V. ENVIRONMENTAL IMPACT ANALYSIS
E. GEOLOGY AND SOILS

INTRODUCTION

This section describes the proposed project's geologic environment and potential impacts based on a site reconnaissance, published and unpublished geologic reports and maps, and site-specific technical reports. This section evaluates information from the following site-specific technical reports, which are included by reference or available in Volume II (Technical Appendices) of this DEIR:

- *Phase I Environmental Site Assessment 37-Acre Haystack Landing Property, Petaluma, California*, prepared for the Dutra Group, Project No. 659.009, Fugro West, Inc., March 30, 2004, updated February 2006;
- *Geotechnical Investigation Dutra Materials - Haystack Landing Asphalt and Recycling Facility, Petaluma, California*, prepared for the Dutra Materials, Project No. 209.02, Miller Pacific Engineering Group, September 3, 2004a;
- *Geotechnical Investigation, Haystack Landing Wetlands Restoration, Petaluma, California*, prepared for Ms. Lucy Macmillan, Project No. 1139.01, Miller Pacific Engineering Group, October 1, 2004b; and
- *Wetland Mitigation and Monitoring Plan - Haystack Landing Wetland Mitigation Project, Petaluma, California*, U.S. Army Corp of Engineers, April 2006.

ENVIRONMENTAL SETTING

This section assesses potential impacts from seismically-induced fault rupture, strong ground shaking, liquefaction, slope failure, lateral slope deformation, differential settlement and unstable or expansive soils. Mitigation measures for the identified significant impacts are provided, as appropriate.

Geologic and Seismic Conditions

The geology, topography, and soils of the project site and vicinity are described below.

Geology

The project site is located within the Coast Ranges Geomorphic Province, a relatively geologically young and seismically active region on the western margin of the North American plate. In general, the Coast Ranges are composed of sedimentary bedrock with layers of recent alluvium filling the intervening valleys.[1] Specifically, the project site is near the western edge of the floor of the Petaluma Valley.[2] The near-surface geology of the eastern two-thirds of the project site is mapped by the California Geologic Survey as Holocene (last 11,000 years) Bay Mud with the remainder being mapped primarily as Franciscan Complex bedrock (more than 65-190 million years old).[3]

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[1] *California Geographic Survey (CGS), 2002, California Geomorphic Provinces, Note 36.*

[2] *Fugro West, Inc.,. 2004, Phase I Environmental Site Assessment 37-Acre Haystack Landing Property, Petaluma California, Prepared for the Dutra Group, Project No. 659.009, March 30.*

[3] *Wagner, D.L., et. al., 2002, Geologic Map of the Petaluma Quadrangle, California Geologic Survey.*

Topography

The approximately 37-acre project site is located on nearly flat land and is surrounded by the rising terrain of the Coast Range to the west and the Petaluma River immediately to the east. The existing ground surface elevation of the project site varies, with a high of about 32 feet above mean sea level (msl) at a small hill at the northernmost portion of the site. The rest of the project site slopes gently to the south-southeast with elevations from about 15 feet msl to about five feet msl.[4] Several areas of the site are shallow hollows that retain water, or are jurisdictional seasonal wetlands[5] that are hydrologically connected to the Petaluma River.[6]

Soils

Surface soils at the project site are mapped by the Natural Resource Conservation Service. The southern three-fourths of the project site is primarily Reyes Silty Clay with the northern remainder being Goulding Cobbly Clay Loam. Reyes Silty Clay is rated high for linear extensibility (shrink-swell potential), and high for corrosivity. Goulding Cobbly Clay Loam is rated as moderate for linear extensibility and corrosivity.[7]

Twelve soil borings were taken on May 26, 2004 as part of the field exploration in support of the two site-specific geotechnical reports by Miller Pacific. Six borings were on the northern 26-acre portion of the site proposed for development. The samples from these six borings consisted of gravely, sandy or silty clays, or imported fill near the surface (up to eleven feet in the southern and western portions of the site), with the deeper materials being weathered bedrock or Bay Mud respectively.[8]

Seismicity

Regional Seismicity

The entire San Francisco Bay Area is located within the San Andreas Fault Zone (SAFZ), a complex of active faults forming the boundary between the North American and Pacific lithospheric plates. Movement of the plates relative to one another results in the accumulation of strain along the faults, which is released during earthquakes. The SAFZ has generated numerous moderate to strong historic earthquakes. The California Building Code classifies the area as seismic risk zone 4 (the highest risk category). The SAFZ includes numerous faults found by the California Geological Survey under the Alquist-Priolo Earthquake Fault Zoning Act (A-PEFZA) to be "active" (i.e., to have evidence of fault rupture in the past 11,000 years). Regional active faults are shown on Figure V.E-1.[9]

4 *Miller Pacific Engineering Group, 2004a, Geotechnical Investigation Dutra Materials - Haystack Landing Asphalt and Recycling Facility, Petaluma California, Prepared for the Dutra Materials, Project No. 209.02, September 3.*

5 *U.S. Army Corp of Engineers, 2006, Wetland Mitigation and Monitoring Plan - Haystack Landing Wetland Mitigation Project, April.*

6 *Miller Pacific Engineering Group, 2004b. Geotechnical Investigation, Haystack Landing Wetlands Restoration, Petaluma California, Prepared for the Ms. Lucy Macmillan, Project No. 1139.01, October 1.*

7 *Natural Resources Conservation Service, Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov, Soil Survey Area: Sonoma County, California, Version of Data: 2.*

8 *Miller Pacific Engineering Group, 2004a. op. cit.*

9 *Hart, Earl W., Bryant, William A., Revised 1997, Supplements 1 And 2 Added 1999, Special Publication 42, Fault-Rupture Hazard Zones In California, Alquist-Priolo Earthquake Fault Zoning Act (A-PEFZA), California Department Of Conservation (CDC), Division Of Mines And Geology (CDMG).*

The U.S. Geological Survey's Working Group on California Earthquake Probabilities estimated that there is a 62 percent probability that one or more Moment Magnitude[10] (MW) 6.7 or greater earthquakes will occur in the San Francisco Bay Area between 2002 and 2031. The Group estimated the probability of a MW6.7 magnitude or greater earthquake to be 21 percent along the San Andreas Fault, 27 percent along the Hayward-Rodgers Creek Fault, eleven percent along the Calaveras Fault, four percent along the Concord-Green Valley Fault, ten percent along the San Gregorio Fault, three percent on the Greenville Fault, and three percent for the Mt. Diablo Thrust fault. In addition, there is a cumulative 14 percent chance of a background (other earthquake source, either mapped or undiscovered) event occurring. It is estimated that about three MW6.7 or greater events could occur in the next 100 years. Thus the probability of at least one MW6.7 or greater magnitude earthquake rises to the near certainty of about 96 percent when calculated for a 100-year span.[11]

Site-Specific Seismicity

The project site is not within an A-PEFZA fault zone; however, the project site is approximately 4.5 miles west of the Rodgers Creek A-PEFZA fault zone, approximately 14.5 mile east of the San Andreas Fault, and approximately 3.1 miles northeast of the potentially active Burdell Mountain Fault. Both the San Andreas and Hayward-Rodgers Creek faults are right lateral strike-slip faults[12] with a northwest-southeast axis. As noted above, the Hayward-Rodgers Creek fault has a 27 percent chance, and the San Andreas a 21 percent chance, of an MW6.7 earthquake between 2002 and 2031.

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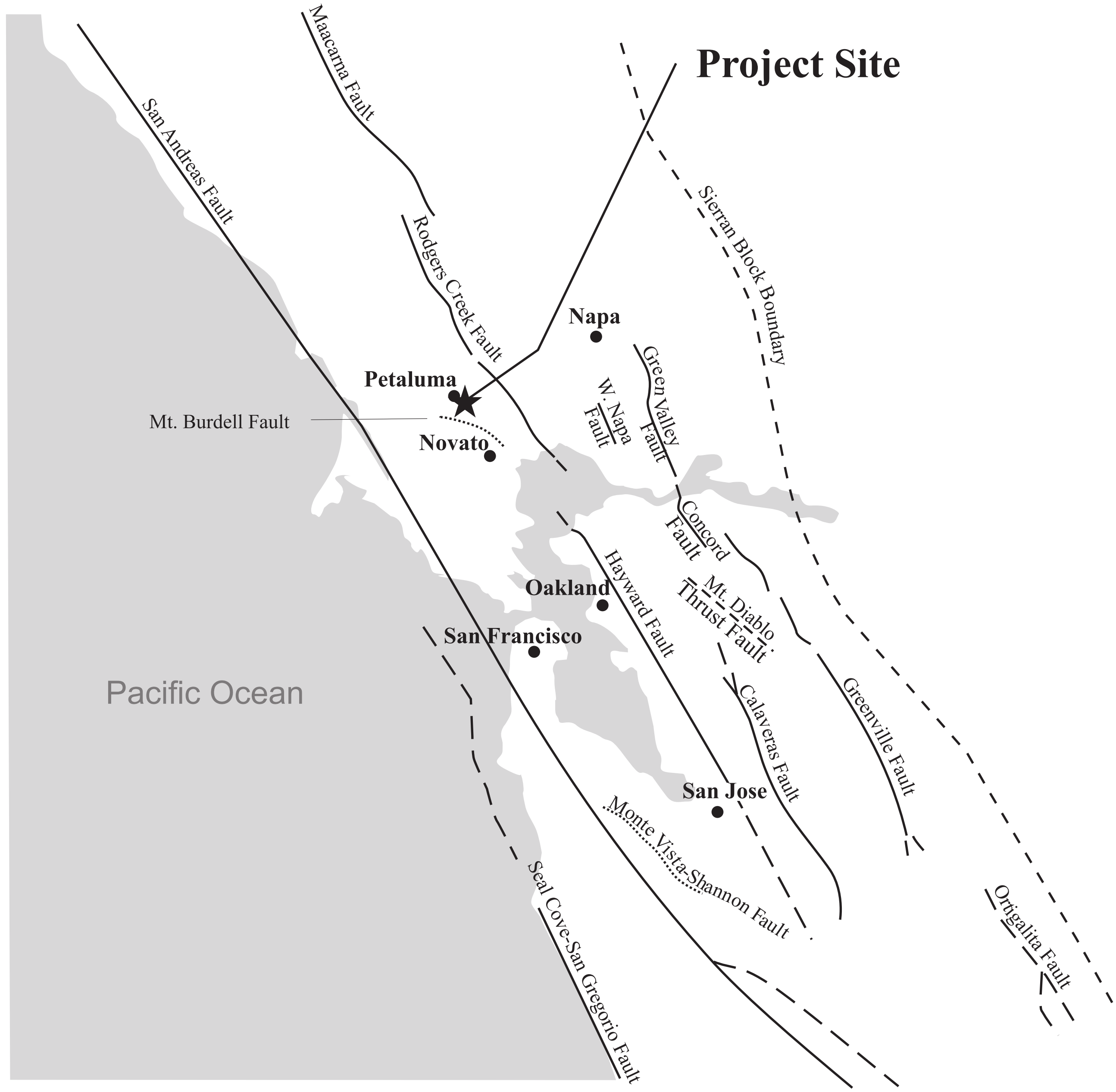
[10] *Moment magnitude (MW) is now commonly used to characterize seismic events as opposed to Richter Magnitude. Moment magnitude is determined from the physical size (area) of the rupture of the fault plane, the amount of horizontal and/or vertical displacement along the fault plane, and the resistance to rupture of the rock type along the fault.*

[11] *USGS, 2003, Earthquake Probabilities in the San Francisco Bay Region: 2002 to 2031 – A Summary of Findings, Open File Report 03-214.*

[12] *Right-lateral: if the trace of the fault were viewed while standing on one side during an event, it would appear that the ground on the other side of the fault moved to the right. Strike-slip: the sides are moving laterally relative to each other with little or no vertical movement.*

REGIONAL FAULTS



Legend

Active Fault - Fault has evidence of surface displacement within the past 11,000 years (dashed where inferred)

Potentially Active Fault - Fault has evidence of surface displacement in the past 1.6 million years, but not within the past 11,000 years

Seismic Source without Surface Rupture

0 10 20 30 40
Scale (Miles)

Source: Baseline, 2006.

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Figure V.E-1
Regional Faults

Seismic and Geologic Hazards

Surface Rupture

Surface rupture occurs when the ground surface is broken due to fault movement during an earthquake. The location of surface rupture generally can be assumed to be along an active or potentially active major fault trace. No portion of the project site is located within an A-PEFZA fault zone and no active faults have been mapped at the site.[13] Therefore, potential for fault rupture at the project site is negligible.

Ground Shaking

Ground shaking is a general term referring to all aspects of motion of the earth's surface resulting from an earthquake, and is normally the major cause of damage in seismic events. The extent of ground shaking is controlled by the magnitude and intensity of the earthquake, distance from the epicenter, and local geologic conditions. The Modified Mercalli Intensity Scale (MMI) is the most commonly used scale for measurement of the subjective effects of earthquake intensity (Table V.E-1). A related concept, acceleration, is measured as a fraction or percentage of the acceleration under gravity (g).

The closest active fault to the project site, the Hayward-Rodgers Creek fault zone, is considered capable of generating approximately a MW 7.0 earthquake. An earthquake of this magnitude would generate strong to violent seismic shaking (MMI VII to IX) at the project site.[14] Such ground shaking is expected to result in significant structural damage, as indicated in Table V.E-1. This is a potentially significant hazard.

Peak Acceleration

Estimates of the peak ground acceleration have been made for the Bay Area based on probabilistic models that account for multiple seismic sources. Under these models, consideration of the probability of expected seismic events is incorporated into the determination of the level of ground shaking at a particular location. The California Geological Survey has estimated the expected peak horizontal acceleration (with a ten percent chance of being exceeded in the next 50 years) generated by any of the seismic sources potentially affecting the project site as 0.51.[15] This level of ground acceleration at the project site is a potentially significant hazard.

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[13] *CDMG, 1983, State of California Special Studies Zones, Petaluma River Quadrangle Map.*

[14] *ABAG, 2005. Earthquake Shaking Scenario Map, http://www.abag.ca.gov/bayarea/eqmaps/mapsba.html.*

[15] *California Geological Survey (CGS), 2005, Probabilistic Seismic Hazards Mapping Ground Motion Page, accessed 1/10/2006, www.consrv.ca.gov/cgs/rghm/pshamap/pshamain.html.*

Table V.E-1
Modified Mercalli Scale

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

Source: California Geological Survey, 2002. How Earthquakes and Their Effects are Measured: Note 32

Liquefaction and Lateral Spreading

Liquefaction is the temporary transformation of loose, saturated granular sediments from a solid state to a liquefied state as a result of seismic ground shaking. In the process, the soil undergoes transient loss of strength, which commonly causes ground displacement or ground failure to occur. Since saturated soils are a necessary condition for liquefaction, soil layers in areas where the groundwater table is near the surface have higher liquefaction potential than those in which the water table is located at greater depths. The project site is within an area rated to have high susceptibility for seismic liquefaction, as mapped by the USGS and presented by the Association of Bay Area Governments.[16]

The site-specific geotechnical investigation concluded that there is a low potential for liquefaction to occur at the project site in sand seams stratified in Bay Mud. Depending on specifics of a seismic event, along with variables of the soil and substructure makeup, localized sand boils may occur. Sand boils may locally disrupt pavements in access roads and slabs.[17]

Lateral spreading is a form of horizontal displacement of soil toward an open channel or other "free" face, such as an excavation boundary. Lateral spreading can result from either the slump of low cohesion unconsolidated material or more commonly by liquefaction of either the soil layer or a subsurface layer underlying soil material on a slope. Earthquake shaking leading to liquefaction of saturated soil can result in lateral spreading where the soil undergoes a temporary loss of strength.

The lateral spreading hazard will tend to mirror the liquefaction hazard for the project site, and by definition needs an open channel or "free" face to expand into; this can include temporary excavations resulting from the construction process. As noted above, the site-specific geotechnical investigation concludes that the potential for liquefaction at the project site is low. This is considered a less than significant hazard.

Expansive Soils

Expansion and contraction of volume can occur when expansive soils undergo alternating cycles of wetting (swelling) and drying (shrinking). During these cycles, the volume of the soil changes markedly, and can cause structural damage to building and infrastructure if the potentially expansive soils were not considered in project site design and construction.

The site-specific geotechnical investigation did not observe any surface soils with highly expansive characteristics. It noted that though the layer of Bay Mud has moderate to high expansion potential, a layer of fill material overlying the native Bay Mud would be thick enough to deter changes in moisture content in the Bay Mud, subsequently reducing its potential for changes in volume. The site-specific geotechnical investigation concludes that the potential for structural damage due to expansive soils is low.[18]

Slope Stability

Slope failure can occur as either rapid movement of large masses of soil ("landslide") or slow, continuous movement ("creep"). The primary factors influencing the stability of a slope are: 1) the nature of the underlying soil or bedrock, 2) the geometry of the slope (height and steepness), 3) rainfall, and 4) the presence of previous landslide deposits.

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[16] *ABAG, 2005. Liquefaction Susceptibility Map, http://quake.abag.ca.gov, USGS Open File Report 00-444.*
[17] *Miller Pacific, 2004a, op. cit.*
[18] *Miller Pacific, 2004a, op. cit.*

Regional mapping shows that the easternmost portion of the project site is mapped as Category 1A, unstable areas of zero to five percent slope that include tidelands, marshlands, and swamplands that are underlain by moist unconsolidated muds. The remainder of the project site is classified as Category 1, stable areas of zero to five percent slope that are not underlain by landslide deposits.[19]

The site-specific geotechnical investigation concluded that traditional slope stability issues are not a geologic hazard for the project site. However, the soft compressible Bay Mud underlying the areas proposed for stockpiles may create a high potential for deep rotational failures within the Bay Mud. The original site-specific geotechnical investigation recommends either the relocation for the stockpiles to alleviate the risk, or the use of soil improvement methods to improve the strength properties of the Bay Mud and improve site stability.[20] Miller Pacific provided additional stability analysis of the proposed 42-foot high gravel stockpiles and supplemented and superceded its original geotechnical recommendations. Miller Pacific has recommended maintaining stability through a combination of high strength geogrid reinforcement in the underlying fill layer and staged construction of the gravel stockpiles.[21]

Settlement and Differential Settlement

Differential settlement or subsidence could occur if buildings or other improvements are built on low-strength foundation materials (including imported fill) or if improvements straddle the boundary between different types of subsurface materials (e.g., a boundary between native material and fill). Although differential settlement generally occurs slowly enough that its effects are not dangerous to inhabitants, it can cause significant building damage over time. Portions of the project site that contain loose or uncontrolled (non-engineered) fill may be susceptible to differential settlement.

Starting about 1950, the site has been altered by a variety of events. Levees were constructed along portions of the Petaluma River, and the once marshy portions of the site dried out as the marshes receded east in response to the altered river flow. The project site was partially graded in the 1950s and the nearby Highway 101 corridor was developed. Between 1968 and 1973 the currently existing ponds on the site were developed as sedimentation and retention ponds for the quarry located in the hills northwest of the site. The ponds are no longer in use for this purpose, and the northern-most pond has been filled.[22]

REGULATORY SETTING

Federal

Federal Earthquake Hazards Reduction Act

In 1997, the U.S. Congress passed the Earthquake Hazards Reduction Act to reduce the risks to life and property from future earthquakes through the establishment and maintenance of an effective earthquake hazards and reduction program. To accomplish this, the act established the National Earthquake Hazards Reduction Program (NEHRP). The agencies responsible for coordinating NEHRP are the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF); and the United States Geological Survey (USGS). In 1990 NEHRP was amended

[19] *USGS, 1970. Regional Slope Stability Map of the Northeastern San Francisco Bay Region, Professional Paper 944.*

[20] *Miller Pacific, 2004a, op. cit.*

[21] *Miller Pacific, 2004c, Stability of Gravel Stockpiles - Haystack Landing Asphalt and Recycling Facility, Petaluma California, Prepared for the Dutra Materials, Project No. 209.02bltr.doc, December 2.*

[22] *Fugro West, Inc., 2004, op. cit.*

by the National Earthquake Hazards Reduction Program Act (NEHRPA), which refined the description of the agency responsibilities, program goals, and objectives. The four goals of the NEHRP are as follows:

- Develop effective practices and policies for earthquake loss-reduction and accelerate their implementation;
- Improve techniques to reduce seismic vulnerability of facilities and systems;
- Improve seismic hazards identification and risk-assessment methods and their use; and
- Improve the understanding of earthquakes and their effects.

State

Alquist-Priolo Earthquake Fault Zoning Act

Alquist-Priolo Earthquake Fault Zoning Act is the State law that focuses on hazards from earthquake fault zones. The purpose of this law is to mitigate the hazard of surface fault rupture by regulating structures designated for human occupancy near active faults. As required by the Act, the California Geological Survey has delineated Earthquake Fault Zones along known active faults in California.

California Uniform Building Code

The California Code of Regulations (CCR), also known as Title 24, California Building Standards Codes contain the laws regarding the construction of buildings. Title 24, Part 2 of the California Uniform Building Code (UBC) specifies standards for geologic and seismic hazards, other than surface faulting. Chapter 23 of the California UBC addresses seismic safety, and includes regulations for earthquake-resistant design and construction.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was enacted in 1997 to protect the public from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and from other hazards caused by earthquakes. This act requires the State Geologist to map areas subject to seismic hazards. A geotechnical investigation of the site must be conducted and appropriate mitigation measures incorporated into the project design before development permits will be granted. Additionally, the Act requires a Standardized Natural Hazards Disclosure Statement form be completed by real estate sellers if a property is within one of the designated natural hazards areas.

Local and Regional

The applicable policies contained in the Geological Hazards Section of the Public Safety Element are analyzed in the Sonoma County General Plan Policy Analysis, in Section V.H (Land Use), Table V.H-2. Additionally, the Petaluma Daily Belt Area Plan, of which the project site is a part, includes development policies related to Slope and Geology. These Area Plan policies are analyzed in further detail in Section V.H (Land Use), Table V.H-3.

ENVIRONMENTAL IMPACTS

Thresholds of Significance

The following criteria of significance from Appendix G of the *CEQA Guidelines* are used to establish the thresholds for determining whether an impact is significant. The project would have a significant impact related to geology, soils, or seismicity if it would:

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

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

  ii) Strong seismic ground shaking.

  iii) Seismic-related ground failure, including liquefaction.

  iv) Landslides.

- Result in substantial soil erosion or the loss of topsoil.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- Be located on expansive soil, as defined in Table 18-1-B of the UBC (1994), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Project Impacts and Mitigation Measures

Impact GEO-1 Seismically-Induced Ground Shaking at the Project Site Could Result in Injuries, Fatalities, and Property Damage

All structures and improvements in the Bay Area could be affected by ground shaking in the event of an earthquake on regional active faults. Ground shaking potential is estimated on a worst-case basis by assessing the maximum expected earthquakes and designing for peak accelerations that may be generated. The project site is approximately 4.5 miles from the Rodgers Creek fault, which is likely to produce an earthquake during the life of the project.

Strong to violent ground shaking is expected at the project site during a large earthquake on the Rodgers Creek fault. Violent ground shaking corresponds to an MMI-IX, during which some masonry and frame structures would be damaged, and unbolted structures shifted off their foundations. This level of seismic shaking could cause injuries and/or fatalities and extensive structural and non-structural damage to buildings at the site during both the start-up phase and full build out phase of the project. It is acknowledged that seismic hazards cannot be completely eliminated, even with site-specific geotechnical methods and advanced building practices. However, exposure to seismic hazards is a generally accepted part of living in the seismically active areas of California. Furthermore, various mitigation measures have been included in the proposed project in order to reduce the potential hazards associated with seismic activity to a ***less-than-significant*** level.

Mitigation Measure GEO-1

Project design and construction shall be in conformance with current best standards for earthquake resistant construction in accordance with the California Building Code (Seismic Zone 4). In addition, project design shall follow the recommendations of the site-specific geotechnical investigation report. The report provides specific design criteria for construction of the project in response to expected seismic events.

Impact GEO-2 Surface Instability Could Result in Damage to Buildings, Equipment and Present a Physical Hazard to Workers

The project site consists of nearly flat slopes, and slope stability is not a geologic hazard. However, due to the presence of soft compressible Bay Mud and the proposed placement of heavy stockpile loads, the risk of deep rotational failures during both the start-up phase and full build out phase of the project within the Bay Mud are high.[23] This is a ***significant*** impact.

Mitigation Measure GEO-2

The applicant shall retain a qualified geotechnical engineering firm to fully evaluate the potential for aggregate stockpiles (both new and recycled) to cause overloading and instability of the underlying Bay Mud. The geotechnical firm shall design and construct a stockpile storage area that is stable under both static and dynamic (i.e., seismic) conditions. The geotechnical design shall include overexcavation of the Bay Mud and replacement with engineered fill, placement of geogrid reinforcement under the stockpiles, or other means to ensure that the stockpiles would not cause rotational failures or damage to the nearby railroad tracks. Controlled settlement over time at the stockpile storage area is acceptable. The design shall allow for no displacement at or adjacent to the railroad tracks. Post-construction monitoring of the performance of the geotechnical solution, including detailed measurement of settlements, shall be required and conducted on a yearly basis for five years. The applicant shall ensure that annual monitoring reports are submitted to the County for review and approval. Any unexpected failures or settlements exceeding those that were predicted shall be addressed by prompt corrective active (at no cost to the County). If at the end of five years, the geotechnical consultant and the County are in agreement, the monitoring and reporting may be terminated.

The geotechnical design shall be reviewed and approved by the County technical staff prior to approval of the grading permit for the project.

Impact GEO-3 Lurching and Ground Cracking at the Project Site Could Result in Damage to Project Buildings and Other Improvements

Lurching and ground cracking can occur during strong ground shaking. Ground cracking tends to occur at the top of slopes where stiff soils overlie soft deposits or along channel banks. Bay Mud deposits up to 15-feet in thickness underlie the southern two-thirds of the site near the River.[24] Lurching and ground cracking could result in damage to site improvements and present a hazard to workers during both the start-up phase and full build out phase of the project. This is a ***significant*** impact.

[23] *Miller Pacific, 2004a, op. cit.*
[24] *Miller Pacific, 2004a, op. cit.*

Mitigation Measure GEO-3

Reduction in the potential for damage due to soil lurching and resulting surface cracking shall be achieved by either soil improvements techniques, such as deep soil mixing, the replacement of unstable soils with engineered fill, or a minimum of 20 foot setbacks for all improvements from channel banks as recommended by the geotechnical reports.

Impact GEO-4 Differential Settlement at the Project Site Could Result in Damage to Project Buildings and Other Improvements

Soft, compressible Bay Mud ranges in thickness from 0 to 15-feet across the project site. This layer has the potential to compress under moderate foundation loads or placement of new fill or stockpiles.[25] Southern and eastern portions of the site have been identified as containing variable artificial fill and grading of the project site in preparation for construction of buildings and utilities will result in additional areas of cut and fill.

Fills of different thickness and fills adjacent to cut areas where native soils are exposed at the surface could create the potential for differential settlements if structures straddle this interface. The areas most susceptible to differential settlement are those where thick fills or fills over Bay Mud are adjacent to native soil or bedrock. If the settlement is not uniform for the fill and native materials (i.e., differential settlement), structural damage can occur. Buried utilities crossing the boundaries of different materials may also experience differential settlements along their alignments. The geotechnical investigation report for the proposed project provides specific recommendations for mitigating settlement, including replacing Bay Mud with engineered fill. The start-up phase and full build out phase of the project could result in improvements being damaged due to differential settlement; this is a ***significant*** impact.

Mitigation Measure GEO-4

The recommendations of the geotechnical investigation report regarding settlement shall be implemented. The specific recommendations for mitigation of potential settlements associated with native soil, Bay Mud and fill boundaries shall be implemented, such as excavation of the soft compressible Bay Mud and replacement with compacted fill.

CUMULATIVE IMPACTS

Other development proposed in the area of the project site could be impacted by some or all of the same issues as the proposed project. However, these issues are site-specific and there is little, if any, cumulative relationship between the development of the project as proposed, and past or future development. Therefore, cumulative geology and soils impacts would be ***less than significant***.

LEVEL OF SIGNIFICANCE AFTER MITIGATION

All geologic and soils impacts are reduced to ***less than significant*** by implementation of required mitigation measures.

[25] *Miller Pacific, 2004a, op. cit.*