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## 15. GEOLOGY AND SOILS

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This EIR chapter describes existing geologic and soil conditions in the Precise Plan area, identifies associated potential geotechnical impacts related to development in accordance with the Precise Plan, and sets forth measures designed to mitigate identified significant adverse impacts. Data sources used to complete these descriptions include the Redwood City Strategic General Plan, San Mateo County geotechnical maps, and other environmental assessments completed by the City.

### 15.1 SETTING

#### 15.1.1 Regional Geologic Setting

The Precise Plan area is within a broad structural trough of the California Coast Ranges that extends from an area south of Hollister northward beyond San Pablo Bay. This structural depression, which contains San Francisco Bay, has been subsiding and filling with alluvium during the past five to eight million years.<sup>1</sup>

#### 15.1.2 Seismicity

(a) Earthquake Fault Locations. The Precise Plan is in a seismically active region, but no active or probable active fault traverses the Precise Plan area. The major known active faults in the project vicinity include the Monte Vista (approximately 4.2 miles southeast of the Plan area), San Andreas (approximately 4.5 miles southwest of the Plan area), San Gregorio (approximately 13 miles west of the Plan area), and Hayward (approximately 14 miles northeast of the Plan area).<sup>2</sup>

(b) Earthquake Probability. In 1999, the Working Group on California Earthquake Probabilities (WGCEP) at the U.S. Geological Survey (USGS) predicted a 70-percent probability of a magnitude 6.7 or greater earthquake occurring in the San Francisco Bay Area by the year 2030, with the following estimates of probability for particular faults: Hayward-Rogers Creek--32 percent, San Andreas--21 percent, Calaveras--18 percent, San Gregorio--10 percent, and Mount Diablo--4 percent.<sup>3</sup>

(c) Earthquake Hazards. Hazards that can result from an earthquake include surface rupture, landsliding, violent ground shaking, differential settlement, liquefaction, and lateral spreading.

(1) *Potential for Surface Rupture*. Surface rupture occurs along active fault traces, or at locations where compressed and distorted soils break open to relieve earthquake-induced

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<sup>1</sup>City of Redwood City, Bayside Gardens Project Draft EIR, June 2004, p. 11-1.

<sup>2</sup>City of Redwood City, p. 11-3.

<sup>3</sup>City of Redwood City, p. 11-4.

stress. Structures and other improvements built across the actual trace or line of such fractures are generally destroyed. As noted above, no active or probable active fault has been identified in the Precise Plan area; therefore, the risk of surface rupture is considered very low.

(2) *Potential for Landsliding.* Landsliding entails sudden slope failures. Because the Plan area and its surroundings are relatively flat, landsliding is not considered a significant hazard.

(3) *Potential for Ground Shaking.* Ground shaking is caused by the seismic waves that radiate out from an earthquake's epicenter. The severity of ground shaking at a particular location is primarily determined by distance from the epicenter of the earthquake and by the local soil profile. Loose, unconsolidated sedimentary deposits can transform the relatively high frequency (back and forth) motion of underlying bedrock into lower frequency but higher amplitude motion at the surface. The stability of unconsolidated soils versus bedrock is illustrated by published records from the 1989 Loma Prieta Earthquake. Surface motion measured in the bedrock of San Francisco Bay's Yerba Buena Island was only 38 percent as strong as that measured on the surface of fill material used to create Treasure Island, less than one mile away.<sup>1</sup>

Ground shaking can result in the differential settlement of unconsolidated soils in response to unequal surface loading. Movement of the ground causes an additional compaction of the soil that is proportional to the soil's pre-existing density and to the magnitude of imposed surface loads. These conditions often result in unequal settlement, which can cause the failure of poorly stabilized cut-and-fill embankments and of foundations that cannot span areas of discontinuous support.

The Precise Plan area is expected to experience strong to very strong ground shaking during a major earthquake on any of the nearby faults.

(4) *Potential for Liquefaction and Lateral Spreading.* Liquefaction and lateral spreading are similar losses of foundation support that occur in saturated (submerged) granular soils, most notably loose, clean, saturated, uniformly graded, fine-grained sand. Under liquefaction, saturated, cohesionless soil experiences a temporary loss of strength due to build-up of excess pore water pressure, especially during cyclic loadings such as those induced by earthquakes.

According to the Official Map of Seismic Hazards Zones published by the California Geological Survey (Palo Alto Quadrangle, released October 18, 2006),<sup>2</sup> the Precise Plan area is generally considered susceptible to liquefaction, particularly during an earthquake originating on the San Andreas fault, with individual construction projects therefore requiring the associated standard geotechnical mitigations identified at the end of this EIR chapter.

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<sup>1</sup>California Department of Conservation, Division of Mines and Geology, Office of Strong Motion Studies. Report OSMS 89-06: *California Strong Motion Instrumentation Program, Strong Motion Records from the Santa Cruz Mountains (Loma Prieta) California Earthquake of 17 October 1989.*

<sup>2</sup>Seismic hazard zones maps available at [www.conservation.ca.gov/cgs/shzp](http://www.conservation.ca.gov/cgs/shzp).

## 15.2 PERTINENT PLANS AND POLICIES

### **15.2.1 Redwood City Strategic General Plan**

The Redwood City Strategic General Plan Safety Element (adopted in 1990) incorporates the countywide *Seismic* and *Safety Elements* prepared by San Mateo County with the cooperation of Redwood City. The *Safety Element* contains the following geotechnical objective and policy pertinent to consideration of the potential environmental impacts of the proposed project:

- *Protect the community from the hazards of soil erosion, weak and expansive soils, and geologic instability.* (Safety Objective 1, page 12-3)
- *Identify structural types and land uses highly sensitive to earthquake activity, and abate or modify them to achieve acceptable levels of risk.* (Safety Policy S-12, page 12-3)

### **15.2.2 Uniform Building Code**

The construction of all buildings within Redwood City is regulated by the Uniform Building Code (UBC, 2001 Edition). The UBC has been formulated to ensure that buildings constructed in conformance with its earthquake design provisions can safely withstand the effects of earthquake-induced ground shaking. As a result, it is not expected that newly constructed buildings in Redwood City would collapse or otherwise fail structurally during a major (e.g., Magnitude 6.0) earthquake, although they may sustain substantial damage.

## 15.3 IMPACTS AND MITIGATION MEASURES

### **15.3.1 Significance Criteria**

Based on the CEQA Guidelines, development in accordance with the Downtown Precise Plan would be expected to have a significant soils and geology impact if it would:<sup>1</sup>

- (1) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - (a) 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 (Division of Mines and Geology Special Publication 42);
  - (b) strong seismic ground shaking;
  - (c) seismic-related ground failure, including liquefaction; or
  - (d) landslides;
- (2) Result in substantial soil erosion or the loss of topsoil;

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<sup>1</sup>CEQA Guidelines, Appendix G, items VI(a-e) and IX(b).

- (3) 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;
- (4) Be located on expansive soil, as defined by Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property;
- (5) 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 waste water; or
- (6) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project adopted for the purpose of avoiding or mitigating an environmental effect.

### **15.3.2 Future Study and Subsequent Mitigation**

Before the specific terms of required mitigation can be developed for the geotechnical aspects of future development in the Precise Plan area, additional, more detailed studies would need to be performed to address site-specific concerns.

Geotechnical mitigation requirements identified in subsequent sections of this chapter include completion of additional, more detailed studies to address specific concerns as future project designs are refined. With regard to any such mitigation recommendations that have been described in this EIR chapter that require future additional determinations, the CEQA Guidelines and recent court decisions indicate that mitigation measures must be mandated that will alter the significant impacts of the project. In particular, EIR mitigation measures must ensure that a project would be implemented in a manner that renders insignificant or minimizes potentially significant soil and geology impacts of the project. There is substantial, reasonable, historic information to support the conclusion that the specific subsequent geotechnical/geologic investigations, inspections, and specific formulations required to meet the standards identified in this EIR would adequately mitigate related impacts to less-than-significant levels. The City routinely requires such geotechnical/geologic investigations and specifications at phases of development review that follow EIR certification.

The techniques and standards for geotechnical mitigation described in this EIR are widely known and accepted, but individual measures for particular projects are typically, and most efficiently, specified at a detailed level of design that cannot be expected at this stage for future site-specific development in accordance with the proposed Precise Plan.

A significant record exists demonstrating the effectiveness of such post-EIR-certification design and engineering requirements in mitigating the potential soil and geologic impacts of concern identified in this EIR. Under the City's grading permit and building permit provisions, requirements, and regulations, an individual development project cannot be given final approval without project compliance with geotechnical/geologic requirements. These requirements and related City inspection and verification procedures prior to project occupancy provide reasonable assurances that the project would incorporate the design and engineering refinements necessary to reduce the degree of impact to less-than-significant levels by either avoiding identified soil and geologic impact areas altogether (i.e., basic project design changes),

or by rectifying the impact through conventional engineering and construction procedures (e.g., suitable stiffened grid foundations, mat foundations, driven concrete piles, etc.) identified throughout the post-EIR investigation and monitoring process.

### **15.3.3 Seismic Impacts**

The following impact and mitigation findings apply to both the Maximum Intensity project scenario and the Moderate Intensity project scenario.

**Impact 15-1: Ground Shaking.** Under either the Maximum or Moderate Intensity Precise Plan alternative, future development in accordance with the proposed Draft Precise Plan would place new residences and businesses in a subregion that is expected to experience severe earthquake-induced ground shaking during the useful life of the project improvements. This ground movement could cause differential settlement of any poorly consolidated soils and induce ground failure within alluvial soils that may be prone to liquefaction. These possible responses to anticipated seismic activity represent a ***potentially significant impact*** (see criteria 1, 3, and 4 in subsection 15.3.1, "Significance Criteria," above).

**Mitigation 15-1.** At the City Building Official's discretion, future discretionary development projects proposed within the Precise Plan area shall be required to undertake *detailed, design-level geotechnical investigations* that include analysis of project site seismic stability, liquefaction potential, and soil response characteristics with respect to ground acceleration, in accordance with Special Publication 112, "Guidelines for Analyzing and Mitigating Liquefaction in California," published by the California Division of Mines and Geology.

The *detailed, design-level geotechnical investigations* should include the following:

- Seismic stability analysis of the existing on-site soil;
- Evaluation of liquefaction potential through the performance of additional cone penetration tests, borings, and/or equivalent methods; and
- Determination of site-specific soil response characteristics and maximum credible ground acceleration for an earthquake recurrence interval specified by the City.

Recommendations from the investigations, including appropriate soil stabilization and foundation construction techniques, minimum setbacks around potentially unstable areas, and criteria for the compaction and treatment of on-site fills, shall be incorporated into the final project grading and foundation plans. In general, these recommendations are expected to include the following requirements:

**(continued)**

**Mitigation 15-1 (continued):**

- that all construction comply with the most current edition of the Uniform Building Code) for Seismic Zone 4, or with the most recently adopted building codes.
- that all project structural designs be based on proper estimates by the project geotechnical engineer of peak and maximum repeatable earthquake-induced ground surface accelerations expected to occur on the project site; and
- that excavations will be adequately sloped or shored in order to minimize ground movements.

Implementation of these measures--combined with conformance with standard Uniform Building Code, City of Redwood City, and other applicable regulations--would reduce the potential effects of ground shaking to a ***less-than-significant level***.

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**Impacts Due to Surface Failure/Fault Rupture.** No active or probably active fault has been identified in the Precise Plan area. The potential for surface failure or fault rupture is very low, and potential impacts are ***less-than-significant***.

**Mitigation.** No significant impact has been identified; no mitigation is required.

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**15.3.4 Soil Erosion and Sedimentation Impacts**

The following impact and mitigation findings apply to both the Maximum Intensity project scenario and the Moderate Intensity Precise Plan alternative.

**Impact 15-2: Soil Erosion and Sedimentation.** Under either the Maximum or Moderate Intensity Precise Plan alternative, grading for future development in accordance with the proposed Precise Plan would temporarily disturb the site's existing topography and vegetative cover, leaving soils exposed to wind and water erosion during the construction period. Eroded soils could be washed into on-site or off-site drainage facilities. Resulting sedimentation could affect the flows in these drainage facilities, increasing flooding potential and maintenance problems and degrading water quality. These possible effects of soil erosion represent a ***potentially significant impact*** (see criterion 2 in subsection 15.3.1, "Significance Criteria," above).

**Mitigation 15-2.** Require applicants for future development projects in the Precise Plan area involving a grading area of 10,000 or more square feet to prepare *erosion control plans* subject to City approval and consistent with the required project *Stormwater Pollution Prevention Plans* (SWPPPs) as well as Best Management Practices (BMPs) specified by the Redwood City Stormwater Management and Discharge Control Program (Municipal Code Chapter 27A). Implement the plan during construction. Erosion during all phases of construction shall be controlled through the use of erosion and soil transport control facilities. These shall include the use of catch basins and filter fabrics, and the direction of stormwater runoff away from disturbed areas. The plan shall also provide for long-term stabilization and maintenance of remaining exposed soils after construction is completed. Areas disturbed by construction shall be either covered with impervious surfaces (e.g., buildings and pavement) or fully stabilized with landscaping and/or native vegetation. All revegetated areas shall be irrigated and maintained as necessary to ensure the long-term survival of the vegetation. Implementation of this measure would reduce this potential impact to a ***less-than-significant level***.

