2 Setting

The Project site is located in the southeastern area of San Francisco and extends east to San Francisco Bay (refer to Figure II-1 [Project Location]). This promontory is bounded on the south and west by the Bayview Hunters Point neighborhood and on the north and east by San Francisco Bay. The ground surface across the entire Project site is relatively flat with elevations ranging from approximately 0 feet to

[342] ENGEO, Inc., *Preliminary Geotechnical Conceptual Design Report, Hunters Point Shipyard Phase II and Candlestick Point, San Francisco, California*, May 2009.
[343] ENGEO, 2009.

+20 feet (San Francisco City Datum [SFCD]).[344] Maximum ground surface elevation near the Project site is on Bayview Hill (west of Candlestick Point), which reaches an elevation of approximately 400 feet SFCD.

Regional Geology

San Francisco Bay and the alluvial, colluvial, and estuarine deposits that underlie much of the Project site (and surrounding areas) occupy a structurally controlled basin in California's Coast Ranges province, which consists of 500 miles of northwest-trending ridges and valleys. Late Pleistocene and Holocene sediments (less than 1.0 million years old) were deposited in the basin as it subsided.[345] In the Project site, these sediments comprise estuarine deposits of Old Bay Clay, undifferentiated sedimentary deposits, Young Bay Mud, and alluvial/colluvial deposits, all of which rest on a variety of bedrock types associated with the Franciscan Complex. The Franciscan Complex makes up much of the basement rock of the Coast Ranges and consists of an assemblage of deformed and metamorphosed rock units. It formed in association with continuous east-dipping subduction at the margin of the North American and Pacific plates.[346] These two plates move relative to each other, with the San Andreas Fault Zone at the junction. The Pacific plate, on the west side of the fault zone, is moving north relative to the North American plate on the east.

Hunters Point Shear Zone

The Franciscan Complex north of Yosemite Slough is part of the Hunters Point shear zone, most of which is in the HPS Phase II site (refer to Figure III.L-1 [Geologic Map]). The Hunters Point shear zone consists of a shale matrix and serpentinite mélange that contains lenses of different lithologies (rock types). Regionally, the shear zone strikes northwestward and dips northeast at shallow to moderate angles.[347] The shear zone is thought to be part of a major structural zone marked by shallow bedrock that extends across the southeastern section of the San Francisco Peninsula, and southeast into the Bay. In the Project site, the southeastern margin of the shear zone extends from the Bay shoreline between Yosemite Slough and the southern base of Hunters Point in a northwest direction that intersects US-101 east of and adjacent to Islais Creek. The shear zone probably is not active, based on lack of offset of overlying sediments recorded by detailed seismic reflection studies.[348]

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344 San Francisco City Datum (SFCD) is a local vertical geodetic reference system specific to the City and County of San Francisco and formally established in 1964 as 8.616 feet above the National Geodetic Vertical Datum of 1929 (NGVD29), making it about 8.13 feet above mean sea level. The North American Vertical Datum was established in 1988 (NAVD88) and generally has replaced NGVD29 as a standard reference. Elevations expressed in NGVD29 may be converted to NAVD88 by adding 2.69 feet.
345 Schlocker, J., *Geology of the San Francisco North Quadrangle, California*, 1974, USGS professional paper 782.
346 Wahrhaftig, C., *A Streetcar to Subduction*, 1984; Wahrhaftig, C. and Wakabayashi, J., *Tectonostratigraphic Terranes* in *Geology of SF and Vicinity, Field Trip Guide T105*, 1989, p. 6-8; Schlocker, J., 1974.
347 Wakabayashi, J., *Nappes, tectonics of oblique plate convergence, and metamorphic evolution related to 140 million years of continuous subduction, Franciscan complex, CA*: Journal of Geology, v. 100, 1992, pp. 19-40.
348 Marlow, M. et al, *High-resolution seismic-reflection profiles and interpretation pitfalls created by acoustic anomalies from Holocene muds beneath south SF Bay*, USGS OFR 94-639, 1994, p. 16.

SOURCE: Geotechnical Consultants Inc., USGS, 1998, Open File Report 98-354.

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GEOLOGIC UNITS

- Qaf – Artificial fill
- Qaf/tf – Artificial fill over Tidal flat
- Ql – Landslide deposits
- Qsr – Slope debris and Ravine fill
- Qu – Undifferentiated surficial deposits

Franciscan Complex

- KJs – Sanstone and Shale
- KJc – Chert
- KJg – Greenstone
- KJu – Sheared rocks/Melange
- sp – Serpentine

GEOLOGIC CONTACTS

- Contact, approximately located
- Approximate 1800's shoreline
- Project Boundary
- NAP Not-a-Part

GEOLOGIC MAP

FIGURE III.L-1

The Franciscan Complex south of the Hunters Point shear zone is referred to as the Central terrane,[349] which is bound by the Hunters Point shear zone to the north and the City College fault zone, an inactive fault zone about one mile southwest of Candlestick Point, to the south (refer to Figure III.L-2 [Regional Fault Map]).[350]

Local Geology

Five soil and geologic units underlie the Project site. In general, basement units of the Franciscan Complex are covered by Quaternary sands, Bay Mud deposits, and artificial fill on the topographically low areas bordering San Francisco Bay.[351] The units are described from youngest to oldest, which approximates their vertical distribution from the top to the deeper units. Table III.L-1 (Summary of Geologic Conditions at Candlestick Point) and Table III.L-2 (Summary of Geologic Conditions at Hunters Point Shipyard Phase II) present general descriptions of the geologic units.

Table III.L-1 Summary of Geologic Units at Candlestick Point

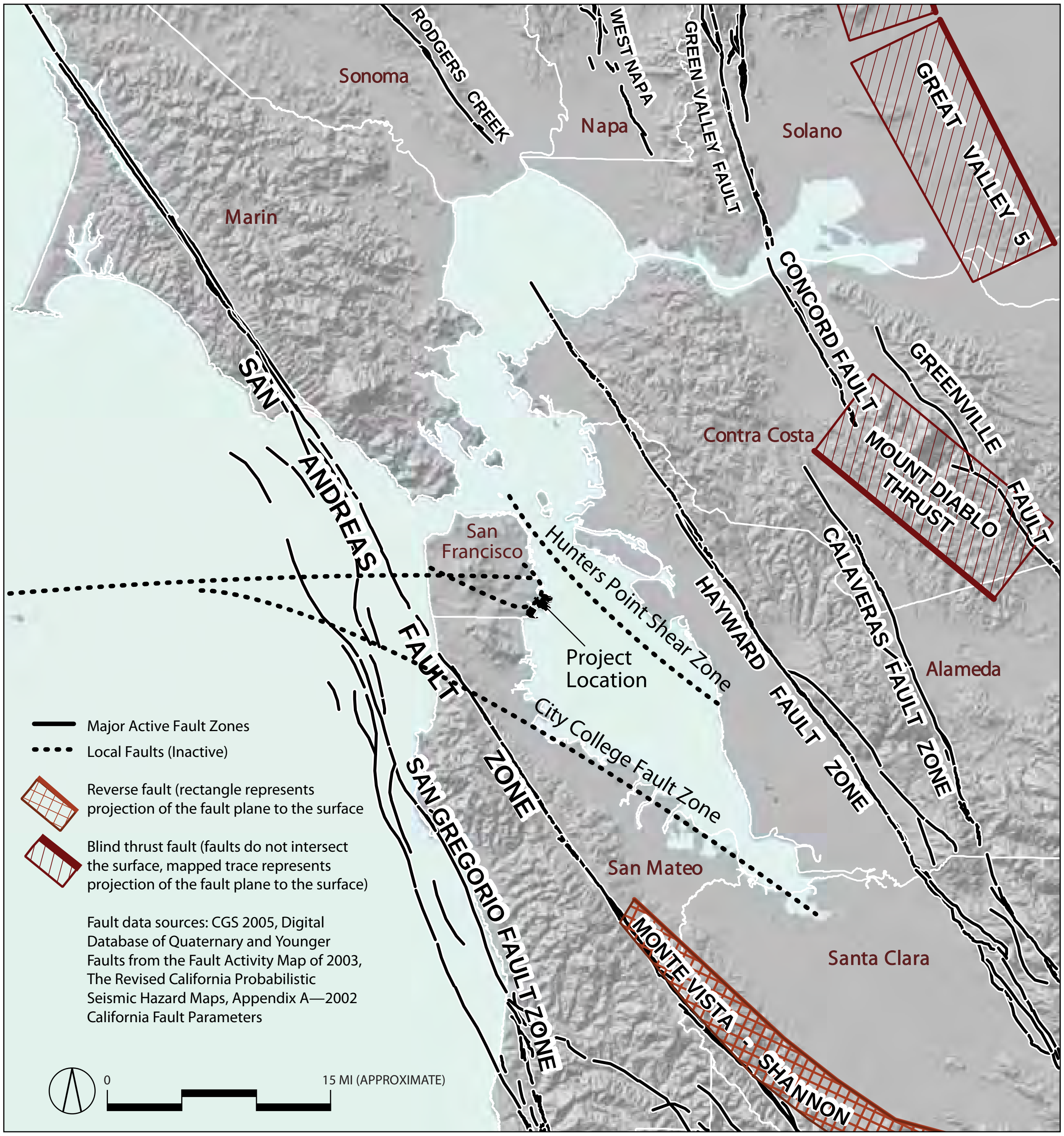
Geologic Unit	Map Symbol	Age	Lithology
Artificial Fill	Qaf	Historic (0-200 years old)	Mixture of sand, gravel, and some clay. Abundant debris including wood, glass, and brick.
Slope Debris and Ravine Fill	Qsr	Holocene to Pleistocene (0-1.8 million years old)	Undifferentiated deposits of alluvium/colluvium consisting of clay to sandy clay, sandy silt, clayey to silty sand, clean sand, and silty gravel.
Bay Mud Deposits	Qm	Holocene to Pleistocene (0-1.8 million years old)	Highly compressible clay with minor layers of silt and clayey sand. Some shell fragments.
Undifferentiated Sedimentary Deposits	Qu	Holocene to Pleistocene (0-1.8 million years old)	Interbedded alluvial and marine deposits, light brown to yellowish brown, fine to medium grained, clean to clayey sand, and interbedded with stiff to very stiff, lean clay. Contains shell fragments. May contain some Colma Formation (Qc)
Franciscan Complex	KJs, KJc, KJg	Cretaceous to Jurassic (65 to 165 million years old)	Mixed assemblage of distinct bedrock types, including shale, chert, sandstone, and greenstone.

SOURCE: Bonilla, 1998; ENGEO, 2009

349 Blake, M., et al, *Preliminary Tectonostratigraphic Terrane Map of CA*, USGS OFR 82-593, 1982, *Tectonostratigraphic Terranes of the San Francisco Bay Region* in *Franciscan Geology of Northern CA, Pacific Section*, Society of Economic Paleontologists and Mineralogists, 1984, v.43 p. 5-22; Graymer, R., et al, *Beyond the Golden Gate—Oceanography, Geology, Biology and Environmental Issues in the Gulf of the Farallones*, "Earthquakes, Faults and Tectonics", USGS circular 1198, 2000, pp.37-46; Wahrhaftig, C. and Wakabayashi, J., 1989.

350 Ninyo &Moore, *Geologic Hazards Assessment and Geotechnical Evaluation, Ocean Campus Soccer Field, City College of San Francisco, San Francisco, California*, Project Number 400943008, November 14, 2008, pp. 11–12.

351 ENGEO, Lennar Urban, MACTEC Proposed Infrastructure and Implementation Schedule, Hunters Point/Candlestick Point Redevelopment Project, ENGEO Geotechnical Design, May 7, 2008.



SOURCE: Geotechnical Consultants Inc, 2008.

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FIGURE III.L-2

Candlestick Point — Hunters Point Shipyard Phase II EIR

REGIONAL FAULT MAP

Table III.L-2 Summary of Geologic Conditions at Hunters Point Shipyard Phase II

Geologic Unit	*Map Symbol*	*Age*	*Lithology*
Artificial Fill	Qaf	Historic (0-200 years old)	Mixture of sand, gravel, and some clay. Abundant debris including wood, glass, and brick.
Slope Debris and Ravine Fill	Qsr	Holocene to Pleistocene (0-1.8 million years old)	Undifferentiated deposits of alluvium/colluvium consisting of clay to sandy clay, sandy silt, clayey to silty sand, clean sand, and silty gravel.
Bay Mud Deposits	Qm	Holocene to Pleistocene (0-1.8 million years old)	Highly compressible clay with minor layers of silt and clayey sand. Some shell fragments.
Undifferentiated Sedimentary Deposits	Qu	Holocene to Pleistocene (0-1.8 million years old)	Interbedded alluvial and marine deposits, light brown to yellowish brown, fine to medium grained, clean to clayey sand, and interbedded with stiff to very stiff, lean clay. Contains shell fragments. May contain some Colma Formation (Qc)
Franciscan Complex	KJs, KJc, KJg, sp	Cretaceous to Jurassic (65 to 165 million years old)	Mixed assemblage of distinct bedrock types, including serpentinite, shale, chert, sandstone, and greenstone.

SOURCE: ENGEO, 2009

Artificial Fill (Qaf). Based on geotechnical borings, the Project site is blanketed with artificial fill, typically ranging in thickness from approximately 1 to 70 feet.[352] These deposits are thickest over closed depressions and gullies in the upper surface of the Bay Mud deposits (refer to discussion below), and thinnest over ridges in the Bay Mud surface.[353] Historical shoreline maps show artificial fill has been extended as far as 3,500 feet beyond the original shoreline in some areas around Candlestick Point and the HPS Phase II.[354] The fill lies on the Young Bay Mud, on competent alluvial/colluvial deposits, or on bedrock. In some instances, the weight of the fill created "mud waves" as the fill was placed on top of the soft Bay Mud surface. In this case, the process of fill placement pushed the soft Bay Mud beneath the fill out toward the Bay. This created deeper sections of fill where the Bay Mud was displaced beneath it.[355] The fill is primarily granular in nature, generally composed of excavated Franciscan Complex bedrock,[356] with the majority comprising a heterogeneous matrix of sand and gravel with varying amounts of clay and silt. The density of the fill is wide ranging, from loose to very dense granular materials and soft to stiff clays and silts. The artificial fill may include man-made debris such as wood, glass, brick, concrete blocks, and other industrial debris.[357] In the vicinity of the southeast-facing shoreline of Parcels D and E at HPS Phase II, it appears that a portion of the fill was constructed by

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352 PRC, et al., *Parcel E Remediation Investigation Draft Report, Hunters Point Shipyard, San Francisco, CA*, 1997, Part of Comprehensive Long Term Environmental action Navy (Clean II).
353 PRC, et al., 1997.
354 ENGEO, 2009.
355 ENGEO, 2009.
356 PRC, et al., 1997.
357 Geotechnical Consultants, Inc., (GTC), *Report and Assessment of Available Geotechnical/Geologic Information*, Revision 1.0, Bayview Transportation Improvements Project, 2005; Bonilla, M., *Preliminary Geologic Map of the San Francisco South 7.5-minute Quadrangle and Hunters Point 7.5-minute Quadrangle, SF, CA*, 1998, USGS OFR 98-354; PRC, et al., 1997.

placing dredged sand over Bay Mud. This fill consists of poorly graded (uniform) loose sands and its properties are inherently different than the fill elsewhere on site.

Slope Debris and Ravine Fill (Qsr). In the Project site, undifferentiated deposits of alluvium/colluvium occur primarily in areas immediately adjacent to bedrock exposures, at the base of slopes, and in accumulations in swales and gullies and are designated slope debris and ravine fill.[358] These deposits consist primarily of clay to sandy clay, sandy silt, clayey to silty sand, clean sand, and silty gravel.[359] These deposits include older colluvium that typically occurs between estuarine deposits and bedrock.

Bay Mud Deposits (Qm). Bay Mud is divided into younger and older deposits. Young Bay Mud underlies artificial fill in areas on which estuarine sediments were deposited and ranges in thickness from approximately 1 to 70 feet.[360] The Young Bay Mud consists predominantly of high plasticity clay with minor layers of lean to sandy clay, silt to clayey silt, and clayey sand, with some peat interbeds and lenses.[361] The Young Bay Mud typically is olive to dark greenish gray to blue gray, very soft to medium stiff, and contains abundant shell fragments.[362] The Young Bay Mud generally is normally consolidated and moderately to highly compressible. Where the Bay Mud has been further consolidated under the weight of fill, it has moderate shear strength. The Bay Mud thins to zero inland and thickens toward the Bay.[363] In some areas, where mud waves formed during placement of fill, the Bay Mud may be thicker or thinner than the original deposit. Locally, the deeper units of older Bay Mud, known as Old Bay Clay, are overconsolidated, and are composed of stiff to very stiff, silty to sandy clay, clayey silt, and clayey to silty sand.

Undifferentiated Sedimentary Deposits (Qu). These interbedded alluvial and marine deposits underlie younger Bay Mud deposits and overlie and interfinger with older Bay Mud deposits. Locally, they overlie basement rock directly.[364] Mostly composed of light brown to yellowish brown, fine to medium grained, poorly graded, medium dense to very dense, clean sand to clayey sand, these deposits are interbedded with stiff to very stiff, lean clay and contain some shell fragments.[365] Locally, these deposits may include sands of the Colma Formation (Qc).[366]

Franciscan Complex (KJ). The Franciscan Complex is a mixed assemblage of lithologically distinct rock types that are interbedded and tectonically disturbed.[367] The predominant Franciscan Complex rock types in the Project site are serpentinite, sandstone, chert, shale, and greenstone.[368] In the Project site,

358 Bonilla, 1998.
359 CGKT, Consulting Engineers, "Bayside Facilities Plan, Expanded Geotechnical Investigation, Geotechnical Reference Report," Prepared for San Francisco Clean Water Program, City and County of San Francisco, 1982; Bonilla, 1998.
360 GTC, 2005.
361 PRC, et al., 1997.
362 Bonilla, 1998.
363 PRC, et al., 1997.
364 GTC, 2005.
365 PRC, et al., 1997.
366 PRC, et al., 1997.
367 Schlocker, 1974.
368 Wahrhaftig, C.,1984.

bedrock outcrops predominantly consist of chert, shale, and greenstone in the Candlestick Point site adjacent to the Bay and serpentinite, chert, sandstone, and shale in the HPS Phase II site.[369]

Soils

Soils at the Project site are imported fill material, and are derived from weathered materials and underlying rock or other natural deposits.[370] Soil types on the Project site were identified from soil survey data published by the US Department of Agriculture, Natural Resources Conservation Service.[371] The basic soil types mapped at the Project site are as follows:

- **Candlestick Point.** Candlestick Point site soils are predominantly "Urban land, Urban land—Orthents" (both cut & fill complex and reclaimed complex); Orthents soils in the low-lying areas; and Barnabe-Candlestick complex in the upland areas near Bayview Hill.
- **HPS Phase II.** HPS Phase II site soils are predominantly "Urban land, Orthents—cut and fill" and Urban land—Orthents (reclaimed complex).

Soil corrosivity against concrete and uncoated steel is moderate in the Barnabe-Candlestick complex soils. All the soil types at the Project site are interpreted to have a moderate corrosivity rating.[372]

A soil erosion hazard rating determines how likely it is that a soil will erode. Ratings are based on geology, topography, soil depth, vegetative cover, soil texture, and a climatic stress factor, which is a function of mean annual precipitation. Because of the variable nature of the deposits, all soil types at the Project site are interpreted to have a slight to severe erosion hazard rating.[373]

Consolidation Settlement of Young Bay Mud

Consolidation settlement occurs when a fine-grained soil (silt or clay) is loaded with the weight of new fill or of improvements such as structures or roads. New loads cause increases in soil pore water pressure. As the excess pore pressures dissipate, the soil volume decreases and water is expelled slowly. The rate of settlement depends on the permeability and thickness of the soil layers. Thick layers of clay with low permeability can take years for pore pressures to dissipate fully. It appears that most, if not all, the Young Bay Mud underlying the Project site is normally consolidated under the load of the existing fill and buildings. Placement of new fill to raise grades and construction of new buildings with shallow foundations in areas underlain by Young Bay Mud may trigger new consolidation settlement.

Compressible clays such as Young Bay Mud also exhibit secondary consolidation or compression as a function of the increased effective stress. The mechanism of secondary compression generally is thought to result from re-orientation of clay minerals under stress. Decomposition of organic content may be a factor in materials such as Young Bay Mud. Although settlement caused by secondary compression will decrease eventually, it will continue for an order of magnitude longer than primary consolidation. Continuing settlement caused by secondary compression in response to placing new fill is likely to be

369 Bonilla, 1998.
370 PRC, et al., 1997.
371 Natural Resources Conservation Service (NRCS) Web Soil Survey website. http://websoilsurvey.nrcs.usda.gov/app/websoilsurvey.aspx (accessed April 2008).
372 Natural Resources Conservation Service website. http://sdmdataaccess. nrcs.usda.gov (accessed April 2008).
373 NRCS (accessed April 2008).

very small, except near the eastern shoreline of Candlestick Point where an area of deeper Young Bay Mud exists.

The deeper-lying Old Bay Clays are overconsolidated and will experience very small settlement as long as their maximum past pressure is not exceeded.

Slope Stability

Slope failures include many phenomena that involve the downslope displacement of material, triggered by static (i.e., gravity) or dynamic (i.e., earthquake) forces, such as landslides, rock-falls, debris slides, and soil creeps. Slope stability can depend on a number of complex variables, including the geology, structure, and amount of groundwater present, as well as external processes such as climate, topography, slope geometry, and human activity. Landslides and other slope failures may occur on slopes of 15 percent or less; however, the probability is greater on steeper slopes that exhibit old landslide features such as scarps, slanted vegetation, and offset surfaces.

- **Candlestick Point.** Potential landslide hazards at the Candlestick Point site are presented in Figure III.L-3 (Seismic Hazard Map). The figure shows that the major landslide hazard area at the Project site is an approximate 2,500-foot-wide and 2,500-foot-long section above Jamestown Avenue, east of US-101 and west of Candlestick Point State Recreation Area (CPSRA).
- **HPS Phase II.** A few smaller landslide hazards existed in a large serpentinite block of the Hunters Point Shear Zone, between Innes and Crisp Roads, northwest of the HPS Phase II site (refer to Figure III.L-3).[374] However, slopes adjacent to HPS Phase II have been rebuilt as subdrained engineered slopes as part of on-going HPS Phase I development. Remaining potential landslide hazard areas are outside of HPS Phase II site boundaries.

Groundwater Levels

Groundwater levels in the artificial fill and the underlying estuarine deposits generally are less than 15 feet below the ground surface and experience varying degrees of tidal fluctuation. In the upland or hilly areas, seasonally influenced groundwater occurs in artificial fill and alluvium/colluvium (slope/ravine deposits) at wide ranging depths below the ground surface.[375] Historically, depths to groundwater in the undifferentiated sedimentary deposits have been measured as shallow as three feet in the lowland areas and as deep as 30 feet below ground surface in the upland areas.[376]

[374] California Geological Survey (CGS), Seismic Hazard Zone Map, CCSF, 2000.
[375] GTC, 2005.
[376] PRC, et al, 1997.

SOURCE: Geotechnical Consultants Inc.; Seismic Hazard Zone Map, City and County of San Francisco, California Geological Survey, November 2001.

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Liquifaction hazard zone

Landslide hazard zone

Project Boundary

NAP Not-a-Part

Candlestick Point — Hunters Point Shipyard Phase II EIR

SEISMIC HAZARD MAP

FIGURE III.L-3

Faulting and Seismic Hazards

Regional Seismicity

The San Francisco Bay Area is in a seismically active region near the boundary between two major tectonic plates, the Pacific Plate to the southwest and the North American Plate to the northeast. Since approximately 23 million years ago, about 200 miles of right-lateral slip has occurred along the San Andreas Fault Zone to accommodate the relative movement between these two plates. The relative movement between the Pacific Plate and the North American Plate generally occurs across a 50-mile zone extending from the San Gregorio Fault in the southwest to the Great Valley Thrust Belt to the northeast. In addition to the right lateral slip movement between tectonic plates, a compressional component of relative movement has developed between the Pacific Plate and a smaller segment of the North American Plate at the latitude of San Francisco Bay during the last 3.5 million years.[377] Strain produced by the relative motions of these plates is relieved by right lateral strike slip faulting on the San Andreas and related faults, and by vertical reverse-slip displacement on the Great Valley and other thrust faults in the central California area.[378]

The San Francisco Bay Area and surrounding areas are characterized by numerous geologically young faults. Figure III.L-2 (Regional Fault Map) illustrates the fault locations in relation to the Project site. These faults can be classified as historically active, active, sufficiently active, or inactive, as defined below.[379]

- Faults that have generated earthquakes accompanied by surface rupture during historic time (approximately the last 200 years) and faults that exhibit a seismic fault creep defined as **historically active**.[380]
- Faults that show geologic evidence of movement within Holocene time (approximately the last 11,000 years) are defined as **active**.
- Faults that show geologic evidence of movement during the Holocene along one or more of their segments or branches and if their traces may be identified by direct or indirect methods are defined as **sufficiently active** and **well defined**.
- Faults that show direct geologic evidence of inactivity or lack of offset, during all of Quaternary time or longer are classified as **inactive**.

The California Geological Survey (CGS) does not attempt to quantify the probability that an earthquake will occur on any specific fault, but this classification is based on the reasonable assumption that if a fault has moved during the last 11,000 years, it is likely to produce earthquakes in the future.

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[377] Fenton and Hitchcock, *Recent geomorphic and paleoseismic investigations of thrust faults in Santa Clara Valley, California*, in Ferriz, H., and Anderson, R. eds., *Engineering Geology Practice in Northern California: California Division of Mines and Geology Bulletin 210*, 2001, pp. 239-257.

[378] A "reverse-slip" fault is one with predominantly vertical movement in which the upper block moves upward in relation to the lower block.

[379] CGS, *Fault Rupture Hazard Zones in California*, CDMG Special Publication 42, 2007, p.5.

[380] Fault creep is movement along a fault that does not entail earthquake activity.

Groundshaking

An earthquake is classified by the amount of energy released, which traditionally has been quantified using the Richter scale. Recently, seismologists have begun using a moment magnitude (M) scale because it provides a more accurate measurement of the size of major and great earthquakes. For earthquakes of less than M 7.0, the moment and Richter magnitude scales are nearly identical. For earthquake magnitudes greater than M 7.0, readings on the moment magnitude scale are slightly higher than a corresponding Richter magnitude.

The intensity of the seismic shaking, or strong ground motion, during an earthquake is dependent on the distance and direction between a particular area and the epicenter of the earthquake, the magnitude of the earthquake, and the geologic conditions underlying and surrounding that area. Earthquakes occurring on faults closest to the Project site probably would generate the largest ground motions.

A review of historic earthquake activity from 1800 to 2005 indicates that 13 earthquakes of magnitude M 6.0 or greater have occurred in the vicinity of the Project site during this time frame. The two most consequential were the earthquakes of April 18, 1906 and October 17, 1989. The April 18, 1906 earthquake caused building collapses and fires, approximately 3,000 deaths, and $524 million in damage as far as 350 miles from the epicenter. The earthquake of October 17, 1989 caused 63 deaths, more than 3,000 injuries, and an estimated $6 billion in property damage from San Francisco to Monterey and in the East Bay, including damage and destruction of buildings, roads, bridges, and freeways. There have been 25 earthquakes with magnitudes between M 5.5 and M 6.0 in this area during this time period, including numerous aftershocks of larger earthquakes.[381]

The intensity of earthquake-induced ground motions can be described using peak ground accelerations, represented as a fraction of the acceleration of gravity (g).[382] The interactive CGS Probabilistic Seismic Hazard Assessment map provides data to estimate peak ground accelerations in California.[383] Taking into consideration the uncertainties regarding the size and location of earthquakes and the resulting ground motions that can affect a particular site, the map depicts peak ground accelerations with a 10 percent probability of being exceeded in 50 years, which equals an annual probability of 1 in 475 of being exceeded in any given year.

Fault Rupture

Faults are geologic zones of weakness. Surface rupture occurs when movement on a fault deep in the earth breaks through to the ground surface. Surface ruptures associated with the 1906 San Francisco earthquake extended for more than 260 miles with displacements of up to 21 feet. Not all earthquakes result in surface rupture. The 1989 Loma Prieta earthquake caused major damage in the San Francisco Bay Area, but the fault trace does not appear to have broken at the ground surface.

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[381] California Geologic Survey website: Regional Geologic Mapping Program, Significant California Earthquakes. http://www.consrv.ca.gov/cgs/rghm/quakes/Pages/eq_chron.aspx.

[382] Acceleration of gravity (g) = 980 centimeters per second squared. 1.0 g of acceleration is a rate of increase in speed equivalent to a car traveling 328 feet from rest in 4.5 seconds.

[383] CGS, Probabilistic Seismic Hazards Mapping (PSHM) Ground Motion website. http://www.consrv.ca.gov/cgs/rghm/pshamap (accessed June 2006).

Fault rupture almost always follows preexisting faults, which are zones of weakness. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Sudden displacements are more damaging to structures because they are accompanied by shaking.

Liquefaction

Liquefaction is a phenomenon in which saturated granular, non-plastic sediments temporarily lose their shear strength during periods of strong groundshaking, such as that which occurs during earthquakes. Seismic waves traveling through soils can cause deformations that collapse the loose granular structure. This collapse of void space in turn can cause an increase in pore water pressure, reducing the effective stress between the grains. When the pore pressures reach a critical level at which the effective stress of the soil drops below the overburden stress, the previously solid granular soil loses the strength to support itself and may behave like a viscous fluid. Secondary effects associated with liquefaction include flow failures, which occur when liquefied soil moves down a steep slope with large displacement and much internal disruption of material. Soil may also lose its ability to support structures, and this loss of bearing strength may cause structures founded on the liquefied materials to tilt or possibly topple over. Light structures such as pipelines, sewers, and empty fuel tanks that are buried in the ground can float to the surface when they are surrounded by liquefied soil. The susceptibility of a site to liquefaction is a function of the uniformity, depth, density, and water content of the granular sediments beneath the site and the magnitude of earthquakes likely to affect the site.

The vast majority of liquefaction hazards are associated with sandy soils and silty soils of low plasticity. Cohesive soils generally are not considered susceptible to soil liquefaction. In addition to sandy and silty soils, some gravelly soils are potentially vulnerable to liquefaction. Most gravelly soils drain relatively well, but when their voids are filled with finer particles or they are surrounded by less pervious soils, drainage can be impeded and they may be vulnerable to cyclic pore pressure generation and liquefaction. In general, liquefaction hazards are most severe in the first 50 feet below the ground surface, but on a slope near a free face or where deep foundations go beyond that depth, liquefaction potential should be considered for greater depths. There are two general levels of liquefaction hazards: (1) large-scale displacement and (2) localized failures including lateral spreading, vertical settlement from densification, sand boils, ground oscillation, flow failures, loss of bearing strength, and buoyancy effects, as described below.

Lateral Spreading

Lateral spreading is a phenomenon where large blocks of intact, nonliquefied soil move downslope riding on a liquefied substrate of large extent[384]. The mass moves toward an unconfined area, such as a descending slope or stream-cut bluff, and can occur on slope gradients as gentle as one degree.

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[384] Youd, T., et al., "Mapping liquefaction induced ground failure potential", in Proceedings of American Society of Civil Engineers, Journal of the Geotechnical Engineering Division, 1978; Tinsley, J., et al., Evaluating Liquefaction Potential. In *Evaluating Earthquake Hazards in the Los Angeles Region—an Earth Science Perspective*, USGS professional paper 1360, 1985, p. 263-315.

Earthquake-Induced Settlement

Settlement or subsidence of the ground surface can be accelerated and accentuated by earthquakes. During an earthquake, settlement can occur as a result of the relatively rapid rearrangement, compaction, and settling of subsurface materials (particularly loose, uncompacted, and variable sandy sediments). Settlement can occur both uniformly and differentially (i.e., where adjoining areas settle at different rates). Localized differential settlements up to two-thirds of the total settlements anticipated must be assumed until more precise predictions of differential settlements can be made.

Sand Boils

Sand boils occur when localized pore pressures increase to a level greater than the overburden pressure. If there is no pathway for dissipation of the excess pore pressures, the liquefied material may travel upward, following the path of a vertical fracture or zone of weakness. Sand-laden water can be ejected from a buried liquefied layer and erupt at the surface to form sand volcanoes. The surrounding ground often fractures and settles in the vicinity of the sand boil.

Ground Oscillation

During ground oscillation, the surface layer, riding on a buried liquefied layer, is thrown back and forth by the shaking and can be severely deformed.

Seismic Slope Instability/Ground Cracking

Earthquake motions can induce substantial stresses in slopes, causing earthquake-induced landslides or ground cracking when the slope fails. Earthquake-induced landslides can occur in areas with steep slopes that are susceptible to strong ground motion during an earthquake. The 1989 Loma Prieta earthquake triggered thousands of landslides over an area of 770 square miles.

Site Seismicity and Local Seismic Hazards

Table III.L-3 (Active Bay Area Faults) lists fault data for major faults within 30 miles of the Project site. The fault data shown in Table III.L-3 are based on the 2002 Revised California Fault Parameters by the CGS.[385] The closest fault to the Project site is the Peninsula branch of the San Andreas Fault, approximately 6.6 miles to the west.

Fault Rupture

No known active faults cross the Project site, making hazards from fault rupture unlikely. The Hunters Point Shear Zone, which crosses the HPS Phase II site in the northwest, is considered inactive, as is the City College Fault Zone about one mile southwest of Candlestick Point (refer to Figure III.L-1).[386]

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[385] CGS, Revised California Seismic Shaking Analysis, Appendix A, 2002.
[386] Bonilla, 1998; CGS, 2000.

Table III.L-3 Active Bay Area Faults

Fault Name (Branch)	Distance from miles (km)	Fault Length (km)	Maximum Earthquake Magnitude (M)
San Andreas (Peninsula)	6.6 (10.7)	85	7.1
San Gregorio (North)	10.7 (17.2)	110	7.2
San Andreas (North Coast South)	10.8 (17.4)	190	7.4
Hayward (South)	12.0 (19.3)	53	6.7
Hayward (North)	12.4 (20.0)	35	6.4
Monte Vista—Shannon	21.3 (34.3)	45	6.7
Calaveras (North)	21.6 (34.7)	45	6.8
Rodgers Creek	25.2 (40.6)	62	7.0

SOURCE: California Geological Survey, 2002
M = Moment Magnitude, which is directly related to average fault slip and rupture area.

Liquefaction

Holocene-aged alluvial sediments are especially prone to liquefaction. The Project site is in an area of San Francisco that has been designated as potentially liquefiable. As depicted in Figure III.L-1, the majority of the Project site is covered by lowland soils and artificial fill, which is the most susceptible soil layer for liquefaction. The granular materials in the heterogeneous fill typically are loose and saturated beneath the shallow groundwater table, and may liquefy when subjected to groundshaking, resulting in loss of soil strength, settlement, and lateral spreading. Because of the heterogeneous nature of the fill, liquefaction is expected to occur in random layers and pockets, limiting the extent of seismically induced settlement and lateral spreading to localized zones within the fill. The hydraulically placed sand fill in the vicinity of the southeast-facing shoreline of Parcels D and E at HPS Phase II consists of a thick unit of predominantly uniform sand and is, therefore, more susceptible to liquefaction.

Based on existing data, there is little or no risk of large translational movements. Design-level liquefaction studies, which are further described in mitigation measures MM GE-4, would address five general types of localized potential hazards, and provide treatment methods, including the following:

- Potential foundation bearing failure, or large foundation settlements caused by ground softening and near-failure in bearing
- Potential structural and/or site settlements
- Localized lateral displacement; "lateral spreading" and/or lateral compression
- Flotation of light structures with basements, or underground storage structures
- Hazards to Lifelines (utilities critical to emergency response)

Lateral Spreading

Historical soil borings indicate that materials with the potential for lateral spreading are present in the artificial fill near the free face of the Yosemite Slough shoreline.[387] In addition, the area of hydraulically

[387] GTC, *Preliminary Foundation Report: Griffith Bridge and Walker Bridge*, Bayview Transportation Improvements Project, San Francisco, CA, 2008.

placed sand fill in the vicinity of the southeast-facing shoreline of Parcels D and E at HPS Phase II has higher than usual susceptibility to lateral spreading.

Earthquake-Induced Settlement

Areas are susceptible to differential settlement if underlain by compressible sediments, such as poorly engineered artificial fill or Bay Mud. Seismically induced settlements at the Project site will vary considerably because of the heterogeneous nature of the fill. It is estimated that settlement between one to two percent of the zones susceptible to liquefaction, or approximately two to twelve inches, may occur at the site during strong groundshaking. If untreated, structures supported on shallow foundations in areas susceptible to settlement may experience one or more of the following:

- Damaging differential settlement, tilt and possibly be subject to localized bearing capacity failures
- Abrupt differential settlement between unimproved ground and pile-supported improvements
- Differential settlement of buried utilities and disruption of flow gradients
- Damage to non-flexible surface improvements

Treatments to correct settlement hazards are available using options described in mitigation measure MM GE-4. It is common to use several methods in combination to correct settlement hazards, depending on the magnitude of the geotechnical hazard present and the types of structures proposed. Where treatment would be necessary and implemented, total and differential seismic settlement would be reduced to acceptable levels for the types of structures and foundation support conditions encountered, as required by the *San Francisco Building Code*.

Sand Boils

Because of the heterogeneous nature of the fill, liquefaction is expected to occur in random layers and pockets on the Project site, limiting the extent of seismically induced sand boils to localized areas within the fill. The hydraulically placed sand fill in the vicinity of the southeast-facing shoreline of Parcels D and E at HPS Phase II consists of a thick unit of predominantly uniform sand and is, therefore, more susceptible to liquefaction. The mitigation measures to reduce liquefaction and other seismic hazards would also reduce the risk of formation or sand boils during a seismic event.

Ground Oscillation

During ground oscillation, the surface layer, riding on a buried liquefied layer, is thrown back and forth by the shaking and can be severely deformed. While the soils at the Project site have been identified as potentially liquefiable, there is no evidence of a broadly spanning buried liquefiable layer on which the surface layer could be oscillated. The mitigation measures to reduce liquefaction and other seismic hazards would also reduce the risk of damage to structures from deformation by ground oscillation during a seismic event.

Seismic Slope Instability/Ground Cracking

Hazards associated with seismically induced mudslides, rockslides, or landslides are not anticipated because of the relatively flat topography of the Project site and the surrounding vicinity.[388]

III.L.3 Regulatory Framework

Protection of geologic resources and reduction of geologic hazards are governed by state and local jurisdictions. Seismic hazards are addressed by state and local requirements for identifying and avoiding faults and the effects of seismic groundshaking when considering new development. Federal standards, such as those promulgated through the National Earthquake Hazards Reduction Program (NEHRP), apply to new federally owned, constructed, or assisted buildings. The following acts, codes, and local plans are relevant to geologic and seismic issues in the Project site.

Federal

Executive Order 12699

Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction," was signed by President George H. W. Bush on January 5, 1990, to further the goals of Public Law 95-124, the *Earthquake Hazards Reduction Act of 1977*, as amended. The Executive Order applies to new construction of buildings owned, leased, constructed, assisted, or regulated by the federal government. Guidelines and procedures for implementing the order were prepared in 1992 by the federal Interagency Committee on Seismic Safety in Construction. The guidelines establish minimum acceptable seismic safety standards, provide evaluation procedures for determining the adequacy of local building codes, and recommend implementation procedures. Each federal agency is independently responsible for ensuring appropriate seismic design and construction standards are applied to new construction under its jurisdiction.[389]

Under the original Executive Order 12699, the model code for the West Coast was the Uniform Building Code developed by the International Conference of Building Officials (ICBO). In 1994, the ICBO joined with other similar organizations in the Southeast and on the East Coast to form the International Code Council (ICC). In 2000, the ICC published the first International Building Code (IBC) based on the reassessment of earlier codes and the combined updated experience of ICC member organizations. The current 2006 IBC is the result of nearly 100 years of building code improvement and forms the basis of the California and San Francisco building codes (discussed below), which are successively more stringent than the codes in force at the time of the implementation of the original federal guidelines.

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388 GTC, 2006.

389 US Department of Commerce, Technology Administration, National Institute of Standards and Technology, *Guidelines and Procedures for Implementation of the Executive Order on Seismic Safety of New Building Construction*, NISTIR 4852, 1992, pp. 1 through 7.

State

Alquist-Priolo Earthquake Fault Zoning Act

Surface rupture is the most easily avoided seismic hazard. The *Alquist-Priolo Earthquake Fault Zoning Act* was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. In accordance with this act, the State Geologist established regulatory zones, called "earthquake fault zones," around the surface traces of active faults and published maps showing these zones. Buildings for human occupancy are not permitted to be constructed across the surface trace of active faults. Each earthquake fault zone extends approximately 200 to 500 feet on either side of the mapped fault trace, because many active faults are complex and consist of more than one branch. There is the potential for ground surface rupture along any of the branches. The Project site is not in an Alquist-Priolo Earthquake Fault Zone. Therefore, the Project would not be subject to this Act.

Seismic Hazard Mapping Act

The state regulations protecting the public from geo-seismic hazards, other than surface faulting, are contained in California *Public Resources Code* Division 2, Chapter 7.8 (the *Seismic Hazards Mapping Act*), described here, and 2007 *California Code of Regulations* (CCR), Title 24, Part 2 (the *California Building Code* [CBC]), described below. Both of these regulations apply to public buildings, and a large percentage of private buildings, intended for human occupancy.

The *Seismic Hazard Mapping Act* was passed in 1990 following the Loma Prieta earthquake to reduce threats to public health and safety and to minimize property damage caused by earthquakes. The Act directs the CGS to identify and map areas prone to the earthquake hazards of liquefaction, earthquake-induced landslides, and amplified groundshaking. The Act requires site-specific geotechnical investigations to identify potential seismic hazards and formulate corrective measures prior to permitting most developments designed for human occupancy within the Zones of Required Investigation.

As of February 2009, 117 official seismic hazard zone maps showing areas prone to liquefaction and landslides had been published in California, and more are scheduled for 2010. The mapping is being performed in Southern California and San Francisco Bay Area. Twenty-seven official maps for San Francisco Bay Area have been released, with preparation of additional maps for San Mateo, Santa Clara, Alameda, and Contra Costa Counties planned or in progress. The Project site is on the Seismic Hazard Map for the City and County of San Francisco (Hunters Point Quadrangle), published in November 2001, and shows approximately 90 percent of the Project site to be in a Zone of Required Investigation for liquefaction potential. Although past earthquakes have caused ground failures in only a small percentage of the total area in mapped hazard zones, a worst-case scenario of a major earthquake during or shortly after a period of heavy rainfall has not occurred in Northern California since 1906.[390]

Section 2697 of the Seismic Hazards Mapping Act mandates that, prior to the approval of a project in a seismic hazard zone, the City must require the preparation of a geotechnical report defining and delineating any seismic hazard. CGS has published Special Publication 117A, *Guidelines for Evaluating and*

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[390] California Geological Survey, *Guidelines for Evaluating and Mitigating Seismic Hazards in California*, CGS Special Publication 117A, 2008, p. 9.

Mitigating Seismic Hazards in California, to assist the engineering geologist and/or civil engineer who must investigate the site and recommend mitigation of identified earthquake-related hazards and to promote uniform and effective statewide implementation of the evaluation and mitigation elements of the Seismic Hazards Mapping Act. Under the act, the San Francisco Department of Building Inspection (DBI), the local permitting authority, must regulate certain development projects within the mapped hazard zones. For projects in a hazard zone, DBI requires that the geologic and soil conditions of the Project site are investigated and appropriate mitigation measures, if any, incorporated into development plans. "Mitigation" is defined as those measures that are consistent with established practice and reduce seismic risk to acceptable levels.[391] "Acceptable level" of risk is defined as that level that provides reasonable protection of public safety, although it does not necessarily ensure continued structural integrity and functionality of a building.[392] Based on the above definitions of mitigation and acceptable risk, the *Seismic Hazards Mapping Act* and related regulations establish a statewide minimum public safety standard for mitigation of earthquake hazards. That standard is the minimum level of mitigation for a project that would reduce the risk of ground failure during an earthquake to a level that does not cause the collapse of buildings for human occupancy, but in most cases, not to a level at which no ground failure would occur.

The Act and associated regulations state that the site-investigation reports must be reviewed by a certified engineering geologist or registered civil engineer with competence in the field of seismic hazard evaluation and mitigation. As required by the mitigation measures herein, DBI would employ a third-party engineering geologist and/or civil engineer to form a Geotechnical Peer Review Committee (GPRC) which would complete the technical review. After a site investigation report was approved, subsequent site investigation reports would not be required, provided that new geologic information warranting further investigation was not recorded. The *San Francisco Building Code* requires that the recommendations of the report be incorporated in the building design.

The City is required to submit one copy of the approved site investigation report to the State Geologist within 30 days of approval. If the City approves a project that is not in accordance with the policies and criteria of the *Seismic Hazards Mapping Act*, the City is required to explain in writing the reasons for the differences to the State Geologist, within 30 days of the project's approval. The site-specific geotechnical investigation may refine the State's areawide interpretations. If the new documentation supports the site-specific interpretation, the State Geologist would file the report as an amendment to the Seismic Hazard Evaluation for the appropriate United States Geological Survey (USGS) topographic quadrangle map.

Caltrans Bridge Design Specifications and San Francisco Department of Public Works Standard Specifications

State guidelines protecting bridges and overpasses on state roads from geologic and seismic hazards are contained in Caltrans *Bridge Design Specifications*,[393] *Bridge Memo to Designers*,[394] *Bridge Design Practice Manual*,[395]

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391 *Public Resources Code*, Section 2693(c).
392 *California Code of Regulations,* Title 14, Section 3721(a).
393 California Department of Transport (Caltrans), Division of Engineering Services, *Bridge Design Specifications*, 2009. http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-design-specifications/bds.html, last updated November 7, 2008 (accessed June 17, 2009).

and *Bridge Design Aids Manual*.[396] The manuals provide state-of-the-art information to address geo-seismic issues that affect the design of transportation infrastructure in California. Bridge design is required to be based on the "Load Factor Design methodology with HS20-44 live loading (a procedure to incorporate the estimated weight of the vehicles and/or pedestrians on the bridge with the weight of the bridge for loading calculations)" in the *Bridge Design Specifications*. Seismic-resistant design is required to conform to the *Bridge Design Specifications* and Section 20 of *Bridge Memo to Designers*, as well as Caltrans *Seismic Design Criteria*.[397] Section 20 of *Bridge Memo to Designers* outlines the category and classification, seismic performance criteria, seismic design philosophy and approach, seismic demands and capacities on structural components, and seismic design practices that collectively make up Caltrans' seismic design methodology. The methodology applies to all bridges and highways designed in California. A bridge's category and classification determines its seismic performance level and which methods would be used to estimate the seismic demands and structural capacities. The performance criteria include functional and safety evaluations of ground motion, level of service to be attained following a major earthquake, and the level of damage the structure must be designed to withstand.

The Caltrans *Seismic Design Criteria* specify the minimum seismic design requirements that are necessary to meet the performance goals established in Section 20 of *Bridge Memo to Designers*. Each bridge presents a unique set of design challenges and the *Seismic Design Criteria* provide guidelines to determine the appropriate methods and level of refinement necessary to design and analyze each bridge on a case-by-case basis. The Caltrans Offices of Structures Design provide the bridge designer with resources to establish the correct course of action and Senior Seismic Specialists, an Earthquake Committee, and an Earthquake Engineering Office of Structure Design Services and Earthquake Engineering to peer-review proposed methods and provide further recommendations.

The San Francisco Department of Public Works Bureau of Engineering (BOE) Standard Specifications for Streets and Highways,[398] and for Structures[399] are based on the Caltrans design specifications and provide detailed information regarding materials and procedures for road and bridge construction in the City. The BOE provides design and inspection services for City streets, infrastructure, and structures.

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394 Caltrans, Division of Engineering Services, *Bridge Memo to Designers*, 2009. http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-memo-to-designer/bmd.html, last updated March 3, 2009 (accessed June 17, 2009).

395 Caltrans, Division of Engineering Services, *Bridge Design Practice Manual*, 2009. http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-design-practice/bdp.htm>, last updated November 7, 2007 (accessed June 17, 2009).

396 Caltrans, Division of Engineering Services, *Bridge Design Aids Manual*, 2009. http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-design-aids/bda.htm>, last updated April 17, 2009 (accessed June 17, 2009).

397 Caltrans, Division of Engineering Services, *Seismic Design Criteria, version 1.4*, 2009. http://www.dot.ca.gov/hq/esc/techpubs/manual/othermanual/other-engin-manual/seismic-design-criteria/sdc.htm>, last updated August 7, 2008 (accessed June 17, 2009).

398 San Francisco Department of Public Works' Bureau of Engineering, *Standard Specifications—Part 2, Streets and Highways*. http://www.sfgov.org/site/uploadedfiles/sfdpw/boe/ Part2-StreetsAndHighways.pdf, 2000-09, last updated not provided (accessed June 17, 2009).

399 San Francisco Department of Public Works' Bureau of Engineering, *Standard Specifications—Part 4, Structures*. http://www.sfgov.org/site/uploadedfiles/sfdpw/boe/Part4-Structures.pdf, 2000-09, last updated not provided (accessed June 17, 2009).

During the construction phase, BOE would be responsible for assuring that the Project would be consistent with applicable codes, standards, and principles as implemented by the Project contractor.

California Building Code and the San Francisco Building Code

Until January 1, 2008, the *California Building Code* (CBC) was based on the then current *Uniform Building Code* and contained Additions, Amendments and Repeals specific to building conditions and structural requirements in California. The 2007 CBC, effective January 1, 2008, is based on the current (2006) *International Building Code* (IBC).[400] Each jurisdiction in California may adopt its own building code based on the 2007 CBC. Local codes are permitted to be more stringent than Title 24, but, at a minimum, are required to meet all state standards and enforce the regulations of the 2007 CBC beginning January 1, 2008.

San Francisco adopted the 2007 CBC as the basis for its Building Code (*Municipal Code* Title 17, Chapter 17.04) through Ordinance No. 3789, on December 3, 2007. The full 2007 San Francisco Building Code (SFBC) consists of the 2006 IBC, as amended by the 2007 CBC, and as further modified by San Francisco amendments designed to be used in conjunction with the 2007 CBC. The SFBC amendments were adopted by the Board of Supervisors on November 6, 2007, through Ordinance 258-07, effective January 1, 2008.

Chapter 16 of the SFBC deals with structural design requirements governing seismically resistant construction (Section 1604), including (but not limited to) factors and coefficients used to establish seismic site class and seismic occupancy category for the soil/rock at the building location and the proposed building design (Sections 1613.5 and 1613.6). Chapter 18 of the SFBC includes (but is not limited to) the requirements for foundation and soil investigations (Section 1802); excavation, grading, and fill (Section 1803); allowable load-bearing values of soils (Section 1804); and the design of footings, foundations, and slope clearances (Section 1805), retaining walls (Section 1806), and pier, pile, driven, and cast-in-place foundation support systems (Section 1808, 1809 & 1810). Chapter 33 of the SFBC includes (but is not limited to) requirements for safeguards at work sites to ensure stable excavations and cut or fill slopes (Section 3304). Appendix J of the SFBC includes (but is not limited to) grading requirements for the design of excavations and fills (Sections J103 through J107) and for erosion control (Sections J109 & J110).

Compliance with the SFBC is mandatory for development in San Francisco. Throughout the permitting, design, and construction phases of a building project, Planning Department staff, DBI engineers, and DBI building inspectors confirm that the SFBC is being implemented by project architects, engineers, and contractors.

During the design phase for buildings in the Project, foundation support and structural specifications based on the preliminary foundation investigations would be prepared by the Project engineer and architect and would be reviewed for compliance with the SFBC by the Planning Department and DBI.

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400 California Building Standards Commission, *2007 California Building Code*, California Code of Regulations, Title 24, Part 2, Volumes 1 and 2, effective January 1, 2008.

During the Project construction phase, DBI inspectors would be responsible for enforcing the provisions of the SFBC as implemented by the contractor.

San Francisco General Plan

The City of San Francisco *General Plan* (1996) provides long-term guidance and policies maintaining and improving the quality of life and the man-made and natural resources of the community. The Community Safety Element includes policies for the avoidance of geologic hazards and/or the protection of unique geologic features. The plan requires detailed site-specific geologic hazard assessments in areas delineated with geologic hazards (seismic hazards, landslides, and liquefaction). Filled land and geologic hazards, such as landslides and shoreline erosion, are addressed in the Environmental Protection Element of the City of San Francisco *General Plan*. The Element includes policies for the promotion of the highest standards of soils engineering, the correction of landslide and shore erosion conditions, and the avoidance of construction on land subject to slide or erosion.

San Francisco Bay Plan

The San Francisco Bay Conservation and Development Commission (BCDC) is a federally designated state coastal management agency for San Francisco Bay. Bay shoreline construction projects, such as filling or dredging in the Bay, certain tributaries to the Bay, salt ponds, and managed wetlands around the Bay, or grading within 100 feet of the Bay shoreline, require permit approval from the BCDC. The BCDC issues an Administrative Permit for minor repairs or improvements along the Bay shoreline and a Major Permit for more extensive projects along the Bay shoreline. The Project would involve the construction of a marina, a bridge across Yosemite Slough, and various shoreline improvements. Such activities would require a permit from BCDC.

In accordance with *McAteer-Petris Act of 1965*, the BCDC is responsible for maintaining and carrying out the policies of the *San Francisco Bay Plan* (Bay Plan). The Bay Plan, adopted in 1969 and more recently amended in 2008, specifies goals, objectives and policies for existing and proposed waterfront land uses use and other BCDC jurisdictions areas. Part III of the Bay Plan contains findings and policies pertinent to the development of the Project.

III.L.4 Impacts

■ Significance Criteria

The City and Agency have not formally adopted significance standards for impacts related to geology and soils, but generally consider that implementation of the Project would have significant impacts if it were to:

L.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 California Geological Survey Special Publication 42)

ii. Strong seismic groundshaking
iii. Seismic-related ground failure, including liquefaction
iv. Landslides

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

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

L.d Be located on expansive soil, as defined in Section 1802.3.2 of the 2007 SFBC, creating substantial risks to life or property

L.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

L.f Change substantially the topography or any unique geologic or physical features of the site

Analytic Method

Preliminary geotechnical assessment of the Project site, including both Candlestick Point and HPS Phase II, has been completed by ENGEO for the Applicant.[401] PBS&J staff have peer-reviewed all ENGEO reports. The preliminary geotechnical assessment was based on previous site-specific geotechnical and hazardous material investigations, some of which include subsurface borings, and review of published geologic reports and maps. The preliminary geotechnical assessment report provides a summary and compilation of available geotechnical information that has been used as part of the analysis of geologic, seismic, and geotechnical issues for this EIR.

This preliminary geotechnical assessment is the first step in identifying, evaluating, and addressing the geotechnical conditions on the Project site and provides necessary information and recommendations to support Project planning and conceptual-level design. Site-specific, design-level geotechnical studies would be completed on a parcel-by-parcel basis during development of construction plans for Project infrastructure and buildings.[402] During the final design, development of individual blocks and foundation recommendations, which may involve further geotechnical exploration, would be required. For high-rise structures, a unique foundation recommendation report would be required for each building.

The Project would develop residential uses, commercial space, office and research and development space, civic and community uses, open space, a marina, and a new 49ers Stadium. Project structures would be designed in accordance with the current SFBC, and would be based on design criteria resulting from required evaluation of site-specific geologic and seismic hazards, including potential for fault rupture, ground motions generated by earthquakes (groundshaking), slope instability, liquefaction, lateral spreading, settlement, and loss of soil strength. In addition to evaluating potential long-term or operational impacts from seismic hazards, potentially corrosive soils, or expansive soils, this section also analyzes short-term soils impacts that could occur during construction, such as erosion and local slope instability. With regard to the marina component of the Project, the analysis in this section considers the landside improvements (which could include parking, restroom facilities, a classroom to teach sailing, and

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401 ENGEO, Inc., *Preliminary Geotechnical Conceptual Design Report Hunters Point Shipyard Phase II and Candlestick Point, San Francisco, California*, May, 2009.

402 ENGEO, 2009.

a harbormaster's office) that could be affected by geologic hazards, and shoreline modifications that would be needed to accommodate the gangways and extension of utility infrastructure.

The analysis includes review of regional and local geologic maps and reports, as well as Project-specific geologic and geotechnical reports to identify geologic conditions and geologic hazards in the Project site that, because of their proximity, could be directly or indirectly affected by the Project or affect the Project itself. The overall geotechnical and soil conditions across the Project site are similar. To determine potential effects of the Project that relate to geologic hazards during construction and operation, this section analyzes the Project site with respect to identified geological hazards, such as landslides, unstable slopes, liquefaction hazards, and active faults.

Table III.L-4 (Summary of Geologic Conditions, Design Details, and Treatments) through Table III.L-8 (Geotechnical Treatment for HPS Phase II Geotechnical Subparcels) summarize the geological and geotechnical information compiled by ENGEO for the portions of the Project site proposed for construction of physical facilities related to the uses listed above. Table III.L-4 summarizes the geological conditions, design details, and treatments available for the Project site. Table III.L-5 (Grading and Fill Conditions for Candlestick Point Geotechnical Subparcels) and Table III.L-6 (Grading and Fill Conditions for HPS Phase II Geotechnical Subparcels) provide the grading and fill conditions for the geotechnical subparcels. Table III.L-7 (Geotechnical Treatments for Candlestick Point Subparcels) and Table III.L-8 (Geotechnical Treatments for HPS Phase II Subparcels) provide the geotechnical treatments and foundation types for structures in each geotechnical subparcel. Figure III.L-4 (Geotechnical Subparcels) shows the location and boundaries of the geotechnical subparcels and illustrates the relationship of the Project's districts to the geotechnical subparcels identified in Table III.L-5 and Table III.L-6.

Table III.L-4 Summary of Geologic Conditions, Design Details, and Treatments

Districts	*Candlestick Point*	*HPS Phase II*
Geologic Conditions	Artificial Fill thickness up to 70 ft; Bay Mud thickness up to 70 ft; Bedrock elevations range from -220 to + 150 ft (SFCD; Groundwater elevations range from -3 to -9 ft (SFCD)	Artificial Fill thickness up to 50 ft; Bay Mud thickness up to 40 ft; Bedrock elevations range from -200 to + 50 ft (SFCD); Groundwater elevations range from -1 to -15 ft (SFCD)
Design Details	Low-rise residential, mid- and high-rise towers with below grade parking, low- and mid-rise commercial; bridge and roadway corridor	Low-rise and mid-rise residential, low- to mid-rise mixed-use, and commercial; high-rise towers; sports facility and parking, utility corridor
Treatments	Mat, spread footing and deep foundations; foundation selection on pad-by-pad basis; depth of foundations determined during design level study; some remedial grading and placement of geogrid; some surcharging; and some overexcavation for utilities	Mat and deep foundations; foundation selection on pad-by-pad basis; depth of foundations determined during design level study; some remedial grading; and some overexcavation for utilities

SOURCE: ENGEO, April 2009

Table III.L-5 Grading and Fill Conditions for Candlestick Point Geotechnical Subparcels				
Districts	*Geotech Subparcel*	*Existing Grades*	*Proposed Grading*	*Artificial Fill*
Candlestick Point North	H	Varies from -5 ft to +7 ft (CCSF)	Cuts up to 4 ft; Fills up to 9 ft	Bottom of artificial fill ranges from elevation -10 ft to -40 ft; thickness ranges from 20 ft to 50 ft
Alice Griffith	G1	Varies from 0 to +15 ft (CCSF)	Cuts up to 23 ft; Fills up to 13 ft	Bottom of artificial fill ranges from elevation -10 to -20 ft; thickness of up to 30 ft
	G2	Varies from +10 to +45 ft (CCSF)	Fills up to 7 ft	Bottom of artificial fill extends to elevation -10 ft; thickness of up to 20 ft
Jamestown Avenue	J	Varies from +113 to +150 ft (CCSF)	Cuts up to 33 ft	n/a
Candlestick Point Center	K1	Varies from +4 to +50 ft (CCSF)	Cuts up to 40 ft; Fills up to 5 ft	n/a
	K2	Varies from +1 to +25 ft (CCSF)	Cuts up to 4 ft; Fills up to 4 ft	Bottom of artificial fill extends to elevation -50 ft; thickness of up to 40 ft
Candlestick Point South	L1	Varies from +5 to -5 ft (CCSF)	Cuts up to 8 ft; Fills up to 10 ft	Bottom of artificial fill ranges from elevation -10 ft to up to -70; thickness ranges from 10 ft to 70 ft
	L2	Varies from -2 to +6 ft (CCSF)	Cuts up to 2 ft; Fills up to 6 ft	Bottom of artificial fill ranges from elevation -10 ft to -50 ft; thickness ranges from 15 ft to 40 ft
Yosemite Slough bridge	YB	Varies from -3 to +6 ft (CCSF)	Cuts up to 8 ft; Fills up to 10 ft	Bottom of artificial fill ranges from elevation -10 ft to -20 ft; thickness ranges from 10 to 20 ft

SOURCE: ENGEO, April 2009.
For location of Geotechnical Parcels, refer to Figure III.L-4 (Geotechnical Subparcels)

Table III.L-6 Grading and Fill Conditions for HPS Phase II Geotechnical Subparcels						
Districts	*Geotech Subparcel*	*Existing Grades*	*Proposed Grading*	*Artificial Fill*	*Young Bay Mud*	*Depth to Bedrock*
Hunters Point North and Hunters Point Village Center	B1 (includes Hunters Point Village Center)	Majority of the site varies from 0 to +5 ft elevation; increases to 35 ft along the southwestern boundary	Cuts up to 14 ft; Fills up to 24 ft	Bottom of artificial fill ranges from elevation 0 ft to -25 ft; thickness ranges from up to 25 ft	Bottom of Bay Mud ranges from elevation -15 ft to -25 ft; thickness less than 10 ft	Bedrock at surface within higher portion of site and extends to elevation -60 ft beneath fill
	B2	Varies from 0 to +3 ft elevation	Fills up to 2 ft	Bottom of artificial fill ranges from elevation -10 to -85 ft; thickness ranges from 10 ft to 85 ft	Bottom of Bay Mud ranges from elevation -5 ft to -25 ft; thickness of up to 10 ft	Top of bedrock located between elevation -10 ft and -80 ft
	B3	Varies from +1.5 to +20 ft elevation	Fills up to 2 ft	Bottom of artificial fill ranges from elevation +10 ft to -35 ft; thickness of up to 35 ft	Bottom of Bay Mud ranges from elevation -30 ft to -40 ft; thickness of up to 10 ft	Top of bedrock located between elevation -20 ft and -40 ft

Table III.L-6 Grading and Fill Conditions for HPS Phase II Geotechnical Subparcels

Districts	*Geotech Subparcel*	*Existing Grades*	*Proposed Grading*	*Artificial Fill*	*Young Bay Mud*	*Depth to Bedrock*
Research and Development	C1	Varies from 0 to +3 ft elevation	Fills up to 4 ft	Bottom of artificial fill ranges from elevation 0 ft to -15 ft; thickness of up to 20 ft	Bottom of Bay Mud ranges from elevation -5 ft to -25 ft; thickness of up to 10 ft	Top of bedrock located between elevation +10 ft and -25 ft.
	C2	Varies from -1 to +2 ft elevation	Fills up to 4 ft	Bottom of artificial fill ranges from elevation -5 ft to -30 ft; thickness ranges from 5 ft to 30 ft	Bottom of Bay Mud ranges from elevation -15 ft to -30 ft; thickness of up to 10 ft	Top of bedrock located between elevation -5 ft and -30 ft
Hunters Point South	Stadium	Varies from -2.5 to +1.5 ft elevation	Fills up to 9 ft	Bottom of artificial fill ranges from elevation 0 ft to -40 ft; thickness of up to 40 ft	Bottom of Bay Mud ranges from elevation -15 ft to -50 ft; thickness of up to 10 ft	Top of bedrock located between elevation 0 ft and -50 ft
	Parking	Varies from -4 to +3 ft elevation	Fills up to 12 ft	Bottom of artificial fill ranges from elevation 0 to -50 ft; thickness of up to 50 ft	Bottom of Bay Mud ranges from elevation -20 ft to -60 ft; thickness of up to 50 ft	Top of bedrock located between elevation 0 ft and -200 ft
Roadways	UC1	Varies from 0 to +3 ft elevation	Fills up to 5 ft	Bottom of artificial fill ranges from elevation +30 ft to +5 ft; thickness of up to 5 ft	n/a	Depth to bedrock generally less than 5 ft
	UC2	Varies from 0 to +15 ft elevation	Fills up to 10 ft	Bottom of artificial fill ranges from elevation +10 ft to 0 ft; thickness of up to 5 ft	n/a	Depth to bedrock generally less than 5 ft
	UC3	Varies from +20 to +54 ft elevation	Cuts up to 1 ft; Fills up to 24 ft	Bottom of artificial fill ranges from elevation +5 ft to -5 ft; thickness of up to 5 ft	n/a	Depth to bedrock generally less than 5 ft

SOURCE: ENGEO, April 2009
All elevations shown in SFCD
For location of Geotechnical Parcels, refer to Figure III.L-4 (Geotechnical Subparcels).

Table III.L-7 Geotechnical Treatments for Candlestick Point Geotechnical Subparcels

Subareas	*Geotech Subparcel*	*Development Type*	*Proposed Geotechnical Remediation*	*Proposed Foundations*
Candlestick Point North	H	Low-rise residential structures with basement parking level (10 ft deep). Mid-rise and high-rise towers on podium with basement (10 ft deep).	Remove and recompact undocumented fill within 5-feet of finish grade. Placement of geogrid below shallow foundations. Possible surcharging in select areas.	Low-rise structures supported on structural mat. Mid-rise structures will vary from shallow to deep foundations to be determined on a pad-by-pad basis. High-rise structures on deep foundations.
Alice Griffith	G1	Low-rise residential structures constructed at grade.	Remove and recompact undocumented fill within 5-feet of finish grade. Placement of geogrid below shallow foundations.	Low-rise structures supported on structural mat.
	G2	Low-rise residential structures constructed at grade.	Remove and recompact undocumented fill within 5-feet of finish grade.	Low-rise structures supported on shallow foundation on bedrock or shallow engineered fill.
Jamestown Ave.	J	Mid-rise residential structures constructed at grade.	Remove and recompact undocumented fill within 5-feet of finish grade.	Mid-rise structures supported on shallow foundation on bedrock or shallow engineered fill.
Candlestick Point Center	K1	Mid-rise commercial structures constructed at grade.	Remove and recompact undocumented fill within 5-feet of finish grade.	Mid-rise structures supported on shallow foundation on bedrock or shallow engineered fill.
	K2	Mid-rise commercial structures constructed at grade.	Remove and recompact undocumented fill within 5-feet of finish grade.	Mid-rise structures will vary from shallow to deep foundations to be determined on a pad-by-pad basis.
Candlestick Point South	L1	Low-rise residential with ½ basement (5 ft deep) parking level. One high-rise building located mid-parcel along western boundary.	Remove and recompact undocumented fill within 5-feet of finish grade. Placement of geogrid below shallow foundations. Surcharging over entire parcel.	Low-rise structures supported on structural mat. High-rise structures supported on deep foundations.
	L2	Mid-rise mixed-use structures constructed at grade.	Remove and recompact undocumented fill within 5-feet of finish grade.	Mid-rise structures supported on deep foundations.
Yosemite Slough Bridge	YB	Bridge and roadway corridor	Remove and recompact undocumented fill within 5-feet of finish grade. Placement of geogrid below roadway and approach.	Bridge structure supported on deep foundations.

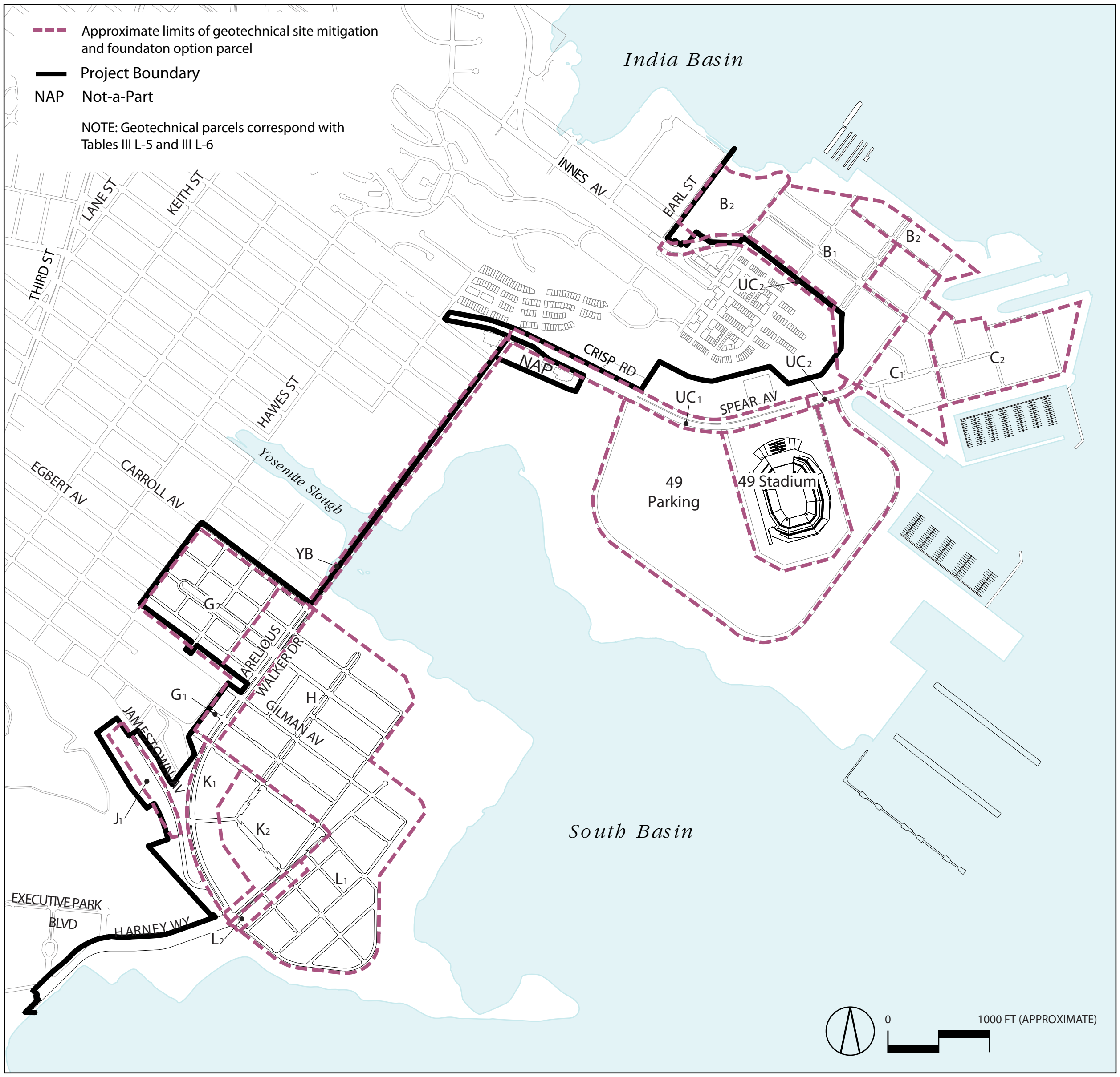
SOURCE: ENGEO, May 2009

Table III.L-8 Geotechnical Treatment for HPS Phase II Geotechnical Subparcels

Subareas	*Geotech Subparcel*	*Development Type*	*Proposed Geotechnical Remediation*	*Proposed Foundations*
Hunters Point and Hunters Point Village Center (Parcel B)	B1 (Includes Hunters Point Village Center)	Low-rise and mid-rise residential and mid-rise mix-use structures constructed at grade	Remove and recompact undocumented fill within 5-feet of finish grade. Placement of geogrid below shallow foundations.	Low-rise structures supported on structural mat. Mid-rise structures supported on deep foundations.
	B2	Low-rise residential with one high-rise building at the east corner constructed at grade	Remove and recompact undocumented fill within 5-feet of finish grade.	Structures supported on deep foundations founded in competent material.
	B3	Park/open space and surface water treatment facilities constructed at grade	No remedial measures planned.	No structures proposed.
Research and Development (Parcel C)	C1	Mid-rise commercial structures constructed at grade	Remove and recompact undocumented fill within 5-feet of finish grade. Placement of geogrid below shallow foundations.	Low-rise structures supported on structural mat. Mid-rise structures will vary from shallow to deep foundations to be determined on a pad-by-pad basis.
	C2	Mid-rise commercial structures constructed at grade	Remove and recompact undocumented fill within 5-feet of finish grade.	Structures supported on deep foundations founded in competent material.
Stadium (Parcel D and E)	Stadium	Professional level sport facility with playing field	Remove and recompact undocumented fill within 5-feet of finish grade.	Structures supported on deep foundations founded in competent material.
	Parking	Turf area for stadium parking capable of supporting recreation	Gravity utilities designed for on-going settlement.	No structures proposed.
Roadways	UC1	Utility corridor	No remedial measures planned.	No structures proposed.
	UC2	Utility corridor and traffic thoroughfare	No remedial measures planned.	No structures proposed.
	UC3	Utility corridor and traffic thoroughfare	No remedial measures planned.	No structures proposed.

SOURCE: ENGEO, May 2009

Table III.L-9 (Summary of Waterfront Structures Field Investigative Observations) summarizes the condition of the existing structures along the area that would become waterfront open space with implementation of the Project. Table III.L-10 (Overview of Waterfront Structures Construction Activities) indicates the work proposed (demolition, repair, fill, and/or construction) to turn the shoreline areas into stable open space. Marina facilities including a floating dock system with guide piles and vessel berths, concrete sheet pile breakwaters supported by batter piles, steel dolphin piles with floating donut-type fenders, and landside marina-serving facilities and utilities (dock abutment, parking lot, restrooms, sewage pump-out, harbormaster office) would be constructed in the open space. Shoreline stabilization treatments would include grading and filling to raise the ground surface, rock



SOURCE: Engeo, 2009.

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GEOTECHNICAL SUBPARCELS

FIGURE III.L-4

slopes and buttresses for protection for portions of the shoreline, and timber cribs to support the remaining piers and wharves. Figure III.L-4 shows the shoreline areas outside the geotechnical subparcels (but within the Project boundaries) that would become open space.

Table III.L-9 Summary of Waterfront Structures Field Investigative Observations

Facility	*Condition Rating*	*General Comments*
Wharf at Berth 55 to 61 (Parcel B)	Fair	Concrete structural elements appear to be sound. Minor spalling
Drydocks 2 and 3 (Parcel C)	Poor	Vertical cracks extending full height of walls, air pockets have expanded into large voids.
Berths 1 and 2 (Parcel C)	Serious	Advanced deterioration, deck edge spalling, exposed rebar, pile cracking, apparent collision/impact damage, broken concrete support elbows.
Berth 3 and 4 (Parcel C)	Poor	Advanced deterioration, frequent spalls and corrosion cracks, some exposed corroded rebar.
	Poor to Serious Sta. 10+60 to south edge of pile supported Berth 2 (U/W)	Advanced deterioration, open corrosion spalls with exposed rebar, spalls 6 inches deep.
Berth 5 (Parcel C)	Poor	Advanced open corrosion spalling, impact spalls, cracks and delaminations spalls up to approx. 100 sq. ft.
Berths 6 and 7 (Parcel C)	Poor	Advanced deterioration, open corrosion spalling, cracking on 20% or more walls, 1 to 10 sq. ft. spalls.
Berths 8 and 9	Poor	Advanced corrosion spalling, cracking, and delamination of 20% or more for walls, vertical spalls along cold joints.
Drydock 4 (Parcel C)	Poor	Advanced deterioration, more than 40% has patches of open and closed corrosion spalls and consistent delaminations (full height).
Berth 10 (Parcel D)	Poor	Open corrosion spalls and cracks along 20% or more of the wall. Exposed rebar along damages below caping.
Berth 11 (Parcel D)	Serious	Advanced deterioration and broken concrete throughout majority of wall. Open corrosion spalls and cracks.
Berths 12 and 13 (Parcel D)	Poor	Advanced deterioration along 25% or more; open corrosion spalls and delamination patches; exposed rebar, corrosion cracks along walls.
Berth 14 (Parcel D)	Poor	More than 30% of concrete wall has damages; spalls, exposed and corroded rebar; patches of delaminations and open corrosion spalls at the caping. Spalling at vertical cold joints.
Berths 15–22 and 29 (Parcel D)	Serious	Top 2 ft has 50% to 100% section loss; gaps found between steel sheets. Majority of concrete cap is spalled and exposed rebar. Damage at Berth 29 suspected to be caused by impact.

SOURCE: Moffatt & Nichol, August 2009

Table III.L-10 Overview of Waterfront Structures Construction Activities

Parcel	Demolish and Remove		Repair	Construction
B	—		Concrete, Steel	Buttress
C	Timber Cribbing Structure, Concrete	Miscellaneous Fill	Concrete, Steel	Rock slopes, Buttress, Sheet Pile Wall
D	Timber Cribbing Structure, Cellular Sheet Pile Wall, Miscellaneous	Concrete Steel Fill	Concrete, Steel	Rock slopes, Buttress
E	Cellular Sheet Pile Wall, Concrete	Miscellaneous Fill	Steel	Rock slopes, Buttress, Revetment
E-2				Mudflatt
CSP	Miscellaneous Fill		—	Beach, Marsh, Revetment

SOURCE: Moffatt & Nichol, August 2009

Construction Impacts

Impact GE-1: Soil Erosion

Impact of Candlestick Point

Impact GE-1a **Construction at Candlestick Point, including the Yosemite Slough bridge, would not result in the loss of topsoil caused by soil erosion. (Less than Significant with Mitigation)** ***[Criterion L.b]***

Construction activities in the Candlestick Point site, such as removal of paved areas, grading, and excavation, could remove stabilizing vegetation and expose areas of loose soil that, if not properly stabilized, could be subject to soil loss and erosion by wind and stormwater runoff. Newly constructed and compacted engineered slopes could undergo substantial erosion through dispersed sheet flow runoff, and more concentrated runoff can result in the formation of erosional channels and larger gullies, each compromising the integrity of the slope and resulting in significant soil loss. The erosion hazard rating for the local soils in the Candlestick Point site is slight to severe.

Requirements to control surface soil erosion during and after construction at Candlestick Point would be implemented with mitigation measure MM HY-1a.1. The requirements of this mitigation measure are described under Impact HY-1a in Section III.M (Hydrology and Water Quality) and include implementation of a Stormwater Pollution Prevention Plan (SWPPP) and use of best management practices (BMPs) for construction sites. Mitigation measure MM HY-1a.1 would require preparation of a SWPPP and would be required to identify the specific measures and BMPs that are applicable to Candlestick Point construction activities. Installation of erosion mitigation measures would be the responsibility of the Project contractor and would be monitored by DBI inspectors for compliance with the SFBC requirements. Adherence to these requirements through the implementation of standard BMPs for the control of erosion during construction would include a variety of techniques that would be implemented based on site-specific conditions and could include plastic covers and erosion control blankets, soil binders, silt fencing, straw bales, wood mulch, and drainage ditches. Erosion controls could include performing construction activities in the dry season, and minimizing removal of, and damage to native vegetation. To control an increase in dust during construction activities, disturbed areas could be sprayed with water, or a non-toxic soil stabilizer. (Also refer to Section III.H (Air Quality) regarding construction dust control measures.)

Construction activities for the Yosemite Slough bridge, such as grading and excavation of the bridge approaches, could remove stabilizing vegetation and expose areas of loose soil that, if not properly stabilized, could be subject to soil loss and erosion by wind and stormwater runoff. Newly constructed and compacted engineered slopes could undergo substantial erosion through dispersed sheet flow runoff, and more concentrated runoff can result in the formation of erosional channels and larger gullies, each compromising the integrity of the slope and resulting in significant soil loss. The erosion hazard rating for the local soils in the Candlestick Point site is slight to severe.

With implementation of mitigation measure MM HY-1a.1, adverse effects on the soil, such as soil loss from wind erosion and stormwater runoff, would be avoided or reduced to less-than-significant levels.

Impact of Hunters Point Shipyard Phase II

Impact GE-1b **Construction at HPS Phase II would not result in the loss of topsoil caused by soil erosion. (Less than Significant with Mitigation)** ***[Criterion L.b]***

The potential for exposure to adverse affects caused by soil erosion in the HPS Phase II site exists. Construction activities, such as grading and excavation, could remove stabilizing vegetation and expose areas of loose soil that, if not properly stabilized, could be subject to soil loss and erosion by wind and stormwater runoff. Newly constructed and compacted engineered slopes could undergo substantial erosion through dispersed sheet flow runoff, and more concentrated runoff can result in the formation of erosional channels and larger gullies, each compromising the integrity of the slope and resulting in significant soil loss. The erosion hazard rating for the local soils in the HPS Phase II site is slight to severe.

Requirements to control surface soil erosion during and after construction at HPS Phase II would be implemented through the requirements of mitigation measure MM HY-1a.1 and adverse effects on the soil, such as soil loss from wind erosion and stormwater runoff, would be avoided or reduced to less-than-significant levels.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-1 **Construction activities associated with the Project would not result in the loss of topsoil caused by soil erosion. (Less than Significant with Mitigation)** ***[Criterion L.b]***

Construction activities, such as removal of paved areas, grading, and excavation, could remove stabilizing vegetation and expose areas of loose soil that, if not properly stabilized, could be subject to soil loss and erosion by wind and stormwater runoff. Newly constructed and compacted engineered slopes could undergo substantial erosion through dispersed sheet flow runoff, and more concentrated runoff can result in the formation of erosional channels and larger gullies, each compromising the integrity of the slope and resulting in significant soil loss. Requirements to control surface soil erosion during and after construction associated with the Project would be implemented through the requirements of mitigation measure MM HY-1a.1 and adverse effects on the soil such as soil loss from wind erosion and stormwater runoff would be avoided or reduced to a less-than-significant level.

Impact GE-2: Settlement from Dewatering Activities

Impact of Candlestick Point

Impact GE-2a **Construction at Candlestick Point and the Yosemite Slough bridge would not result in damage to structures from settlement caused by lowering of groundwater levels. (Less than Significant with Mitigation)** ***[Criterion L.c]***

At Candlestick Point, construction activities would have the potential to affect groundwater levels. Project construction may include dewatering procedures during excavation, construction, and operation of foundations and buried utilities. Groundwater levels in the artificial fill and the underlying estuarine deposits at Candlestick Point generally are less than 15 feet below the ground surface and experience varying degrees of tidal fluctuation. Some minor dewatering may be needed to reduce heads to several feet or more below excavation bottoms and to address seepage and the potential for settlement. Dewatering during construction activities could cause settlement of adjacent soils; however, since there are no existing structures at Candlestick Point that will remain with the Project, no damage to overlying foundations of existing buildings would result.

Construction activities for the Yosemite Slough bridge would have the potential to affect groundwater levels. Project construction may include dewatering procedures during excavation, construction, and operation of foundations and buried utilities. Groundwater levels in the artificial fill and the underlying estuarine deposits near Yosemite Slough are generally less than 15 feet below the ground surface and experience varying degrees of tidal fluctuation. Some minor dewatering may be needed to reduce heads to several feet or more below excavation bottoms and to address seepage and the potential for settlement. However, as there are no structures adjacent to the location of the proposed bridge, dewatering during construction would not affect foundations of existing structures.

Section 1803.1 of the SFBC requires that excavations for any purpose not remove support from adjacent or nearby structures without first protecting them against settlement or lateral movement. To ensure this protection during dewatering, the following mitigation measure shall be implemented where adjacent or nearby structures exist:

MM GE-2a <u>*Mitigation to Minimize Dewatering Impacts During Construction.*</u> *Prior to the issuance of any permit for a construction activity that would involve dewatering that could affect structures on adjacent or nearby properties, the Applicant shall, in compliance with Section 1803.1 of the* San Francisco Building Code *(SFBC), include in the permit application methods and techniques to ensure that dewatering would not lower the water table such that unacceptable settlement (as determined by a California Certified Engineering Geologist [CEG] or California Registered Geotechnical Engineer [GE]) at adjacent or nearby properties would occur. Such methods and technologies shall be based on the specific conditions at the construction site and could include, but are not necessarily limited to, the following:*

- *Excavating below the groundwater table in confined areas with steel sheet piling driven below the base elevation of the proposed excavation, installation of bracing to support the excavation walls as required and, if necessary, underpinning the foundations of adjacent structures. Subsequently,* *the excavation would be carried out and seepage that enters the dammed area would be pumped out.*

- *Perform dewatering using methods such as wellpoint systems, drainage ditches, and sump pumps.*

The excavation or dewatering methods shall be monitored to detect ground settlement and to monitor individual dewatering activities in the vicinity of an excavation. Monitoring results shall be submitted to the San Francisco Department of Building Inspection (DBI). In the event of unacceptable ground movement, as determined by DBI inspections and/or the review of monitoring results, all excavation work shall cease and corrective measures (including, for example, different dewatering methods and/or ground stabilization methods) shall be determined by the Project CEG or GE and reviewed and approved by DBI. No construction permit involving dewatering would be issued until the Project CEG or GE and DBI have approved dewatering and/or ground stabilization methods. The Project CEG or GE shall implement the corrective measures and continue monitoring activities.

With implementation of those dewatering techniques, groundwater level monitoring, and subsurface controls, as specified in the SFBC and required by mitigation measure MM GE-2a, groundwater levels in the area would not be lowered such that that unacceptable settlement at adjacent or nearby properties would occur. Consequently, settlement hazards related to dewatering would be less than significant.

Impact of Hunters Point Shipyard Phase II

Impact GE-2b **Construction at HPS Phase II would not result in damage to structures caused by settlement from lowering of groundwater levels. (Less than Significant with Mitigation)** ***[Criterion L.c]***

At HPS Phase II, construction activities would have the potential to affect groundwater levels. Project construction may include dewatering procedures during excavation, construction, and operation of foundations and buried utilities. The dewatering could cause settlement of adjacent soils that could damage the overlying foundations of existing buildings. Groundwater levels in the artificial fill and the underlying estuarine deposits at HPS Phase II are generally less than 15 feet below the ground surface and experience varying degrees of tidal fluctuation. Some minor dewatering may be needed to reduce heads to several feet or more below excavation bottoms and to address seepage and the potential for settlement.

The requirements of Section 1803.1 of the SFBC as indicated above would be applicable to dewatering activities at HPS Phase II. With implementation of the dewatering techniques, groundwater level monitoring, and subsurface controls as specified in the SFBC and required by mitigation measure MM GE-2a, groundwater levels in the area would not be lowered such that that unacceptable settlement at adjacent or nearby properties would occur. Consequently, settlement hazards related to dewatering would be less than significant.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-2 **Construction activities associated with the Project would not result in damage to structures caused by settlement from lowering of groundwater levels. (Less than Significant with Mitigation)** ***[Criterion L.c]***

Project construction activities would have the potential to affect groundwater levels. Project construction may include dewatering procedures during excavation, construction, and operation of foundations and buried utilities. The dewatering could cause settlement of adjacent soils that could damage the overlying foundations of existing buildings. Groundwater levels in the artificial fill and the underlying estuarine deposits generally are less than 15 feet below the ground surface and experience varying degrees of tidal fluctuation. Some minor dewatering may be needed to reduce heads to several feet or more below excavation bottoms and to address seepage and the potential for settlement. With implementation of the dewatering techniques, groundwater level monitoring, and subsurface controls as specified in the SFBC and required by mitigation measure MM GE-2a, groundwater levels in the area would not be lowered such that that unacceptable settlement at adjacent or nearby properties would occur. Consequently, settlement hazards related to dewatering would be less than significant.

Impact GE-3: Destabilization of Bedrock from Rock Removal Activities

Impact GE-3 **Rock removal activities at the Alice Griffith Public Housing site and the Jamestown area would not result in damage to structures from vibration and/or settlement caused by the fracturing of bedrock for excavation. (Less than Significant with Mitigation)** ***[Criterion L.c]***

At the Alice Griffith Public Housing site and the Jamestown area, the removal of bedrock through heavy equipment methods or controlled rock fragmentation activities would have the potential to fracture rock adjacent to the excavation, thereby destabilizing it and possibly causing settlement of structures above it. Heavy equipment rock removal methods could include ripping (such as a large tractor equipped with a ripper attachment) or mechanical rock-breaking using hammers, hoe-rams, splitters, and/or cutters. Harder areas of bedrock may need to be removed using a technique known as controlled rock fragmentation. Controlled rock fragmentation technologies include pulse plasma rock fragmentation (PPRF), controlled foam injection, and controlled blasting. It may be necessary to use a combination of these techniques. Controlled blasting usually can be performed at noise levels below typical building demolition noise levels (80-100 dBA).[403] PPRF can be performed at noise and vibration levels below those of controlled blasting (1/36 and 1/20, respectively, at 20 meters [about 65 feet]).[404] Controlled foam injection reduces the airblast, flyrock, and fumes associated with uncovered explosive-based techniques.[405]

Controlled blasting fractures bedrock by using explosives to produce a vibration or shockwave that breaks the rock. Controlled foam injection forces an aqueous polymer into existing rock fractures and

[403] MACTEC, *CP-HPSII Rock Fragmentation*, prepared for Lennar Urban, June, 2009.
[404] KAPRA & Associates, *Pulse Plasma Rock Fragmentation Technology*, 2001.
[405] Young, C. and C. Graham, *Controlled Foam Injection - Progress Towards Automated Hard Rock Excavation*, 5th International Symposium on Mine Mechanics and Automation, Ontario, Canada, June, 1999.

enlarges them until the rock fails. PPRF uses an electrical impulse to create a flash of extremely high heat that shatters the rock by causing it to expand beyond its capacity to maintain its structural integrity.

The majority of the area at the Alice Griffith Public Housing site consists of thin fill over bedrock and artificial fill underlain by young bay mud over bedrock. The bedrock is at elevations ranging from +45 feet San Francisco City Datum (SFCD) to -10 feet SFCD. The bedrock, which may include localized well-cemented beds, would need to be removed in the northern portion of the parcel to depths ranging from 2 feet to 23 feet below the existing ground surface. It's estimated that 140,000 cubic yards of rock will need to be removed; at least 70 percent of this rock would be removed by heavy equipment, but the remaining 30 percent (approximately 42,000 cubic yards) may need to be removed by controlled rock fragmentation.[406]

The majority of the area at Jamestown is underlain by bedrock at an elevation of +100 feet SFCD to the northeast and +150 feet SFCD to the southwest. Development of this parcel would involve the removal of bedrock, which may include localized well-cemented beds, to depths ranging from 2 feet to 62 feet below the existing ground surface. It's estimated that 140,000 CYs of rock will need to be removed; at least 30 percent of this rock would be removed by heavy equipment; the remaining 70 percent (approximately 98,000 cubic yards) may need to be removed by controlled rock fragmentation. Access constraints caused by the steep slopes in the area may reduce the amount of rock that could be removed using heavy equipment.[407]

Section 1803.1 of the SFBC requires that excavations for any purpose not remove support from adjacent or nearby structures without first protecting them against settlement or lateral movement. To ensure this protection during controlled rock fragmentation activities, the following mitigation measure would be implemented:

MM GE-3 <u>*Mitigation to Minimize Rock Fragmentation Impacts During Construction*</u>. *Prior to the issuance of any permit for a construction activity that would involve controlled rock fragmentation that could cause settlement or lateral movement of structures on adjacent or nearby properties, the Applicant shall, in compliance with Section 1803.1 of the* San Francisco Building Code *(SFBC), include in the permit application methods and techniques to ensure that controlled rock fragmentation would not cause unacceptable vibration and/or settlement or lateral movement of structures at adjacent or nearby properties. Such methods and technologies shall be based on the specific conditions at the construction site such as, but not limited to, the following:*

- *Pre-excavation surveying of potentially affected structures.*
- *Underpinning of foundations of potentially affected structures, as necessary.*
- *The excavation plan shall include a monitoring program to detect ground settlement or lateral movement of structures in the vicinity of an excavation. Monitoring results shall be submitted to DBI. In the event of unacceptable ground movement, as determined by DBI inspections, all excavation work shall cease and corrective measures shall be implemented. The controlled rock fragmentation program and ground stabilization measures shall be reevaluated and approved by the DBI.*

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[406] MACTEC, June, 2009.
[407] MACTEC, June, 2009.

With implementation of those techniques, ground surface and building damage monitoring, as specified in the SFBC and required by mitigation measure MM GE-3, vibration from controlled rock fragmentation in the area would not cause unacceptable settlement or damage at adjacent or nearby properties would occur. Consequently, settlement hazards related to controlled rock fragmentation would be less than significant. Rock removal activities would not be required at any other areas on the Project site.

Operational Impacts

Impact GE-4: Seismically Induced Groundshaking

Impact of Candlestick Point

Impact GE-4a **Implementation of the Project at Candlestick Point, including the Yosemite Slough bridge and Alice Griffith Housing, would not expose people or structures to substantial adverse effects caused by seismically induced groundshaking. (Less than Significant with Mitigation) *[Criterion L.a(ii)]***

Candlestick Point

Candlestick Point could be exposed to groundshaking hazards. Groundshaking is the most widespread effect of earthquakes and would pose a seismic threat to the development at Candlestick Point. Active faults capable of producing strong groundshaking exist near the Project site. Most notable of these faults are the San Andreas, San Gregorio, and Hayward Faults. The proposed new structures could experience strong groundshaking from an earthquake on any of these faults.

To address groundshaking, the design-level geotechnical investigations to be performed must include site-specific seismic analyses to evaluate the peak ground accelerations for design of Project components, as required by Chapter 16, Structural Design, and Chapter 18, Soils and Foundations, of the SFBC. Accordingly, the following mitigation measure shall be implemented:

MM GE-4a.1 *Site-Specific Geotechnical Investigation with Seismic Analyses. Prior to the issuance of any building permits for the Project site:*

- *The Applicant shall submit to the San Francisco Department of Building Inspection (DBI) for review and approval a site-specific, design-level geotechnical investigation prepared by a California Certified Engineering Geologist (CEG) or California Registered Geotechnical Engineer (GE), as well as project plans prepared in compliance with the requirements of the* San Francisco Building Code *(SFBC), the* Seismic Hazards Mapping Act*, and requirements contained in CGS Special Publication 117A "Guidelines for Evaluating and Mitigating Seismic Hazards in California." In addition, all engineering practices and analyses of peak ground accelerations and structural design shall be consistent with SFBC standards to ensure that structures can withstand expected ground accelerations. The CEG or GE shall determine and DBI shall approve design requirements for foundations and all other improvements associated with the permit application.*
- *DBI shall employ a third-party CEG and California Registered Professional Engineer (Civil) (PE) to form a Geotechnical Peer Review Committee (GPRC), consisting of DBI and these*

third-party reviewers. The GPRC shall review the site-specific geotechnical investigations and the site-specific structural, foundation, infrastructure, and other relevant plans to ensure that these plans incorporate all necessary geotechnical mitigation measures. No permits shall be issued by DBI until the GPRC has approved the geotechnical investigation and the Project plans, including the factual determinations and the proposed engineering designs and construction methods.

- *All Project structural designs shall incorporate and conform to the requirements in the site-specific geotechnical investigations.*
- *The Project CEG or GE shall be responsible for ensuring compliance with these requirements.*

Implementation of site-specific design measures would ensure that Project structures would withstand expected seismic ground accelerations. Consequently, seismic hazards related to groundshaking would be less than significant.

Alice Griffith Public Housing

The Alice Griffith Public Housing site and new development on the site would be subject to HUD approval and Executive Order 12699. The new development would also be subject to the SFBC, which would meet the requirements of the Executive Order. The San Francisco Department of Building Inspection (DBI) would be the agency responsible for implementing and enforcing appropriate seismic design and construction standards for the new development. DBI would be the City's responsible agency. Federal implementation and enforcement of the seismic safety program would be achieved through notification by the City to the building owner, architect, engineer, or contractor of the required minimum standards and requiring written acknowledgement of awareness of the requirements and of intent to comply.

HUD could require some form of compliance certification, such as the engineer's and architect's signed and stamped verification of seismic design codes, standards, and practices used in the design and construction of the buildings, or submittal of Planning Department and/or DBI permit review and inspection documents to HUD. To ensure compliance with any such requirements, the following mitigation measure shall be implemented for the Alice Griffith Public Housing development:

MM GE-4a.2 <u>*Seismic Design Compliance Documentation*</u>*. Prior to the issuance of building permits for the replacement of the Alice Griffith Public Housing site, the Applicant shall submit any and all seismic design compliance documentation to the HUD, as required by that agency. The Project Developer shall confirm, by copy of all documents submitted, including transmittal, compliance with this requirement to DBI. The Project California Certified Engineering Geologist (CEG) or California Registered Geotechnical Engineer (GE) shall be responsible for verifying Project compliance with this requirement.*

Implementation of mitigation measures MM GE-4a.1 and MM GE-4a.2 would ensure that impacts to the Alice Griffith Public Housing from seismic ground acceleration and groundshaking would be reduced a less-than-significant level.

Yosemite Slough Bridge

The Yosemite Slough bridge could be exposed to groundshaking hazards. Groundshaking is the most widespread effect of earthquakes and would pose a seismic threat to the Project. Active faults capable of producing strong groundshaking exist near the Project site. Most notable of these faults are the San Andreas, San Gregorio, and Hayward Faults. The proposed new structures could experience strong groundshaking from an earthquake on any of these faults.

To address groundshaking, design-level geotechnical investigations as required by mitigation measure MM GE-4a.3 would include site-specific seismic analyses to evaluate the seismic safety of bridge design of the bridge based on Caltrans and Department of Public Works Bureau of Engineering (BOE specifications. The following mitigation measure shall be implemented:

MM GE-4a.3 *Site-specific Seismic Analyses to Ensure Safety of Bridge Design. Prior to the issuance of any building permits for the Project site, the California Certified Engineering Geologist (CEG) or California Registered Geotechnical Engineer (GE) for the Project shall confirm that the design-level geotechnical investigation for the Yosemite Slough bridge is based on Caltrans specifications (*Bridge Design Specifications*, Section 20 of* Bridge Memos to Designers*,* Seismic Design Criteria *as previously described) and meets the San Francisco Department of Public Works Bureau of Engineering (BOE) requirements. The Project CEG or GE and California Registered Structural Engineer ((SE) shall approve bridge design. No building permits shall be issued until the CEG or GE and SE verify that the Project's bridge design complies with all Caltrans specifications and BOE requirements.*

Implementation of mitigation measures MM GE-4a.1 and MM GE-4a.3 would be required for the bridge. Based on the seismic analyses required by mitigation measures MM GE-4a.1 and MM GE-4a.3, bridge design would be modified or strengthened and constructed to the highest feasible seismic safety standards consistent with the BOE requirements, as deemed appropriate by the Project CEG or GE and SE and verified by BOE, if the anticipated seismic forces (calculated peak vertical and horizontal ground accelerations caused by groundshaking) were found to be greater than anticipated. Compliance with these BOE requirements would ensure potential impacts on the bridge from groundshaking would be less than significant.

Impact of Hunters Point Shipyard Phase II

Impact GE-4b **Implementation of the Project at HPS Phase II would not expose people and structures to substantial adverse effects caused by seismically induced groundshaking. (Less than Significant with Mitigation)** ***[Criterion L.a(ii)]***

There is a potential for exposure to adverse affects caused by groundshaking in the HPS Phase II site. Groundshaking is the most widespread effect of earthquakes and would pose a seismic threat to the development at HPS Phase II. Active faults capable of producing strong groundshaking exist near the Project site. Most notable of these faults are the San Andreas, San Gregorio, and Hayward Faults. The proposed new structures could experience strong groundshaking from an earthquake on any of these faults.

To address groundshaking, the design-level geotechnical investigations to be performed must include site-specific seismic analyses to evaluate the peak ground accelerations for design of Project components, as required by Chapter 16 (Structural Design) and Chapter 18 (Soils and Foundations) of the SFBC. Accordingly, mitigation measure MM GE-4.a1 would be implemented for development of HPS Phase II. Based on the seismic analyses, structure designs would be modified or strengthened and constructed to the highest feasible seismic safety standards, consistent with the requirements of the SFBC, as deemed appropriate by the Project engineer and verified by DBI, if the anticipated seismic forces (calculated peak vertical and horizontal ground accelerations caused by groundshaking) were found to be greater than anticipated. Implementation of this mitigation measure would ensure that potential impacts from groundshaking would be less than significant.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-4 **Implementation of the Project would not expose people and structures to substantial adverse effects caused by seismically induced groundshaking. (Less than Significant with Mitigation)** ***[Criterion L.a(ii)]***

The potential for exposure to adverse affects caused by seismic groundshaking exists at the Project site. Mitigation measures MM GE-4a.1, MM GE-4a.2, and MM GE-4a.3 would require design-level geotechnical investigations that would include site-specific seismic analyses to evaluate the peak ground accelerations for design of Project structures and the Yosemite Slough bridge, as required by the SFBC and Caltrans. Implementation of these mitigation measures would ensure that potential impacts from groundshaking would be less than significant.

Impact GE-5: Seismically Induced Ground Failure

Impact of Candlestick Point

Impact GE-5a **Implementation of the Project at Candlestick Point, including the Alice Griffith Housing and Yosemite Slough bridge, would not expose people or structures to substantial adverse effects caused by seismically induced ground failure such as liquefaction, lateral spreading, and settlement. (Less than Significant with Mitigation)** ***[Criterion L.a(iii)]***

Candlestick Point

The Candlestick Point site could be exposed to liquefaction hazards. Liquefaction-related phenomena can include lateral spreading, ground oscillation, loss of bearing strength, vertical settlement from densification (subsidence), buoyancy effects, sand boils, and flow failures, all of which could cause damage to the proposed structures in the Candlestick Point site. Damage from liquefaction and lateral spreading is generally most severe when liquefaction occurs within 15 to 20 feet below the ground surface. The Orthents and Urban Land soils in the lowland areas of the Candlestick Point site have a very high potential for liquefaction. In particular, loosely compacted granular soil below the ground-water table with uniform grain size and low plasticity are most susceptible to liquefaction. Based on the subsurface data reviewed to date, these types of soil deposits generally are limited to isolated pockets and random layers within the overall soil profile, and, therefore, the unmitigated risk is considered low to moderate and can be treated using standard engineering practices to protect improvements, as outlined previously in Table III.L-7 and Table III.L-8.[408] If more extensive zones susceptible to liquefaction were encountered during future exploration, further mitigation measures could be necessary. The proposed foundations for structures, vaults, and pipelines would be the components most vulnerable to damage

[408] ENGEO, 2009.

from liquefaction-related phenomena. Localized hazards could occur in open space areas, but mitigation would not be necessary where no habitable structures or critical utilities would be present.

Seismically induced settlement can occur in areas underlain by compressible or poorly consolidated sediments. Stream channel deposits and recent valley alluvium generally are the most susceptible to earthquake-induced settlement. Additionally, some artificial fills are susceptible to mobilization and densification, resulting in earthquake-induced subsidence. Artificial fills exist in the lowland areas of Candlestick Point (refer to Figure III.L-1). In addition, historical shoreline maps show that artificial fill placement extends as far as 3,300 feet into the Bay.[409]

CGS Special Publication 117A outlines the protocol for analysis and treatment of liquefaction-related hazards, including estimates of vertical settlement and lateral spreading. Prediction of liquefaction-related settlement is necessarily approximate, and related hazard assessment and development of recommendations for treatment of such hazards must be performed conservatively, as recommended by CGS Special Publication 117A. A similarly conservative approach is recommended by CGS Special Publication 117A when estimating the amount of localized differential settlement likely to occur as part of the overall predicted settlement: localized differential settlements up to two-thirds of the total settlements anticipated must be assumed until more precise predictions of differential settlements can be made.

Design and construction of the structures and facilities at Candlestick Point would incorporate appropriate engineering practices to ensure seismic stability, some of which are explained in more detail below, as required by Chapter 16, Structural Design, and Chapter 18, Soils and Foundations, of the SFBC. Sections 1607 through 1614 contain the formulae, tables, and graphs by which the Project engineer would develop the structural specifications for building design and which would be used by DBI to verify the applicability of the specifications. Sections 1804 through 1812 contain similar information for the design and verification of adequate soils and foundation support for individual elements of the Project. Section 1802 requires the use of this information in the seismic analyses prepared for the site-specific investigations that must be prepared in connection with the permits for individual elements of the Project.

Where shallow foundations would be underlain by artificial fill and the estimated settlement would be small, the treatment could employ a combination of removal and recompaction with the placement of geogrid[410] beneath structures to help distribute differential settlement that might occur. Treatment for mid-rise and high-rise structures could include supporting these structures on deep foundations bearing in strata below the potentially liquefiable layer with flexible utility connections to allow some settlement beneath the buildings. Mitigation measure MM GE-4a.1 would reduce risks from liquefaction. If liquefaction estimates were such that MM GE-4a.1 would not address liquefaction and settlement-related impacts adequately, further mitigation would include one or more of the additional structural and/or ground-improvement procedures identified in mitigation measure MM GE-5a. Selection of the

[409] ENGEO, 2008.
[410] Geogrids are synthetic fabrics (fiberglass, polyester, treated steel, etc.) formed into nets with openings more than ¼ inch in size to allow the fabric to interlock with surrounding soil, rock, and other below-ground-level materials and to function as reinforcement.

appropriate procedures would be dependent on the land use, development type, soil profile, and estimated settlement.

To avoid or reduce the potential liquefaction hazards at Candlestick Point to a less-than-significant level, implementation of mitigation measure MM GE-5a would require the Applicant to comply with site-specific requirements established by State and local codes and by DBI and other agencies that would be involved in reviewing and issuing permits for buildings and infrastructure at the Project site.

To reduce or avoid impacts related to seismically induced ground failure such as liquefaction, lateral spreading, and/or settlement where the measures described above are not adequate, the following mitigation measure shall be implemented.

MM GE-5a *<u>Site-Specific Geotechnical Investigation with Analyses of Liquefaction, Lateral Spreading and/or Settlement</u>. Prior to issuance of building permits for the Project site:*

- *The Applicant shall submit to the San Francisco Department of Building Inspection (DBI) for review and approval a site-specific, design-level geotechnical investigation prepared by a California Certified Engineering Geologist (CEG) or California Registered Geotechnical Engineer (GE), as well as project plans prepared in compliance with the requirements of the San Francisco Building Code (SFBC), the Seismic Hazards Mapping Act, and requirements contained in CGS Special Publication 117A "Guidelines for Evaluating and Mitigating Seismic Hazards in California." In addition, all engineering practices, and analyses of structural design shall be consistent with SFBC standards to ensure seismic stability, including reduction of potential liquefaction hazards.*
- *DBI shall employ a third-party CEG and California Registered Professional Engineer (Civil) (PE) to form a Geotechnical Peer Review Committee (GPRC), consisting of DBI and these third-party reviewers. The GPRC shall review the site-specific geotechnical investigations and the site-specific structural, foundation, infrastructure, and other relevant plans to ensure that these plans incorporate all necessary geotechnical mitigation measures. No permits shall be issued by DBI until the GPRC has approved the geotechnical investigation and the Project plans, including the factual determinations and the proposed engineering designs and construction methods.*
- *All Project structural designs shall incorporate and conform to the requirements in the site-specific geotechnical investigations.*
- *The site-specific Project plans shall incorporate the mitigation measures contained in the approved site-specific geotechnical reports to reduce liquefaction hazards. The engineering design techniques to reduce liquefaction hazards shall include proven methods generally accepted by California Certified Engineering Geologists, subject to DBI and GPRC review and approval, including, but not necessarily limited to:*

<u>Structural Measures</u>

- *Construction of deep foundations, which transfer loads to competent strata beneath the zone susceptible to liquefaction, for critical utilities and shallow foundations*
- *Structural mat foundations to distribute concentrated load to prevent damage to structures*

<u>Ground Improvement Measures</u>

- *Additional over-excavation and replacement of unstable soil with engineering-compacted fill*

- *Dynamic compaction, such as Deep Dynamic Compaction (DDC) or Rapid Impact Compaction (RIC), to densify loose soils below the groundwater table*
- *Vibro-compaction, sometimes referred to as vibro-floatation, to densify loose soils below the groundwater table*
- *Stone columns to provide pore pressure dissipation pathways for soil, compact loose soil between columns, and provide additional bearing support beneath foundations*
- *Soil-cement columns to densify loose soils and provide additional bearing support beneath foundations*
- *The Project CEG or GE shall be responsible for ensuring compliance with these requirements.*

Implementation of mitigation measures MM GE-4a.1 and MM GE-5a would reduce or avoid impacts related to seismically induced ground failure such as liquefaction, lateral spreading, and/or settlement by applying structural and ground improvement measures to minimize these risks. Implementation of this mitigation would reduce the impact to less than significant.

Alice Griffith Housing

New development on the Alice Griffith Public Housing site would be subject to HUD approval and Executive Order 12699. The new development would be subject to the SFBC, which would meet the requirements of the Executive Order. The San Francisco Department of Building Inspection (DBI) would be the agency responsible for implementing and enforcing appropriate seismic design and construction standards for the new development. DBI would be the City's responsible agency. Federal implementation and enforcement of the seismic safety program would be achieved through notification by the City to the building owner, architect, engineer, or contractor of the required minimum standards and requiring written acknowledgement of awareness of the requirements and of intent to comply.

HUD could require some form of compliance certification, such as the engineer's and architect's signed and stamped verification of seismic design codes, standards, and practices used in the design and construction of the buildings, or submittal of Planning Department and/or DBI permit review and inspection documents to HUD. Mitigation measures MM GE-4a.1, MM GE-4a.2, and MM GE-5a would apply to this impact, and would reduce this impact a less-than-significant level.

Yosemite Slough Bridge

The Yosemite Slough bridge area could be exposed to liquefaction hazards, as described in the discussion regarding Candlestick Point, above. Artificial fills occur in the lowland areas near the proposed Yosemite Slough bridge (refer to Figure III.L-1). In addition, historical shoreline maps show that artificial fill placement extends as far as 1,100 feet into the Bay near the proposed Yosemite Slough bridge.[411]

CGS Special Publication 117A outlines the protocol for analysis and treatment of liquefaction-related hazards, including estimates of vertical settlement and lateral spreading. Design and construction of the bridge structures would incorporate appropriate engineering practices and building codes to ensure seismic stability, as required by BOE Standard Specifications Part 4 (Structures). The design of the bridge would be based on Caltrans specifications (*Bridge Design Specifications*, Section 20 of *Bridge Memos to*

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411 ENGEO, 2008.

Designers, Seismic Design Criteria), and would meet the BOE requirements. Compliance with BOE requirements would ensure potential impacts would be reduced to a less-than-significant level. Bridge bents likely would be supported on deep foundations bearing in strata below the potentially liquefiable layer. At the bridge approaches, it could be possible to employ a combination of removal and recompaction using engineered fill with the placement of geogrid beneath structures to help distribute differential settlement that might occur. Mitigation measure MM GE-4a.1 would reduce risks from liquefaction. If liquefaction estimates were such that MM GE-4a.1 would not address liquefaction and settlement-related impacts adequately, further mitigation would include one or more of the additional structural and/or ground-improvement identified in mitigation measures MM GE-5a and MM GE-4a.3. Selection of the appropriate procedures would be dependent on the bridge design, soil profile, and estimated settlement.

To reduce the impact of potential liquefaction hazards to a less-than-significant level at Yosemite Slough bridge, implementation of mitigation measure MM GE-4a.1, MM GE-4a.3, and MM GE-5a would require Applicant to comply with site-specific requirements established by DBI and other agencies that would be involved in reviewing and issuing permits for buildings and infrastructure at the Project site. Design and construction of the bridge structures would incorporate appropriate engineering practices as outlined in the site-specific geotechnical report and in Caltrans requirements to ensure seismic stability, as required by BOE Standard Specifications Part 4 (Structures). Implementation of these mitigation measures would ensure compliance with the requirements of the Building Code, Caltrans, and the BOE, and would avoid or reduce potential impacts from seismically induced ground failure a less-than-significant level.

Impact of Hunters Point Shipyard Phase II

Impact GE-5b **Implementation of the Project at HPS Phase II would not expose people or structures to substantial adverse effects caused by seismically induced ground failure such as liquefaction, lateral spreading, and settlement. (Less than Significant with Mitigation)** ***[Criterion L.a(iii)]***

Structures at the HPS Phase II site could be exposed to seismically induced ground failure, including liquefaction hazards. Liquefaction-related phenomena could include lateral spreading, ground oscillation, loss of bearing strength, vertical settlement from densification (subsidence), buoyancy effects, sand boils, and flow failures, any of which could cause damage to the proposed structures in the HPS Phase II site. Damage from liquefaction and lateral spreading generally is most severe when liquefaction occurs within 15 to 20 feet below the ground surface. The Orthents and Urban Land soils in the lowland areas of the HPS Phase II site have a very high potential for liquefaction. In particular, loosely compacted granular soil with uniform grain size and low plasticity below the groundwater table are most susceptible to liquefaction. Because these types of soil deposits generally are limited to isolated pockets and random layers in the overall soil profile, with the exception of the area in the vicinity of the southeast-facing shoreline in Parcels D and E at HPS, the unmitigated risk is considered low to moderate: it can be treated using standard engineering practices to protect improvements.[412] If more extensive zones susceptible to liquefaction were encountered during future exploration, as may be the case in the vicinity of the southeast-facing shoreline in Parcels D and E at HPS which would become open space, additional

[412] ENGEO, 2009.

mitigation measures, such as those described in MM GE-5a, above, could be necessary. The proposed foundations for structures, vaults, and pipelines would be the components most vulnerable to damage from liquefaction-related phenomena. Localized hazards may occur in open space areas, without mitigation, where habitable structures or critical utilities would not be present.

Seismically induced settlement could occur in areas underlain by compressible or poorly consolidated sediments. Stream channel deposits and recent valley alluvium generally are the most susceptible to earthquake-induced settlement. Additionally, some artificial fills are susceptible to mobilization and densification, resulting in earthquake-induced subsidence. Artificial fills exist in the lowland areas of HPS Phase II (refer to Figure III.L-1). In addition, historical shoreline maps show that artificial fill placement extends as far as 3,300 feet into the Bay.[413]

CGS Special Publication 117A outlines the protocol for analysis and treatment of liquefaction-related hazards, including estimates of vertical settlement and lateral spreading. Prediction of liquefaction-related settlement is necessarily approximate, and related hazard assessment and development of recommendations for treatment of such hazards must be performed conservatively, as recommended by CGS Special Publication 117A. A similarly conservative approach is recommended by CGS Special Publication 117A when estimating the amount of localized differential settlement likely to occur as part of the overall predicted settlement: localized differential settlements up to two-thirds of the total settlements anticipated must be assumed until more precise predictions of differential settlements can be made.

Design and construction of the structures and facilities in the HPS Phase II site would incorporate appropriate engineering practices to ensure seismic stability, some of which are explained in more detail below, as required by Chapter 16 (Structural Design) and Chapter 18 (Soils and Foundations) of the SFBC. Sections 1607 through 1614 contain the formulae, tables, and graphs by which the Project engineer would develop the structural specifications for building design and which would be used by DBI to verify the applicability of the specifications. Sections 1804 through 1812 contain similar information for the design and verification of adequate soils and foundation support for a project. Section 1802 requires the use of this information in the seismic analyses of the Project site.

Where shallow foundations would be underlain by artificial fill and the estimated settlements are small, treatment could employ a combination of removal and recompaction with the placement of geogrid beneath structures to help distribute differential settlement that might occur. Treatment for mid-rise and high-rise structures could include supporting these structures on deep foundations bearing in strata below the potentially liquefiable layer with flexible utility connections to allow some settlement beneath the buildings. Mitigation measure MM GE-4a.1 would reduce risks from liquefaction. If liquefaction estimates were such that MM GE-4a.1 would not address liquefaction and settlement-related impacts adequately, further mitigation would include one or more of the additional structural and/or ground-improvement measures identified in mitigation measure MM GE-5a, above. Selection of the appropriate mitigation would be dependent on the land use, development type, soil profile, and estimated settlement. At HPS Phase II, there could be environmental constraints limiting the potential use of certain mitigation measures because of groundwater and soil contamination.

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[413] ENGEO, 2008.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-5 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by seismically induced ground failure such as liquefaction, lateral spreading, and settlement. (Less than Significant with Mitigation)** ***[Criterion L.a(iii)]***

The potential for adverse affects caused by seismically induced ground failure such as liquefaction, lateral spreading, and settlement exists at the Project site. Mitigation measures MM GE-4a.1, MM GE-4a.2, MM GE-4a.3, and MM GE-5a would require design-level geotechnical investigations must include site-specific seismic analyses to evaluate the peak ground accelerations for design of Project structures, as required by the SFBC through review by DBI. It is anticipated that DBI would employ a third-party engineering geologist and/or civil engineer to form a GPRC. The GPRC would complete the technical review of proposed site-specific structural designs prior to building permit approval. The structural design review required by MM GE-4a.1, MM GE-4a.2, MM GE4a.3, and MM GE-5a would ensure that all necessary methods and techniques would be incorporated in the design for Project foundations and structures to reduce potential impacts from ground failure or liquefaction a less-than-significant level.

Impact GE-6: Seismically Induced Landslides

Impact of Candlestick Point

Impact GE-6a **Implementation of the Project at Candlestick Point, including the Alice Griffith Housing, would not expose people or structures to substantial adverse effects caused by seismically induced landslides. (Less than Significant with Mitigation)** ***[Criterion L.a(iv)]***

Candlestick Point

The Candlestick Point site could be exposed to landslide hazards. Earthquakes have the potential to induce landslides on both steep slopes and relatively level ground, especially in upland areas underlain by weathered bedrock or serpentinite. Potential landslide hazards in the Project site are presented in Figure III.L-3. The figure shows that the major landslide hazard area in at Candlestick Point is an approximate 2,500-foot-wide and 2,500-foot-long section on Bayview Hill around Bayview Park Road, east of Highway 101 and west of the State Park.[414]

Risks from landslides can be reduced by employing proven methods generally accepted by California Certified Engineering Geologists, to reduce these hazards. Treatment could employ a combination of removal and recompaction with the placement of geogrid[415] beneath structures and/or supporting mid- and high-rise structures on deep foundations bearing in strata below the potentially liquefiable layer with flexible utility connections to allow some settlement beneath the buildings. Selection of the appropriate procedures would be dependent on the land use, development type, and soil profile. To address the risk of landslides, the following mitigation measure shall be implemented:

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[414] CGS, 2000.

[415] Geogrids are synthetic fabrics (fiberglass, polyester, treated steel, etc.) formed into nets with openings more than ¼ inch in size to allow the fabric to interlock with surrounding soil, rock, and other below-ground-level materials and to function as reinforcement.

MM GE-6a *Site-Specific Geotechnical Investigation with Landslide Risk Analyses. Prior to issuance of building permits for the Project site:*

- *The Applicant shall submit to the San Francisco Department of Building Inspection (DBI) for review and approval a site-specific, design-level geotechnical investigation prepared by a California Certified Engineering Geologist (CEG) or California Registered Geotechnical Engineer (GE), as well as project plans prepared in compliance with the requirements of the San Francisco Building Code (SFBC), the Seismic Hazards Mapping Act, and requirements contained in CGS Special Publication 117A "Guidelines for Evaluating and Mitigating Seismic Hazards in California." In addition, all engineering practices, and analyses of structural design shall be consistent with SFBC standards to ensure seismic stability, including reduction of potential landslide hazards.*
- *DBI shall employ a third-party CEG and California Registered Professional Engineer (Civil) (PE) to form a Geotechnical Peer Review Committee (GPRC), consisting of DBI and these third-party reviewers. The GPRC shall review the site-specific geotechnical investigations and the site-specific structural, foundation, infrastructure, and other relevant plans to ensure that these plans incorporate all necessary geotechnical mitigation measures. No permits shall be issued by DBI until the GPRC has approved the geotechnical investigation and the Project plans, including the factual determinations and the proposed engineering designs and construction methods.*
- *All Project structural designs shall incorporate and conform to the requirements in the site-specific geotechnical investigations.*
- *The site-specific Project plans shall incorporate the mitigation measures contained in the approved site-specific geotechnical reports to reduce landslide hazards. The engineering design techniques to reduce landslide hazards shall include proven methods generally accepted by California Certified Engineering Geologists, subject to DBI and GPRC review and approval. The design-level geologic and geotechnical studies shall identify the presence of landslides and potentially unstable slopes and shall identify means to avoid the hazard or support the design of engineering procedures to stabilize the slopes, as required by Chapter 18 (Soils and Foundations) of the SFBC, as well as the procedures outlined in CGS Special Publication 117A. SFBC Sections 1803 through 1812 contain the formulae, tables, and graphs by which the Project engineer shall develop the Project's slope-stability specifications, including the appropriate foundation designs for structures on slopes and which would be used by DBI to verify the applicability of the specifications. If the presence of unstable slopes is identified, appropriate support and protection procedures shall be designed and implemented to maintain the stability of slopes adjacent to newly graded or re-graded access roads, work areas, and structures during and after construction, and to minimize potential for damage to structures and facilities at the Project site. These stabilization procedures, including, but not necessarily limited to, the following:*
  - *Retaining walls, rock buttresses, screw anchors, or concrete piers*
  - *Slope drainage or removal of unstable materials*
  - *Rockfall catch fences, rockfall mesh netting, or deflection walls*
  - *Setbacks at the toe of slopes*
  - *Avoidance of highly unstable areas*
- *The Project CEG or GE shall be responsible for ensuring compliance with these requirements.*

Implementation of this measure would ensure that hazards caused by the potential effects of seismically induced landslides would be less than significant.

Alice Griffith Public Housing

Given its proximity to Bayview Hill, the Alice Griffith Housing site could be exposed to the risks of landslides. New development on the Alice Griffith Public Housing site would be subject to HUD approval and Executive Order 12699. The new development would be subject to the SFBC, which would meet the requirements of the Executive Order. The San Francisco Department of Building Inspection (DBI) would be the agency responsible for implementing and enforcing appropriate seismic design and construction standards for the new development. DBI would be the City's responsible agency. Federal implementation and enforcement of the seismic safety program would be achieved through notification by the City to the building owner, architect, engineer, or contractor of the required minimum standards and requiring written acknowledgement of awareness of the requirements and of intent to comply.

HUD could require some form of compliance certification, such as the engineer's and architect's signed and stamped verification of seismic design codes, standards, and practices used in the design and construction of the buildings, or submittal of Planning Department and/or DBI permit review and inspection documents HUD. Compliance with mitigation measure MM GE-4a.2 would ensure that all appropriate documentation is submitted to the HUD, if requested. Implementation of this mitigation, as well as mitigation measure MM GE-6a, would ensure that the impact to Alice Griffith Housing from seismically induced landslides would be less than significant.

Yosemite Slough Bridge

The potential for exposure of the Yosemite Slough bridge to adverse affects caused by seismically induced landslides would be unlikely because of the low-lying topography in the vicinity of the bridge. There are no mapped seismically induced landslides areas on the Project site or near the slough. Therefore, there would be no impact on the Yosemite Slough bridge caused by seismically induced landslides.

Impact of Hunters Point Shipyard Phase II

Impact GE-6b **Implementation of the Project at HPS Phase II would not expose people or structures to substantial adverse effects caused by seismically induced landslides. (No Impact)** ***[Criterion L.a(iv)]***

As shown in Figure III.L-3, seismically induced landslides in the HPS Phase II site exist in the areas uphill from the Project boundaries where serpentinite is abundant in the shear zone. A few small landslide hazards exist in a large serpentinite block of the Hunters Point Shear Zone, between Innes Avenue and Crisp Road, northwest of HPS Phase II.[416] Slopes adjacent to the Phase II site have been rebuilt as subdrained engineered slopes during ongoing Phase I development, and any remaining areas of potential landslide hazards are outside the reach of the Phase II boundaries. Therefore, there would be no impact caused by seismically induced landslides. No mitigation is required.

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[416] CGS, Seismic Hazard Zone Map, CCSF, November 2000.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-6 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by seismically induced landslides. (Less than Significant with Mitigation)** ***[Criterion L.a(iv)]***

The potential for adverse affects due to seismically induced landslides exists at the Project site. Implementation of mitigation measures MM GE-6a and MM GE-4a.2 would ensure compliance with the SFBC and any special requirements of the HUD for compliance documentation and would reduce potential impacts from landslides a less-than-significant level.

Impact GE-7: Shoreline Instability

Impact of Candlestick Point

Impact GE-7a **Implementation of the Project at Candlestick Point would not expose people or structures to substantial adverse effects caused by shoreline instability. (Less than Significant with Mitigation)** ***[Criterion L.c]***

The shoreline along Candlestick Point consists of slopes protected by rip-rap or concrete debris and several areas of unprotected, beach-fronted slopes, exposed mudflats, and vegetation. Along the majority of the south-facing shoreline, active erosion exists. Stabilization of the Candlestick Point shoreline would include the placement of additional (rock) riprap to improve the existing rip-rap edge on most of the Northern, Eastern, and Southern shoreline; the creation of new tidal habitat in two reaches of natural edge on the Northern shoreline by laying back the slope to a flatter configuration and adding marsh plantings; and the creation of a sandy recreational beach at the mid-point of the Wind Meadow reach along the Eastern Shoreline by laying the slope back at a 6H:1V or flatter configuration. In addition to improvements to shoreline features, and to reduce the potential for a future rise in sea level that could adversely affect the Project site, the Project includes modification of the land surface through grading and the importation of fill. These modifications would raise the surface elevation by 36 inches above the 100-year base flood elevation and building finish floor elevations would be 6 inches above that (total of 42 inches above Base Flood Elevation) per mitigation measure MM HY-12a.1 to account for future sea level rise, and include an adaptive management strategy that would provide further protection for future sea level rise up to 55 inches if this should become necessary. These improvements are intended to, will be designed to, and, therefore, would improve the stability of the shoreline. Therefore, the Project would not result in exposure of structures and facilities at Candlestick Point to substantial adverse effects caused by shoreline instability. The impact would be less than significant.

Impact of Hunters Point Shipyard Phase II

Impact GE-7b **Implementation of the Project at HPS Phase II would not expose people or structures to substantial adverse effects caused by shoreline instability. (Less than Significant with Mitigation)** ***[Criterion L.c]***

The existing shoreline along the HPS Phase II site consists of rip-rap protected slopes, unprotected embankments fronted by beach, concrete submarine dry-docks, pile-supported wharves, some of which are failing, quay-walls, concrete bulkheads, timber decking and piles, and dilapidated piers. Most of the naval structures are in deteriorated condition. In some areas of the HPS Phase II shoreline, piers and wharfs have deteriorated from lack of maintenance and near-shore settlement has occurred, resulting in damage to seawall structures. Repairs of existing HPS Phase II seawall structures would involve replacement of piles and tie-back systems and replacement of eroded fill material behind seawall structures. In some locations, placement of buttress fill (below the water surface) would be needed to enhance structural stability of some seawall structures. At the submarine drydocks in Parcels B and C, the concrete bulkheads would be left in place, but disconnected from the shoreline by demolishing the near-shore sections to prevent public access. Slope stability would be improved by placing rock or sand buttresses along the quay-wall, applying high strength concrete grout to exposed surfaces and/or epoxy mix application to cracks as needed, and installing weep-holes above low tide elevation to relieve the loading from the fill to be placed along the shoreline. At the berths and wharves in Parcels B, C, D, and E, new steel sheet pile bulkheads would be constructed behind the existing corroded bulkheads; reinforced concrete beams, deck slabs and steel caisson piles would be repaired; the upper 10 to 15 feet of the concrete wall facing, as well as the timber cribbing and bank rock fill would be removed and the facing sloped back at a 2H:1V slope and protected with rock facing to provide a more natural-looking surface without any additional bayfill. The modification of the drydocks, berths, and wharves would preclude public access, thereby creating opportunities for waterbirds to roost on the retained portions of these structures. In addition to improvements to shoreline features, and to reduce the potential for a future rise in sea level that could adversely affect the Project site, the Project includes modification of the land surface through grading and the importation of fill. These modifications would raise the surface elevation by 36 inches above the 100-year base flood elevation and building finish floor elevations would be 6 inches above that (total of 42 inches above Base Flood Elevation) per mitigation measure MM HY-12a.1 to account for future sea level rise and include an adaptive management strategy that would provide further protection for future sea level rise up to 55 inches if this should become necessary. These improvements are intended to, will be designed to, and, therefore, would improve the stability of the shoreline. Therefore, the Project would not result in exposure of structures and facilities at HPS Phase II to substantial adverse effects caused by shoreline instability. The impact would be less than significant.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-7 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by shoreline instability. (Less than Significant with Mitigation) *[Criterion L.c]***

The existing shoreline exhibits active erosion and consists of areas of unprotected slopes and dilapidated naval pier and wharf structures. The Project would make numerous shoreline improvements, including additional rip-rap, creation of new beach and tidal habitat, and some grading and importation of fill at certain locations. These modifications would raise the surface elevation by 36 inches above the 100-year base flood elevation and building finish floor elevations would be 6 inches above that (total of 42 inches above Base Flood Elevation) per mitigation measure MM HY-12a.1 to account for future sea level rise and include an adaptive management strategy that would provide further protection for future sea level rise up to 55 inches if this should become necessary. These improvements are intended to, will be designed to, and, therefore, would improve the stability of the shoreline. Therefore, the Project would not result in exposure of structures and facilities at the Project site to substantial adverse effects caused by shoreline instability. The impact would be less than significant.

Impact GE-8: Landslides

Impact of Candlestick Point

Impact GE-8a **Implementation of the Project at Candlestick Point would not expose people or structures to substantial adverse effects caused by landslides. (Less than Significant with Mitigation) *[Criterion L.c]***

Candlestick Point

The Candlestick Point site, including the Alice Griffith Public Housing site, could be exposed to landslide hazards. Upland areas are most susceptible to landslides. Heavy rainfall contributes to this risk when soil becomes saturated. Site-specific geotechnical investigations would be required, and appropriate support and protection procedures would be designed and implemented for any identified unstable slopes.

Design and construction of the structures and facilities of the Project would incorporate appropriate engineering practices to ensure slope stability, as required by Chapter 16 (Structural Design) and Chapter 18 (Soils and Foundations) of the SFBC. Sections 1607 through 1614 contain the formulae, tables, and graphs by which the Project engineer would develop the structural specifications for building design and which would be used by DBI to verify the applicability of the specifications. Sections 1804 through 1812 contain similar information for the design and verification of adequate soils and foundation support for a project. Section 1802 requires the use of this information in the site-specific geotechnical analyses of the Project site. Implementation of mitigation measure MM GE-6a would ensure that risks to structures from landslides would be avoided or reduced a less-than-significant level.

Yosemite Slough Bridge

The potential for exposure of the Yosemite Slough bridge to substantial adverse affects caused by landslides would be unlikely because of the low-lying topography in the location of the bridge. Therefore, there would be no impact to the Yosemite Slough bridge caused by landslides.

Impact of Hunters Point Shipyard Phase II

Impact GE-8b **Implementation of the Project at HPS Phase II would not expose people or structures to substantial adverse effects caused by landslides. (Less than Significant with Mitigation) *[Criterion L.c]***

The potential for exposure to adverse affects caused by landslides in the HPS Phase II site exists in the upland areas of the shoreline where serpentinite is abundant in the shear zone. Heavy rainfall contributes to this risk when soil becomes saturated. Slopes adjacent to the HPS Phase II site were rebuilt as subdrained engineered slopes during ongoing Phase I development. Any remaining areas of mapped potential landslide hazards are outside the HPS Phase II boundaries.

If the presence of unstable slopes were identified during preparation of the site-specific geotechnical investigations, appropriate support and protection procedures would be designed and implemented, as required by mitigation measure MM GE-6a to maintain the stability of slopes adjacent to newly graded or re-graded access roads, work areas, and structures during and after construction, and to minimize potential for damage to structures and facilities in the HPS Phase II site. Sections 1803 through 1812 contain the formulae, tables, and graphs by which the Project engineer would develop the Project's slope-stability specifications, including the appropriate foundation designs for structures on slopes and which would be used by DBI to verify the applicability of the specifications. Implementation of mitigation measure MM GE-6a would ensure that risks to structures in HPS Phase II from landslides would be avoided or reduced a less-than-significant level.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-8 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by landslides. (Less than Significant with Mitigation)** ***[Criterion L.c]***

The potential for adverse affects caused by landslides exists at the Project site. Site-specific, design-level geotechnical investigations would be required to be submitted to DBI in connection with permit applications for individual Project elements, as specified in mitigation measure MM GE-6a. The site-specific analyses must assess these conditions and prescribe the requirements for foundations on slopes in accordance with the SFBC. All geotechnical investigations and permits must be approved by DBI. With implementation of this mitigation, the Project's impact with regard to landslides would be less than significant.

Impact GE-9: Soil Hazards—Settlement

Impact of Candlestick Point

Impact GE-9a **Implementation of the Project at Candlestick Point, including Alice Griffith Housing and the Yosemite Slough bridge, would not expose people or structures to substantial adverse effects caused by damage from settlement. (Less than Significant with Mitigation)** ***[Criterion L.c]***

Candlestick Point

The Candlestick Point site could be exposed to settlement hazards. Unstable subsurface materials, such as artificial fill or soft Bay Mud deposits, are abundant in the Candlestick Point site (refer to Figure III.L-1). Slight to severe damage to structures could be caused by the settlement of poorly compacted fill or consolidation of very soft natural deposits. Extensive Young Bay Mud deposits are predominant in the eastern half of the site toward the shoreline. The rate of settlement of the Young Bay Mud from the load of the artificial fill is now very small, but further increase in loads, whether resulting from placement of new fill or the construction of buildings, would initiate a new cycle of consolidation settlement. The Young Bay Mud is underlain by firmer soils and bedrock that do not pose settlement hazards.

Site grades would need to be raised over most of the Project site in order to reach minimum final grades and to compensate for settlement caused by densification during ground improvements and Young Bay Mud consolidation and secondary compression settlement caused by fill and building loads. Settlement in response to new loads would occur at rates similar to those that have occurred historically. Based on past observations, settlement caused by new loads could continue for a period of 5 to 50 years (or more) unless mitigated by surcharging, as explained below.

Where the site is underlain by an extensive zone of Young Bay Mud, consolidation settlements could be accelerated by use of surcharging, thereby allowing much of the future settlement to occur prior to construction of new improvements. Surcharging involves adding excess fill, for a limited period of time, above the elevation that is needed to achieve the intended final site grades. Prefabricated vertical drains (wick drains) can be used to decrease surcharge durations by increasing lateral soil drainage and allowing settlement that normally would occur over years to occur in months. Wick drains probably would be needed in most areas of the Project site because the development schedule probably would not allow for longer surcharge durations.

Surcharging can be used to reduce the settlements that result from net building loads. If the net building loads do not increase the stresses in the clay soils beyond those to which they have been consolidated previously under a surcharge load, the resulting settlements would be much smaller than they would be otherwise. When a soil has been loaded previously to a greater stress than the current stress, it is said to be over-consolidated. Over-consolidation reduces secondary compression. Consequently, surcharging offers three benefits: (1) the settlement that results from placement of new fill would be expedited; (2) the primary settlement caused by new building loads would be reduced; and (3) long-term settlements caused by secondary compression would be reduced.

Further secondary compression would occur following primary consolidation. Design-level studies must be conducted to better estimate the expected amounts of secondary compression and to evaluate the effectiveness of surcharging to reduce secondary compression.

Design and construction of structures and facilities in the Candlestick Point site would incorporate appropriate engineering practices, as required by Chapter 16 (Structural Design) and Chapter 18 (Soils and Foundations) of the SFBC. Sections 1607 through 1614 contain the formulae, tables, and graphs by which the Project engineer would develop the structural specifications for building design and which would be used by DBI to verify the applicability of the specifications. Sections 1804 through 1812 contain similar information for the design and verification of adequate soils and foundation support for a project. Section 1802 requires the use of this information in the soils analyses of the Project site.

Where shallow foundations would be underlain by poorly compacted artificial fill that may be subject to static settlement, it could be possible to employ a combination of removal and recompaction with the placement of geogrid beneath structures to help distribute differential settlement that might occur. Mid-rise and high-rise structures probably would be founded on deep foundations bearing in strata below the poorly compacted fill and soft Bay Mud deposits with flexible utility connections to allow some settlement beneath the buildings. If settlement estimates were such that the previously described treatments would not suffice, procedures outlined in mitigation measure MM GE-5a would avoid this impact or reduce it a less-than-significant level.

Selection of the appropriate ground improvement techniques would be dependent on the land use, development type, soil profile, and estimated settlement, as outlined previously in Table III.L-7 and

Table III.L-8.[417] Implementation of mitigation measure MM GE-5a would ensure Project compliance with the requirements of the SFBC and would ensure that potential impacts from unstable subsurface soils would be less than significant.

Alice Griffith Public Housing

The Alice Griffith Public Housing site could be exposed to settlement hazards. New development on the Alice Griffith Public Housing site would be subject to HUD approval and Executive Order 12699. The new development would be subject to the SFBC, which would meet the requirements of the Executive Order. The San Francisco Department of Building Inspection (DBI) would be the agency responsible for implementing and enforcing appropriate seismic design and construction standards for the new development. DBI would be the City's responsible agency. Federal implementation and enforcement of the seismic safety program would be achieved through notification by the City to the building owner, architect, engineer, or contractor of the required minimum standards and requiring written acknowledgement of awareness of the requirements and of intent to comply.

HUD could require some form of compliance certification, such as the engineer's and architect's signed and stamped verification of seismic design codes, standards, and practices used in the design and construction of the buildings, or submittal of Planning Department and/or DBI permit review and inspection documents to HUD. Compliance with mitigation measure MM GE-4a.2 would ensure that all appropriate documentation is submitted to HUD, if requested. Implementation of this mitigation and MM GE-5a would ensure that the impact to Alice Griffith Housing from settlement would be less than significant.

Yosemite Slough Bridge

The Yosemite Slough bridge could be exposed to settlement hazards. Unstable subsurface materials, such as artificial fill or soft Bay Mud deposits are abundant in the Candlestick Point site (refer to Figure III.L-1). Slight to severe damage to structures could occur caused by the settlement of poorly compacted fill or consolidation of very soft natural deposits.

Design and construction of the bridge would incorporate appropriate engineering practices, as required by BOE Standard Specifications Part 4 (Structures) and Part 7 (Excavation, Backfill, and Embankment) and would be based on Caltrans specifications. Implementation of mitigation measure MM GE-4a.3, would ensure that the design of the bridge would be based on Caltrans specifications (*Bridge Design Specifications*, Sections 3, 4, 5, and 23 of *Bridge Memos to Designers*), and would meet the BOE requirements. Implementation of mitigation measures MM GE-5a and MM GE-4a.3 would ensure the potential damage from unstable subsurface soils would be less than significant.

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[417] ENGEO, 2009.

Impact of Hunters Point Shipyard Phase II

Impact GE-9b **Implementation of the Project at HPS Phase II would not expose people or structures to substantial adverse effects caused by damage from settlement. (Less than Significant with Mitigation)** ***[Criterion L.c]***

The potential for exposure to adverse affects caused by settlement in the HPS Phase II site exists. Poorly consolidated artificial fill deposits are abundant in the HPS Phase II site. Slight to severe damage to structures could occur caused by the settlement of poorly compacted fill or consolidation of very soft natural deposits. Extensive Young Bay Mud deposits are predominant in Parcels D and E. The rate of settlement of the Young Bay Mud from the load of the artificial fill is now very small, but any increase in loads, whether resulting from placement of new fill or the construction of buildings, would initiate a new cycle of consolidation settlement. The Young Bay Mud is underlain by firmer soils and bedrock that are not subject to settlement hazards. Where the site is underlain by Young Bay Mud subject to consolidation settlements under new fill loads, the planned development primarily includes open space and parking areas. These areas generally could tolerate a greater amount of consolidation settlement without serious risk because there would be no major structures or utilities to be affected. Gravity utilities can be designed to accommodate a certain amount of planned settlement.

Design and construction of structures and facilities in the HPS Phase II site would incorporate appropriate engineering practices, as required by Chapter 16 (Structural Design) and Chapter 18 (Soils and Foundations) of the SFBC. Sections 1607 through 1614 contain the formulae, tables, and graphs by which the Project engineer would develop the structural specifications for building design and which would be used by DBI to verify the applicability of the specifications. Sections 1804 through 1812 contain similar information for the design and verification of adequate soils and foundation support for a project. Section 1802 requires the use of this information in the soils analyses of the Project site.

Where shallow foundations would be underlain by poorly compacted artificial fill that may be subject to static settlement, it could be possible to employ a combination of removal and recompaction with the placement of geogrid beneath structures to help distribute differential settlement that might occur. Mid-rise and high-rise structures probably would be founded on deep foundations bearing in strata below the poorly compacted fill and soft Bay Mud deposits with flexible utility connections to allow some settlement beneath the buildings. If settlement estimates were such that the previously described treatments would not suffice, procedures outlined in mitigation measure MM GE-5a would avoid this impact or reduce it a less-than-significant level.

Selection of the appropriate ground improvement techniques would be dependent on the land use, development type, soil profile, and estimated settlement, as outlined previously in Table III.L-7 and Table III.L-8.[418] Implementation of mitigation measure MM GE-5a would ensure Project compliance with the requirements of the SFBC and would ensure that potential impacts from unstable subsurface soils would be less than significant.

[418] ENGEO, 2009.

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-9 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by damage from settlement. (Less than Significant with Mitigation) *[Criterion L.c]***

The potential for adverse affects due to settlement exists at the Project site. However, design-level geotechnical investigations must evaluate the structural design, as required by the SFBC through review by DBI. Implementation of mitigation measures MM GE-5a, MM GE-4a.2, and MM GE-4a.3 would ensure compliance with the provisions of the SFBC and would reduce the impact a less-than-significant level.

Impact GE-10: Soil Hazard—Expansive Soils

Impact of Candlestick Point

Impact GE-10a **Implementation of the Project at Candlestick Point, including Alice Griffith Housing and the Yosemite Slough bridge, would not expose people or structures to substantial adverse effects caused by expansive soils. (Less than Significant with Mitigation) *[Criterion L.d]***

Candlestick Point

The Candlestick Point site could be exposed to expansive soil hazards, which can cause damage to structures, foundations and buried utilities and can increase required maintenance. Expansion and contraction of soils in response to changes in moisture content can cause differential and cyclical movements that can cause damage and/or distress to structures and equipment.

Soils at the Candlestick Point site are predominantly Orthents, cut and fill, Urban land and Urban land Orthents, with some Barnabe-Candlestick complex soils in the upland areas. These soils have various levels of risk for expansion.[419] Impacts related to expansive soils would be avoided or reduced a less-than-significant level for structures and facilities in the Candlestick Point site through the implementation of standard engineering and geotechnical practices for the identification and remediation of expansive soils, as required by Chapter 18 (Soils and Foundations) of the SFBC.

To avoid or reduce the potential impact from expansive soils at the Candlestick Point site, the following mitigation shall be implemented:

MM GE.10a *Site-Specific Geotechnical Investigation with Expansive Soils Analyses.* *Prior to issuance of building permits for the Project site:*

- *The Applicant shall submit to the San Francisco Department of Building Inspection (DBI) for review and approval a site-specific, design-level geotechnical investigation prepared by a California Certified Engineering Geologist (CEG) or California Registered Geotechnical Engineer (GE), as well as project plans prepared in compliance with the requirements of the San Francisco Building Code (SFBC). In addition, all engineering practices, and analyses of structural design shall be consistent with SFBC standards to ensure soils stability, including reduction of potential soil expansion hazards.*

[419] NRCS (accessed April 2008).

- *DBI shall employ a third-party CEG and California Registered Professional Engineer (Civil) (PE) to form a Geotechnical Peer Review Committee (GPRC), consisting of DBI and these third-party reviewers. The GPRC shall review the site-specific geotechnical investigations and the site-specific structural, foundation, infrastructure, and other relevant plans to ensure that these plans incorporate all necessary geotechnical mitigation measures. No permits shall be issued by DBI until the GPRC has approved the geotechnical investigation and the Project plans, including the factual determinations and the proposed engineering designs and construction methods.*
- *All Project structural designs shall incorporate and conform to the requirements in the site-specific geotechnical investigations.*
- *The site-specific Project plans shall incorporate the mitigation measures contained in the approved site-specific geotechnical reports to reduce expansive soils hazards. The engineering design techniques to reduce expansive soils hazards shall include proven methods generally accepted by California Certified Engineering Geologists, subject to DBI and GPRC review and approval. The design-level geologic and geotechnical studies shall identify the presence of expansive soils and potentially unstable soils and shall identify means to avoid the hazard or support the design of engineering procedures to stabilize the soils, as required by Chapter 18 (Soils and Foundations) of the SFBC. SFBC Sections 1803 through 1812 contain the formulae, tables, and graphs by which the Project engineer shall develop the Project's soil-stability specifications, including the appropriate foundation designs for structures on expansive soils and which would be used by DBI to verify the applicability of the specifications. If the presence of expansive soils is identified, appropriate support and protection procedures shall be designed and implemented to maintain the stability of soils adjacent to newly graded or re-graded access roads, work areas, and structures during and after construction, and to minimize potential for damage to structures and facilities at the Project site.*
- *The Project CEG or GE shall be responsible for ensuring compliance with these requirements.*

Implementation of this measure would ensure that hazards caused by the potential effects of expansive soils would be less than significant.

Alice Griffith Public Housing

The Alice Griffith Public Housing site could be exposed to hazards from expansive soils. New development on the Alice Griffith Public Housing site would be subject to HUD approval and Executive Order 12699. The new development would be subject to the SFBC, which would meet the requirements of the Executive Order. The San Francisco Department of Building Inspection (DBI) would be the agency responsible for implementing and enforcing appropriate seismic design and construction standards for the new development. DBI would be the City's responsible agency. Federal implementation and enforcement of the seismic safety program would be achieved through notification by the City to the building owner, architect, engineer, or contractor of the required minimum standards and requiring written acknowledgement of awareness of the requirements and of intent to comply.

HUD could require some form of compliance certification, such as the engineer's and architect's signed and stamped verification of seismic design codes, standards, and practices used in the design and construction of the buildings, or submittal of Planning Department and/or DBI permit review and inspection documents to HUD. Compliance with mitigation measure MM GE-4a.2 would ensure that all appropriate documentation is submitted to HUD, if requested. Implementation of this mitigation, as well as MM GE-10a, would ensure that the impact to Alice Griffith Housing from expansive soils would be less than significant.

Yosemite Slough Bridge

The Yosemite Slough bridge could be exposed to expansive soil hazards, which can cause damage to structures, foundations and buried utilities and can increase required maintenance. Expansion and contraction of soils in response to changes in moisture content can cause differential and cyclical movements that can cause damage and/or distress to structures and equipment.

Soils at Candlestick Point are predominantly Orthents, cut and fill, Urban Land and Urban Land Orthents. These soils have various levels of risk for expansion.[420] Impacts related to expansive soils would be rendered less than significant for the bridge through the implementation of standard engineering and geotechnical practices for the identification and remediation of expansive soils, as required by BOE Standard Specifications Part 7 (Excavation, Backfill, and Embankment). The design of the bridge would be based on Caltrans specifications, as required by mitigation measure MM GE-4a.3. Implementation of mitigation measures MM GE-10a and MM GE-4a.3 would reduce the impact from expansive soils on the Yosemite Slough bridge a less-than-significant level.

Impact of Hunters Point Shipyard Phase II

Impact GE-10b **Implementation of the Project at HPS Phase II would not expose people or structures to substantial adverse effects caused by expansive soils. (Less than Significant with Mitigation)** ***[Criterion L.d]***

The HPS Phase II site has the potential to expose Project improvements to adverse effects caused by expansive soils. Expansive soils can cause damage to structures, foundations and buried utilities and can increase required maintenance. Expansion and contraction of soils in response to changes in moisture content can cause differential and cyclical movements that can cause damage and/or distress to structures and equipment.

Soils at HPS Phase II are predominantly Orthents, cut and fill, Urban land and Urban land Orthents, with some Barnabe-Candlestick complex soils in the upland areas. These soils have various levels of risk for expansion.[421] Impacts related to expansive soils would be avoided or reduced a less-than-significant level for structures and facilities in the HPS Phase II site through the implementation of standard engineering and geotechnical practices for the identification and remediation of expansive soils, as required by Chapter 18 (Soils and Foundations) of the SFBC. Implementation of mitigation measure MM GE-10a would avoid or reduce the impact to structures and facilities at HPS Phase II from expansive soils a less-than-significant level by ensuring compliance with the SFBC.

[420] NRCS (accessed April 2008).
[421] NRCS (accessed April 2008).

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-10 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by expansive soils. (Less than Significant with Mitigation)** ***[Criterion L.d]***

The potential for adverse effects caused by expansive soils exists at the Project site. Design-level geotechnical investigations must evaluate the structural design, as required by the SFBC through review by DBI. Implementation of mitigation measures MM GE-10a, MM GE-4a.1, MM GE-4a.2, and MM GE-4a.3 would avoid or reduce the impact to Project structures from expansive soils a less-than-significant level.

Impact GE-11; Soil Hazard—Corrosive Soils

Impact of Candlestick Point

Impact GE-11a **Implementation of the Project at Candlestick Point, including Alice Griffith Housing and the Yosemite Slough bridge, would not expose people or structures to substantial adverse effects caused by corrosive soils. (Less than Significant with Mitigation)** ***[Criterion L.c]***

Candlestick Point

Structures at Candlestick Point could be exposed to corrosive soil hazards. Problematic soils, including corrosive minerals and corrosive saline groundwater, can cause damage to structures, foundations and buried utilities, and can increase maintenance needs. Depending on the degree of corrosivity of subsurface soils, concrete and reinforcing steel in concrete structures and bare-metal structures exposed to these soils can deteriorate, eventually leading to structural failure.

Soils at Candlestick Point are predominantly Orthents, cut and fill, Urban land and Urban land Orthents, with some Barnabe-Candlestick complex soils in the upland areas. These soils have a moderate risk of soil corrosivity to concrete and steel.[422] Impacts related to corrosive soils would be rendered less than significant for structures and facilities in the Candlestick Point site through the implementation of standard engineering and geotechnical practices for the identification and remediation of corrosive soils, as required by Chapter 18 (Soils and Foundations) of the SFBC.

MM GE-11a *Site-Specific Geotechnical Investigation with Corrosive Soils Analyses. Prior to issuance of building permits for the Project site:*

- *The Applicant shall submit to the San Francisco Department of Building Inspection (DBI) for review and approval a site-specific, design-level geotechnical investigation prepared by a California Certified Engineering Geologist (CEG) or California Registered Geotechnical Engineer (GE), as well as project plans prepared in compliance with the requirements of the San Francisco Building Code (SFBC). In addition, all engineering practices, and analyses of structural design shall be consistent with SFBC standards to ensure soils stability, including reduction of potential hazards from corrosive soils.*

422 NRCS (accessed April 2008).

- *DBI shall employ a third-party CEG and California Registered Professional Engineer (Civil) (PE) to form a Geotechnical Peer Review Committee (GPRC), consisting of DBI and these third-party reviewers. The GPRC shall review the site-specific geotechnical investigations and the site-specific structural, foundation, infrastructure, and other relevant plans to ensure that these plans incorporate all necessary geotechnical mitigation measures. No permits shall be issued by DBI until the GPRC has approved the geotechnical investigation and the Project plans, including the factual determinations and the proposed engineering designs and construction methods.*
- *All Project structural designs shall incorporate and conform to the requirements in the site-specific geotechnical investigations.*
- *The site-specific Project plans shall incorporate the mitigation measures contained in the approved site-specific geotechnical reports to reduce potential hazards from corrosive soils. The engineering design techniques to reduce corrosive soils hazards shall include proven methods generally accepted by California Certified Engineering Geologists, subject to DBI and GPRC review and approval. The design-level geologic and geotechnical studies shall identify the presence of corrosive soils and shall identify means to avoid the hazard, as required by Chapter 18 (Soils and Foundations) of the SFBC. SFBC Sections 1803 through 1812 contain the formulae, tables, and graphs by which the Project engineer shall develop the Project's structural design specifications, including the appropriate foundation designs for structures on corrosive soils and which would be used by DBI to verify the applicability of the specifications. If the presence of corrosive soils is identified, appropriate protection procedures shall be designed and implemented to minimize potential for damage from corrosive soils to structures and facilities at the Project site.*
- *The Project CEG or GE shall be responsible for ensuring compliance with these requirements.*

Implementation of mitigation measure MM GE-11a would ensure compliance with the requirements of the SFBC and would avoid or reduce the potential for damage from corrosive soils a less-than-significant level.

Alice Griffith Public Housing

New development at the Alice Griffith Public Housing site could be exposed to corrosive soil hazards. New development on the Alice Griffith Public Housing site would be subject to HUD approval and Executive Order 12699. The new development would be subject to the SFBC, which would meet the requirements of the Executive Order. The San Francisco Department of Building Inspection (DBI) would be the agency responsible for implementing and enforcing appropriate seismic design and construction standards for the new development. DBI would be the City's responsible agency. Federal implementation and enforcement of the seismic safety program would be achieved through notification by the City to the building owner, architect, engineer, or contractor of the required minimum standards and requiring written acknowledgement of awareness of the requirements and of intent to comply.

As the HUD lead agency, the Mayor's Office of Housing could require some form of compliance certification, such as the engineer's and architect's signed and stamped verification of seismic design codes, standards, and practices used in the design and construction of the buildings, or submittal of Planning Department and/or DBI permit review and inspection documents to the Mayor's Office of Housing. Compliance with mitigation measure MM GE-4a.2 would ensure that all appropriate documentation is submitted to the Mayor's Office of Housing, if requested. Implementation of this mitigation and MM GE-11a would ensure that the impact to Alice Griffith Housing from corrosive soils would be less than significant.

Yosemite Slough Bridge

The Yosemite Slough bridge could be exposed to corrosive soil hazards. Problematic soils, including corrosive minerals and corrosive saline groundwater, can cause damage to structures, foundations and buried utilities and can increase required maintenance. Depending on the degree of corrosivity of subsurface soils, concrete and reinforcing steel in concrete structures and bare-metal structures exposed to these soils can deteriorate, eventually leading to structural failure.

Soils in the proposed Candlestick Point site are predominantly Orthents, cut and fill, Urban land and Urban land Orthents. These soils have a moderate risk of soil corrosivity to concrete and steel.[423] Impacts related to corrosive soils would be rendered less than significant for the bridge through the implementation of standard engineering and geotechnical practices for the identification and remediation of corrosive soils, as required by BOE Standard Specifications Part 7 (Excavation, Backfill, and Embankment). The design of the bridge would be based on Caltrans specifications, as required by mitigation measure MM GE-4a.3. Implementation of mitigation measures MM GE-11a and MM GE-4a.3 would reduce the impact from corrosive soils on the Yosemite Slough bridge a less-than-significant level.

Impact of Hunters Point Shipyard Phase II

Impact GE-11b **Implementation of the Project at HPS Phase II would not expose people or structures to substantial adverse effects caused by corrosive soils. (Less than Significant with Mitigation)** ***[Criterion L.c]***

Structures at HPS Phase II could be exposed to corrosive soil hazards. Problematic soils, including corrosive minerals and corrosive saline groundwater, can cause damage to structures, foundations and buried utilities and can increase required maintenance. Depending on the degree of corrosivity of subsurface soils, concrete and reinforcing steel in concrete structures and bare-metal structures exposed to these soils can deteriorate, eventually leading to structural failure.

Soils in the HPS Phase II site are predominantly Orthents, cut and fill, Urban Land and Urban Land Orthents, with some Barnabe-Candlestick complex soils in the upland areas. These soils have a moderate risk of soil corrosivity to concrete and steel.[424] Impacts related to corrosive soils would be rendered less than significant for structures and facilities in the HPS Phase II site through the implementation of standard engineering and geotechnical practices for the identification and remediation of corrosive soils, as required by Chapter 18 (Soils and Foundations) of the SFBC. Implementation of mitigation measure MM GE-11a would ensure compliance with the requirements of the SFBC and would avoid or reduce the impact on structures and facilities in HPS Phase II a less-than-significant level.

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423 NRCS (accessed April 2008).
424 NRCS (accessed April 2008).

Combined Impact of Candlestick Point and Hunters Point Shipyard Phase II

Impact GE-11 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by corrosive soils. (Less than Significant with Mitigation) *[Criterion L.c]***

The potential for adverse effects caused by corrosive soils exists at the Project site. Design-level geotechnical investigations must evaluate the structural design, as required by the SFBC through review by DBI. Implementation of mitigation measures MM GE-11a, MM GE-4a.2, and MM GE-4a.3 would avoid or reduce the impact to Project structures from corrosive soils a less-than-significant level.

Impact GE-12: Surface Fault Rupture

Impact GE-12 **Implementation of the Project would not expose people or structures to substantial adverse effects caused by surface fault rupture. (No Impact) *[Criterion L.a(i)]***

Fault rupture hazards in the Project site are unlikely. Ground rupture occurs most commonly along preexisting faults, which are zones of weakness, but can occur slowly as fault creep or more suddenly as the result of major stress release along the fault plane (earthquakes). Where rupture occurs near buildings or other facilities, there is a potential for injury to persons and significant economic loss because of structural damage.

The Hunters Point shear zone, north of Candlestick Point, is considered inactive. No known active faults cross the Project site, making hazards from fault rupture unlikely.[425] Therefore, there would be no impact caused by surface fault rupture. No mitigation is required.

Impact GE-13: Septic Tanks or Alternative Wastewater Disposal Systems

Impact GE-13 **Implementation of the Project would not result in the use of soils incapable of adequately supporting septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater. (No Impact) *[Criterion L.e]***

The Project would be connected to the City's existing wastewater treatment and disposal system. Development of the Project would not involve the use of septic tanks or alternative wastewater disposal systems. No impact would occur. No mitigation is required.

Impact GE-14: Unique Geologic Features

Impact GE-14 **Implementation of the Project would not result in a substantial change of topography or destruction of unique geologic features. (No Impact) *[Criterion L.f]***

Most of the Project site is relatively flat, with elevations generally ranging from approximately 0 feet to 20 feet SFCD, because the site consists of fill areas or low lying shoreline areas. Maximum ground surface elevation near the Project site is on Bayview Hill (west of Candlestick Point), which reaches an

[425] GTC, 2005.

elevation of approximately 400 feet SFCD. The Jamestown Avenue area of Candlestick Point is at about 75 feet in elevation. There are no unique geologic features, such as prominent hills, exceptional rock outcroppings, or similar features.

The Project would alter surface topography for new development, including about three feet of fill in some areas. The HPS Phase II shoreline would be altered with new seawalls or other shoreline protection. The Project would not substantially change site topography or affect unique geologic features, and would have no impact on such features. No mitigation is required.

Cumulative Impacts

The geographic context for the analysis of cumulative impacts resulting from geologic hazards is generally site-specific, because each Project site has a different set of geologic considerations that would be subject to specific site-development and construction standards. Soil and geologic conditions are site-specific and there is little, if any, cumulative relationship between the Project and other areas in the City. As such, the potential for cumulative impacts to occur is geographically limited for many geology and soils impact analyses; however, variations from a site-specific cumulative context are identified, where they occur.

In common with the rest of California, San Francisco is in a seismically active area and is subject to risk of damage to persons and property as a result of seismic groundshaking. Given the risk from seismic activity associated with all development in seismically active areas, this impact would be significant if it were not mitigated by building code requirements. Building in California is strictly regulated by the CBC, as adopted and enforces by each jurisdiction, to reduce risks from seismic events to the maximum extent possible. Impacts associated with potential geologic hazards related to fault rupture would occur at individual building sites and would be related to the site's location relative to fault zones, the composition of the site's soil, and the structural strength of a particular building. The Project site is not in an Alquist-Priolo fault zone, and no known active faults cross the Project site, making hazards from fault rupture unlikely. The Hunters Point Shear Zone, which crosses the HPS Phase II site in the northwest, is considered inactive, as noted above.

Because the City uses and enforces the requirements of the CBC as part of the SFBC, new buildings and facilities in the City are required to be sited and designed in accordance with the most current geotechnical and seismic guidelines and recommendations. In addition, the Project would implement all necessary design features recommended by the site-specific geotechnical studies to reduce the risk from liquefaction, settlement, lateral spreading, expansive or corrosive soils, and landslides. With implementation of the previously noted mitigation measures and adherence to the SFBC and related plans, regulations, and design and engineering guidelines and practices, the Project would not make a cumulatively considerable contribution to any potential cumulative impact arising from fault rupture. The Project's cumulative impact would be less than significant.

Impacts associated with potential geologic hazards related to groundshaking and seismic-related ground failure would occur at individual building sites. These effects are site-specific, and impacts would not be compounded by additional development. New buildings and facilities in the City are required to be sited and designed in accordance with appropriate geotechnical and seismic guidelines and recommendations, consistent with the requirements of the SFBC. Therefore, although there is risk from seismic events inherent in all development in seismically active areas in the state of California, compliance with applicable regulations reduces this risk. The Project would comply with the SFBC, San Francisco Department of Public Works regulations, the California *Seismic Hazards Mapping Act*, and other agency specifications for new structures. These regulations have been formulated to preserve public safety. The Yosemite Slough bridge design and construction would be required to meet state and local regulations related to protecting against geologic and seismic hazards, including Caltrans *Bridge Design Specifications*, *Bridge Memo to Designers*, *Bridge Design Practice Manual*, and *Bridge Design Aids Manual*. As a result of implementation of these standards, the Project's potential impacts from geological hazards would be avoided and/or reduced a less-than-significant level.

Because the project would comply with the provisions of all applicable codes and regulations and because its building plans would conform to the most current seismic safety design guidelines, the Project would not make a cumulatively considerable contribution to any potential cumulative impacts arising out of strong seismic groundshaking, and the cumulative impact would be less than significant.

The impacts from erosion and loss of topsoil from site development and operation can be cumulative in effect within a watershed. Based on historic drainage patterns, watersheds in the Project vicinity that would form the geographic context for an analysis of erosion impacts are the Islais Creek Basin and the Yosemite Basin.[426] Development throughout the City is subject to runoff, erosion, and sedimentation prevention requirements, including the applicable provisions of Phases I and II of the NPDES permit process and implementation of fugitive dust control measures in accordance with BAAQMD Rule 403. Construction activities would be required to comply with all code requirements, including surface soil erosion control. Any erosion potential would be reduced or avoided through compliance with applicable codes and mitigation measures. Because all development in the watershed would be subject to these provisions, cumulative impacts related to erosion or the loss of topsoil would not be significant.

Implementation of the Project would modify soil and topographic conditions at the site to accommodate development and provide a stable and safe physical environment. The construction phase of the Project could expose soil to erosion by wind or water. Development of other cumulative projects in the vicinity of the Project site could expose soil surfaces and further alter soil conditions. To minimize the potential for cumulative impacts that could cause erosion, the Project and cumulative projects in the adjacent area are required to conform to the provisions of applicable federal, state, County, and City laws and ordinances. Because the Project would be in compliance with applicable BAAQMD and NPDES permit requirements, and would implement and maintain the BMPs required by the Project's SWPPP, the Project would not make a cumulatively considerable contribution to any potential cumulative impact related to soil erosion or loss of topsoil, and the cumulative impact of the Project would be less than significant.

As with seismic groundshaking impacts, the geographic context for analysis of impacts on development from unstable soil conditions, including landslides, liquefaction, subsidence, collapse, or expansive or corrosive soils generally is site-specific. Because all development is required to undergo analysis of

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[426] San Francisco Public Utilities Commission, *Urban Watershed Planning Charrette, Bayside Basins Summary Report*, May 2008.

geological and soil conditions applicable to the specific individual project, and because restrictions on development would be applied in the event that geological or soil conditions pose a risk to safety, it is anticipated that cumulative impacts from development on soils subject to instability, subsidence, collapse, and/or expansive soil would be less than significant. Because the Project would implement the identified mitigation measures, the Project would not make a cumulatively considerable contribution to any potential cumulative impacts, and the cumulative impact of the Project would be less than significant.

Cumulative projects, depending on where they are located, could substantially change site topography and/or unique geologic or physical features at their respective sites. In certain situations this could be a potentially significant impact, particularly if a large number of cumulative projects were to change topography or unique geologic features. Nothing in the Project site circumstance or the surrounding area suggests that such a cumulative impact could occur. Most of the Project site is relatively flat, with elevations ranging from approximately 0 feet to 20 feet SFCD, because the site consists of fill areas or low lying shoreline areas. Maximum ground surface elevation near the Project site is on Bayview Hill (west of Candlestick Point), which reaches an elevation of approximately 400 feet SFCD. The Jamestown Avenue area of Candlestick Point is at about 75 feet SFCD in elevation. There are no unique geologic features, such as prominent hills, exceptional rock outcroppings, or similar features. The Project would alter surface topography for new development, including about three feet of fill in some areas. The HPS Phase II shoreline would be altered with new seawalls or other shoreline protection. Overall, the Project would not substantially change site topography or affect unique geologic features, and would have no impact on such features. Therefore, there is no cumulative impact related to topography and unique geographic features.