3.10 GEOLOGY, SOILS, SEISMICITY

3.10.1 AFFECTED ENVIRONMENT

GEOLOGIC AND SEISMIC SETTING

Geologically, marine sedimentary and volcanic rocks that form the Franciscan Assemblage underlie the Presidio.[1] Outcrops of shale, greenstone, sandstone, and serpentine can be found along the northern coastal bluffs between Battery Crosby and the Golden Gate Bridge. Covering the Franciscan Formation over a large central portion of the Presidio are much younger sand dune deposits. Older sand dune deposits and alluvium (slope wash debris, ravine fill, and landslide debris) including the Colma Formation, an unconsolidated fine to medium grained sand, underlie the southeastern portion of the Presidio. Intertidal deposits, recent beach sand deposits, and artificial fill underlie the area along the San Francisco Bay shoreline, including Crissy Field.

Soils located in the Presidio, as classified by the Natural Resource Conservation Service (NRCS) include the *Urban land-Sidrak complex, Orthents, and Argiustolls*. *Urban land-Sidrak* soils occur on stabilized sand dunes and are composed primarily of material derived from sand dunes. *Orthents* soils are derived primarily from sandstone and occur as cut and fill on alluvial fans, coastal terraces, and hills. Due to the characteristics of underlying materials, portions of the Presidio are prone to geologic hazards such as sheet erosion, rilling, soil creep, gullying, stream downcutting, streambank erosion, and landsliding caused by erodable soils and rock.[2]

The San Francisco Bay Area is considered seismically active, and earthquakes are an unavoidable geologic hazard at the Presidio. The closest active faults to the Presidio are the San Andreas fault located approximately four miles west, and the Hayward fault located approximately 12 miles east. Other active regional faults include the San Gregorio-Hosgri fault, located about 18 miles southwest, and the Rodgers Creek fault, located about 24 miles northeast (Jennings 1994); please refer to Figure 3.10-1 for the locations of these faults. Ground shaking from a seismic event on any of these active faults could cause significant damage in the Presidio, and would have the potential to trigger earthquake-induced landslides or cause liquefaction.

As shown in Figure 3.10-2, portions of the Presidio are located with a Seismic Hazard Zone for landslides and liquefaction, as designated by the California Division of Mines and Geology.[3] Areas susceptible to liquefaction are characterized by saturated, cohesionless, granular soils, while landsliding can occur on slopes made unstable by seismic ground shaking, water saturation, oversteepening, excavation at the base of the toe, or slope creep.

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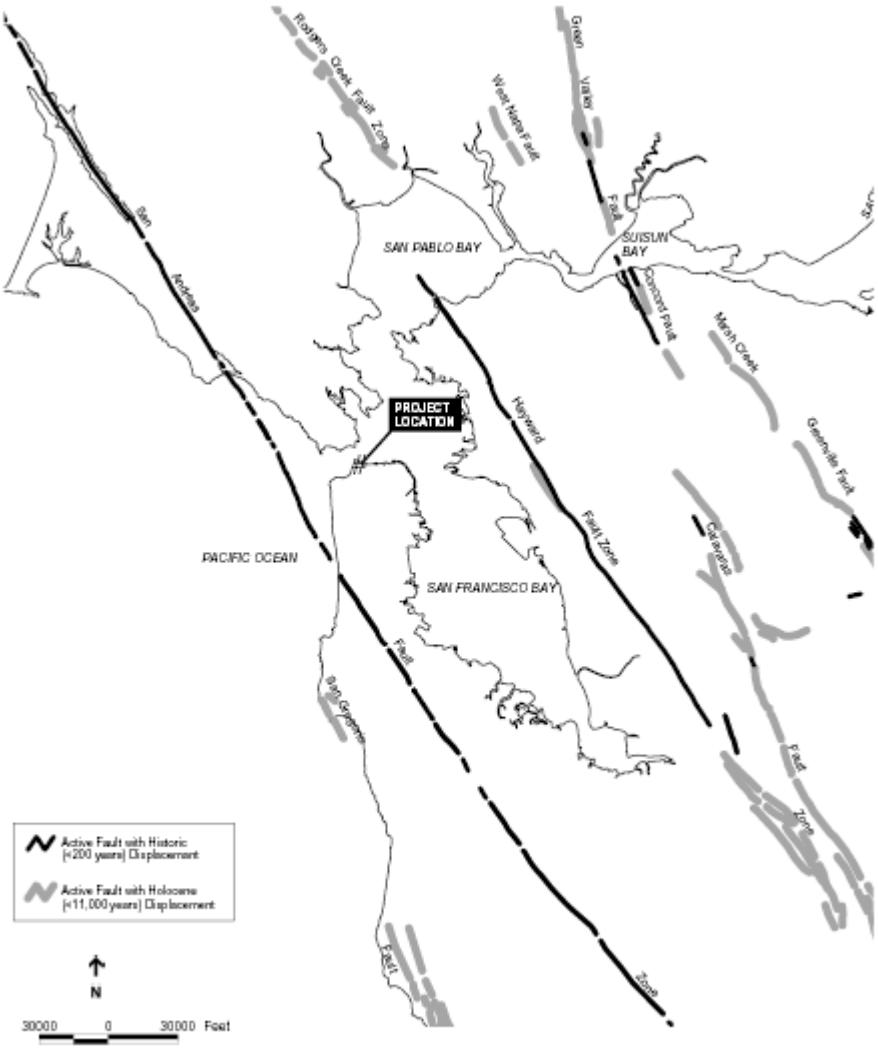
1 The Franciscan Assemblage is the name applied to the rocks that form the bulk of the Coast Ranges. These rocks were first closely studied around San Francisco, hence the name.

2 *Rill erosion or "rilling"* refers to the development of numerous minute, closely spaced channels resulting from the uneven removal of surface soil by running water that is concentrated in streamlets of sufficient volume and velocity to generate cutting power. Rilling is the intermediate process between sheet erosion and gully erosion. *Scour* refers to the powerful and concentrated clearing and digging action of flowing water.

3 Liquefaction is a phenomenon whereby unconsolidated and/or near saturated soils lose cohesion and are converted to a fluid state as a result of severe vibratory motion.



SOURCE: California Department of Conservation, Division of Mines and Geology (After Jennings, 1994)

Presidio Water Recycling Project

Figure 3.10-1
Principal Active Faults in the San Francisco Bay Area

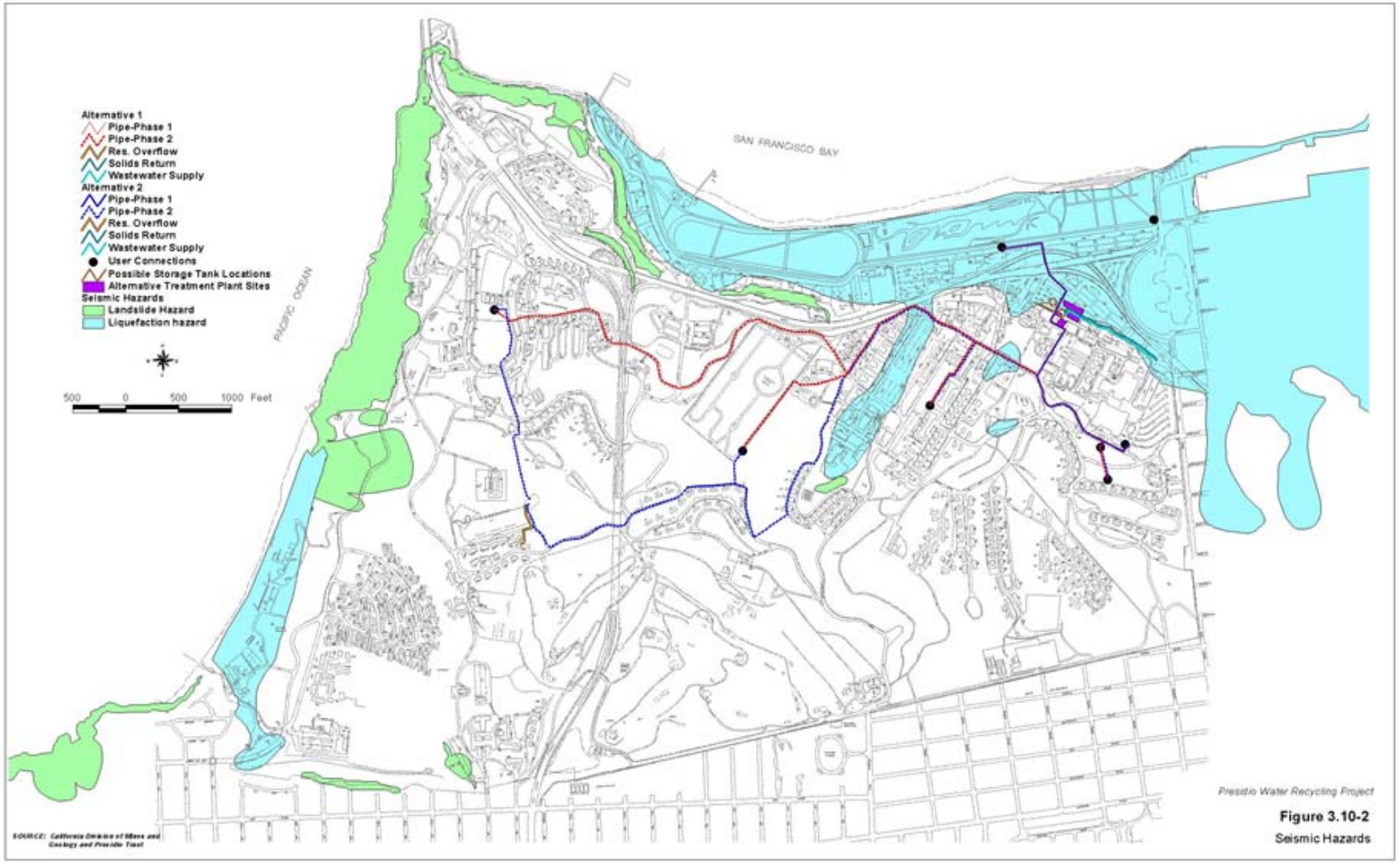


Figure 3.10-2
Seismic Hazards

regulatory background

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was developed 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 delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site must be conducted, and appropriate mitigation measures incorporated into the project design. The *Guidelines for Evaluating and Mitigating Seismic Hazards in California,* California Division of Mines and Geology (CDMG) Special Publication 117, constitutes the guidelines for evaluating seismic hazards other surface fault rupture, and for recommending mitigation as required by Public resources Code Section 2695(a).

3.10.2 ENVIRONMENTAL CONSEQUENCES AND MITIGATION

ALTERNATIVE 1 (CENTRALIZED STORAGE)

Seismic Hazards

The San Francisco Bay Area region contains both active and potentially active faults, and is considered a region of high seismic activity.[4] The U.S. Geological Survey (USGS) Working Group on California Earthquake Probabilities has evaluated the probability of one or more earthquakes of Richter magnitude 6.7 or higher occurring in the San Francisco Bay Area within the next 30 years. The result of the evaluation indicated a 70 percent probability that such an earthquake event will occur in the Bay Area between 2000 and 2030 (USGS 1999). Earthquakes are an unavoidable geologic hazard at the Presidio. The intensity of a seismic event would depend on the causative fault and the distance to the epicenter, the moment magnitude, and the duration of ground shaking. For instance, a large earthquake (magnitude 7 or greater) on the San Francisco peninsula segment of the San Andreas fault could generate higher intensity groundshaking at the Presidio than a similarly large earthquake on a more distant fault such as the Hayward fault or the San Gregorio fault. The nature of underlying geologic materials would also affect the level of groundshaking at the Presidio because areas underlain by artificial fills, inter-tidal deposits, or unconsolidated alluvium can amplify seismic waves, while bedrock areas tend to attenuate ground shaking effects.

[4] An active fault is defined by the State of California as a fault that has experienced surface displacement within Holocene time (approximately the last 10,000 years). A potentially active fault is defined as a fault that has shown evidence of surface displacement during the Quaternary period (last 1.6 million years), unless direct geologic evidence demonstrates inactivity for all of the Holocene or longer. This definition does not, of course, mean that faults lacking evidence of surface displacement are necessarily inactive. “Sufficiently active” is also used to describe a fault if there is some evidence that Holocene displacement occurred on one or more of its segments or branches (Hart 1997).

Ground shaking during an earthquake can cause damage to structures and induce landslides. Ground shaking at the Presidio could be very intense, considering the relatively short distance to the San Andreas and Hayward faults. Portions of the Presidio are located within a newly designated CDMG Seismic Hazard Zone for liquefaction. These zones include areas underlain by artificial fill and intertidal deposits, located along the San Francisco Bay shoreline near Crissy Field. The Seismic Hazards Map for San Francisco also shows an area of potential liquefaction hazard extending from Lobos Creek to the northern end of Baker Beach. (CDMG 2000).

Pipelines

The majority of the pipeline route proposed under Alternative 1 would be placed in alluvial deposits consisting primarily of dune sand. These deposits include younger, less-consolidated dune sand, found in the central and western portions of the Presidio and the older, more consolidated Colma Formation that underlies the Presidio's eastern portion. Segments of the pipeline route in the extreme northeast portion of the project area (former Letterman complex) would intersect artificial fill and intertidal deposits that tend to have less strength, can amplify ground shaking, and are susceptible to liquefaction.

Typically, damage incurred by buried pipelines during an earthquake is minimal compared to potential damage to above-ground facilities. Excessive ground shaking could weaken pipeline welds or laterally displace segments (leading to isolated leaks), but complete rupture is less likely to occur. Damage leading to leakage in a pipeline system can result in temporary service disruption until the damage is identified and repaired. Pipeline segments placed in areas underlain by unconsolidated artificial fill or intertidal deposits would be subjected to a greater level of ground shaking, and therefore could incur more damage than segments placed in consolidated alluvium. This is especially the case in areas where liquefaction causes material surrounding the pipeline to fail. Although a greater number of pipeline failures are possible in liquefaction-prone areas, the damage would be localized and if leaks do occur, they would represent a temporary service disruption until the pipeline segment is repaired or replaced.

Recycled Water Facilities

Alternative 1 proposes construction of a 500,000-gallon reservoir, a treatment facility, pump support structures and other associated above-ground facilities. These facilities would be placed in the northeastern portion of the Presidio, an area partially underlain by intertidal deposits and artificial fill materials. The artificial fill was placed many years ago and consists of primarily dune sand, but includes unconsolidated and semi-consolidated silt, clay, rock debris, and organic waste. In some areas, especially towards the Bay margin, buried structures exist that include ship timbers and other man-made debris. Artificial fill materials are generally less consolidated than native geologic deposits such as dune sand and alluvium associated with the Colma formation.

These unconsolidated, heterogeneous geologic materials could result in strong seismic ground shaking and subsequent damage to the proposed water recycling facility structures. Furthermore, the shallow groundwater and the composition of the materials are susceptible to liquefaction and

associated ground failures (i.e. seismically induced settlement) when subjected to strong seismic shaking. Displacement due to lateral seismic forces or settlement could be more than some structures can tolerate. Damage from strong seismic shaking is typically more severe in older, unreinforced structures and sometimes can lead to their collapse.

In a seismic event, damage to proposed above-ground structures could include ruptured pipelines connections, toppled equipment, cracked concrete, and foundation failure due to settlement. Facility personnel could be injured from equipment upset, isolated flooding, or fallen structural elements. Most of the significant damage incurred during an earthquake would likely cause temporary service disruptions, rendering the facilities inoperable while the damaged components are repaired.

Earthquake ground motions generated on nearby active faults will cause strong ground shaking at the Presidio. Prior to construction of the proposed pipelines, storage and treatment facilities, a geotechnical investigation will be conducted to evaluate potential geologic and seismic hazards and develop recommendations to reduce the potential for structural failure or collapse during an earthquake. Evaluation and mitigation of earthquake-related risks would be evaluated as required by the Seismic Hazard Mapping Act incorporating the *Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117* as required by the California Division of Mines and Geology. A certified engineering geologist and a registered geotechnical engineer (to evaluate geologic subgrade, earthquake ground motion, and liquefaction), as well as a registered structural engineer (to evaluate structural safety) would generate engineering recommendations needed to reduce seismic risk to acceptable levels.

> *Compliance with standard engineering recommendations and practices, and compliance with the Seismic Hazard Mapping Act, would ensure that the potential adverse impacts from seismic ground shaking would be less-than significant.*

Differential Settlement and Erosion

Differential settlement could occur in areas of the proposed treatment facilities, considering the presence of artificial fill and inter-tidal deposits. Differential settlement could damage building foundations, affect underground utilities, and cause settlement in streets and roads. Settlement could be reduced or eliminated in areas that currently support buildings, because the soils have been allowed to settle over time. Settlement would be a concern in areas that have not previously supported structures and where new structures would place loads heavier than the soils could tolerate.

Soil erosion hazards could occur during preliminary stages of construction, especially during trenching, stripping and recompaction of artificial fill, initial site grading, and prior to resurfacing of street and sidewalk installation.

Prior to construction of the proposed pipelines, storage and treatment facilities, a geotechnical investigation will be conducted to evaluate potential geologic hazards and develop mitigation to reduce the potential for settlement, excessive erosion, and soil loss. A certified engineering geologist, a registered geotechnical engineer, and registered structural engineer would prepare engineering recommendations. The pipeline systems and facilities that are proposed under Alternative 1 would be designed to incorporate currently accepted and standard engineering practices and techniques. These facilities would also include BMPs for erosion control (see Section 2.3, BMP-1: Erosion/Runoff Control). The above measures would reduce potential adverse settlement and erosion impacts to less-than significant levels.

> *Compliance with standard engineering recommendations and practices would ensure that the potential adverse impacts from differential settlement and erosion would be less-than significant.*

ALTERNATIVE 2 (MULTIPLE STORAGE SITES)

General Geologic Effects

Impacts under Alternative 2 would be generally the same as described for Alternative 1. Both alternatives share similar potential impacts related to seismic ground shaking, settlement, and soil erosion. The notable difference between the two alternatives is the 100,000-gallon storage reservoir rehabilitation; however, this does not alter the impact analysis because the reservoir would be rehabilitated to accepted engineering design standards and seismically retrofitted to current earthquake design criteria. Furthermore, the tank is not founded on liquefiable soils or substrate susceptible to settlement.

> *Alternative 2 would have no significant impacts on geologic, soil, and seismic safety, with implementation of mitigation identified under Alternative 1.*

ALTERNATIVE 3 (NO ACTION)

General Geologic Effects

Under the No Action Alternative, no new pipeline, treatment plant, or other facilities, associated with the use of recycled water would be implemented. Therefore, all geologic, soil, and seismic safety impacts affiliated with this project would be avoided.

> *The No Action Alternative would not generate geologic, soil, and seismic safety impacts impacts, and no mitigation is recommended or required.*