4.6 GEOLOGY, SOILS, AND MINERAL RESOURCES

4.6.1 INTRODUCTION

The Geology, Soils, and Mineral Resources chapter of this EIR describes the geologic and soil characteristics of the proposed project site and evaluates the extent to which implementation of the project could expose people and structures to the following geologic and seismic hazards: rupture of a known earthquake fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction; soil erosion; soil stability; and expansive soils. The chapter also addresses mineral resources. Information in this chapter is drawn from the *City of Antioch General Plan*[1] and associated EIR,[2] and the *Geotechnical Exploration* prepared for the project site by ENGEO, Inc. (see Appendix F).

4.6.2 EXISTING ENVIRONMENTAL SETTING

The following background setting information focuses on the regional and site geology of the project site and adjacent off-site impact areas.

Regional Geology and Seismicity

The City of Antioch consists of two general topographic areas: the Lowland Area and the Upland Area. The Lowland Area generally corresponds to the estuarine and flatland soils, and the Upland Area includes hillside soils.

The Lowland Area includes the generally level terrain and wetlands adjacent to the San Joaquin River and low-lying areas to the south. Elevations in the Lowland Area generally range from near sea level to approximately 100 feet above mean sea level and contain slopes that range from 0 to 15 percent. The Lowland Area of Antioch is underlain by alluvium that is less than two million years old, and consists mainly of unconsolidated floodplain deposits with sand, silt, gravel, and clay irregularly interstratified. The Upland Area comprises moderate to steeply sloping hills, and is generally located south of the Lowland Area. The Upland Area of the City consists primarily of tilted sedimentary rocks that range in age from Upper Cretaceous (65 million years old) to Holocene (11,000 years old).

The City of Antioch is located in Contra Costa County, within the seismically active San Francisco Bay Area region. Eastern Contra Costa County, like the San Francisco Bay Area, is located in one of the most seismically active regions in the United States. Major earthquakes have occurred in close proximity to Antioch, and are expected to occur again.

1 City of Antioch. *City of Antioch General Plan*. Adopted November 24, 2003.
2 City of Antioch. *City of Antioch General Plan EIR*. July 2003.

Historically active faults in Contra Costa County include the Concord-Green Valley, Hayward, Calaveras, and Marsh Creek-Greenville faults. The largest regional fault, the San Andreas Fault, is located approximately 45 miles west of Antioch.

The project site is located in the Coast Ranges geomorphic province on the eastern side of Mount Diablo, where bedrock is mapped as Tertiary Eocene and Oligocene age marine sedimentary rock. The bedrock in the area generally consists of interbedded sandstone and claystone that vary from friable to strong. Bedrock structures in the area generally strikes to the northwest and dips at an inclination of 15 to 30 degrees to the northeast.

Project Site Geology

The near-surface soils are expected to be highly expansive. Residual natural soils were encountered in test pits excavated along ridgelines and hillside areas. The residual soils generally consisted of dark grayish brown clay with various amounts of silt and sand. Cover ranges from about one to four feet thick. Residual soils have a moderate to high plasticity and are considered moderately to highly expansive when subjected to fluctuations in moisture content.

In addition, it should be noted that the remnants of a former mining town, known as Judsonville, are located near the western border of the project site along Empire Mine Road. Various debris piles were observed near the Judsonville site, including approximately five feet of artificial fills. Given that records pertaining to the placement of these artificial fills could not be found, the artificial fills are therefore considered to be non-engineered, which can be highly variable and potentially compressible. Historic mining operations associated with Judsonville occurred to the east of the project site and were used to mine coal. Two additional historic coal mines, the Teutonia Mine and the Israel Mine, are located to the south of the project site, all were active during the mid-1860s.

Alluvial and Colluvial Deposits

The on-site alluvium is derived from Sand Creek, which drains from the west to the east across the center of the site. According to borings performed by ENGEO, the soil consists of silty to sandy clay in the upper five feet interbedded with layers of clayey to silty sand and sandy to clayey silt at depth. With the exception of the disked soil at the surface, the clayey soils are typically very stiff to hard, and the sandy deposits are typically medium dense to dense consistency. The surficial deposits range from moderate to high plasticity and are considered moderate to highly expansive. Colluvium has been mapped along the base of slopes and within hollows and ravines, located in the southwestern corner of the site. The typical thickness of the colluvial deposits vary from about 3.5 feet to 14 feet. Colluvial deposits in the site vicinity have low to high plasticity characteristics and may be considered high to very highly expansive when subjected to fluctuations in moisture content.

Sandstone Bedrock

Bedrock in the hilly portions, along the norther border and the southwestern corner of the site consists of Markley Sandstone. Excavation of test pits proved the sandstone was generally friable

to moderately strong and thickly bedded to massive, as well as highly weathered. Bedrock located in an east to west trending band through the center of the site consists of Nortonville Shale. Excavation of test pits exposed predominantly claystone with some interbedded siltstone and shale. The claystone bedrock was found to be friable to weak, very closely fractured, and varied from thinly to thickly bedded. Based on laboratory testing and observations, the claystone materials are considered highly expansive.

Landslide Areas

According to the *Geotechnical Exploration*, three landslide deposits exist on the project site, located along the western border of the site near Empire Mine Road. Depth of movement is expected to be approximately two to six feet below the ground surface and are expected to be the result of steep slopes with thin layers or residual soil covering massive sandstone bedrock.

Slope Stability

The identified landslide areas within the project site were deemed to have a relatively high likelihood of experiencing future instability, according to the *Geotechnical Exploration*. Clayey soils on steeper natural slopes are subject to soil creep, which is the slow downslope movement of soil that occurs with the annual cycle of wetting and drying under the influence of gravity. The potential for adverse impacts from soil creep can be reduced by benching through surficial soils during fill placement as well as complete removal of the existing landslides located within the limits of grading.

Expansive Soils

According to the *Geotechnical Exploration* prepared for the proposed project, the clayey soil and claystone materials are considered moderately to highly expansive. Expansive soils are those that increase in volume when they absorb water and shrink when they dry out, commonly referred to as "shrink-swell" potential. Soil surveys generally rate "shrink-swell" potential in soils on a low, medium, and high basis. If the shrink-swell potential is rated moderate to high, shrinking and swelling can cause damage to buildings, roads, and other structures; as a result, special design is often needed.

Project Site Seismicity

The Great Valley Fault was identified approximately five miles from the proposed project site. Although portions of the Great Valley Fault are considered seismically active, the fault does not extend to the ground surface, and therefore, is not zoned as active by the State of California. According to the *Geotechnical Exploration*, active faults do not exist across the project site. However, one segment of the Antioch Fault is mapped near the northwestern corner of the project site, as is shown in Figure 5 of Appendix F. The United States Geological Survey fault map does not classify the Antioch Fault as a Holocene active fault and is therefore, not considered active.

The primary seismic hazard resulting from a nearby moderate to major earthquake would be ground rupture or surface faulting. The secondary seismic hazards include ground shaking, ground

lurching, soil liquefaction, lateral spreading, and seismically-induced landsliding. Based on topographic and lithologic date, the risk from regional subsidence, uplift, tsunamis, or seiches is considered low to unlikely at the project site.

Ground Rupture and Shaking

The Great Valley Fault is considered capable of causing high ground shaking at the site, but the recurrence interval is believed longer than for more distant strike-slip faults. According to the *Geotechnical Exploration*, the project site is not within a State of California Earthquake Fault Hazard Zone nor an Alquist-Priolo Earthquake Fault Zone, indications of active faulting were not found on-site, nor are there any known active faults crossing the site; therefore, primary fault ground rupture is unlikely on the project site.

An earthquake of moderate to high magnitude generated within the San Francisco Bay Region could cause considerable ground shaking at the project site; however, shaking is dependent on the magnitude of the event, distance to the epicenter, and local geologic conditions.

Seismically-Induced Landslides

Seismically-induced landslides are triggered by earthquake ground shaking. The risk of landslide hazards are greatest in the late winter when groundwater levels are highest and hillside colluvium is saturated. Portions along steep-sloping banks of Sand Creek in the northwestern portion of the project area have a risk of landslide hazards. According to the *Geotechnical Exploration*, risk of seismically-induced landslides is present at the project site to varying degrees depending on the slope conditions and time of year.

Liquefaction Potential

Soil liquefaction results from loss of strength during cyclic loading, such as imposed by earthquakes. As a result, the soils are temporarily transformed into a liquid state. Soils most susceptible to liquefaction are clean, loose, saturated, and uniformly graded, fine-grained sands. The *Geotechnical Exploration* prepared for the proposed project determined that the project site is located in a low susceptibility zone for liquefaction based on the soil type and groundwater levels located at the project site.

Lateral Spreading

Lateral spreading is a failure within weaker soil materials, typically due to liquefaction, which causes the soil mass to move toward an open channel, or down a gentle slope. According to the *Geotechnical Exploration*, the soils on the project site have a low susceptibility to liquefaction; therefore, the potential for liquefaction-induced lateral spreading is considered low. However, the northwestern portion of Sand Creek within the project site consists of steep banks ranging up to approximately 30 feet high, thus creating a high susceptibility to lateral spreading along the creek.

Mineral Resources

Regionally significant mineral resources that are currently mined within Contra Costa County include the following: a deposit of diabase, an intrusive igneous rock, is located in the Mount Zion area between Concord and Clayton approximately 9.5 miles from the project site; a deposit of domegine sandstone is located outside of Byron south of Camino Diablo and east of Vasco Road approximately 8.3 miles from the project site; and shale in the Port Costa area approximately 21.4 miles from the project site.[3] According to the County's General Plan, mineral resources are not currently located near the City of Antioch. In addition, the City of Antioch's General Plan EIR does not identify any areas within the City's General Plan area available for new development to contain known mineral resources that would be of value to the region or residents of the State.[4] However, historic mining sites are located to the south and east of the project site, as previously discussed. According to mining reports analyzed in the *Geotechnical Exploration*, the historic mines were primarily used for coal mining in the mid-1860s, but were abandoned prior to 1869 and are not currently active.

4.6.3 REGULATORY CONTEXT

The following section includes a brief summary of the regulatory context under which soils and geologic hazards are managed at the federal, State, and local levels.

Federal Regulations

The following are the federal environmental laws and policies relevant to soils and geologic hazards.

Federal Earthquake Hazards Reduction Act

Passed by Congress in 1977, the Federal Earthquake Hazards Reduction Act is intended to reduce the risks to life and property from future earthquakes. The Act established the National Earthquake Hazards Reduction Program (NEHRP). The goals of NEHRP are to educate and improve the knowledge base for predicting seismic hazards, improve land use practices and building codes, and to reduce earthquake hazards through improved design and construction techniques.

Uniform Building Code

The Uniform Building Code (UBC) was first published in 1927 by the International Council of Building Officials and is intended to promote public safety and provide standardized requirements for safe construction. The UBC was replaced in 2000 by the new International Building Code (IBC), published by the International Code Council (ICC), which is a merger of the International Council of Building Officials' UBC, Building Officials and Code Administrators International's National Building Code, and the Southern Building Code Congress International's Standard Building Code. The intention of the IBC is to provide more consistent standards for safe

[3] Contra Costa County. *Contra Costa County General Plan, Conservation Element* [pg. 8-34]. January 18, 2005.
[4] City of Antioch. *City of Antioch General Plan EIR* [pg. 5-9]. July 2003.

construction and eliminate any differences between the three preceding codes. All State building standard codes are based on the federal building codes.

State Regulations

The following are the State environmental laws and policies relevant to geology, soils, and mineral resources.

Alquist-Priolo Earthquake Fault Zoning Act

The 1972 Alquist-Priolo Earthquake Fault Zoning Act (AP Zone Act) was passed to prevent the new development of buildings and structures for human occupancy on the surface of active faults. The Act is directed at the hazards of surface fault rupture and does not address other forms of earthquake hazards. The locations of active faults are established into fault zones by the AP Zone Act. Local agencies regulate any new developments within the appropriate zones in their jurisdiction.

The AP Zone Act regulates development near active faults so as to mitigate the hazard of surface fault rupture. The AP Zone Act requires that the State Geologist (Chief of the California Department of Mines and Geology [CDMG]) delineate "special study zones" along known active faults in California. Cities and counties affected by these zones must regulate certain development projects within these zones. The AP Zone Act prohibits the development of structures for human occupancy across the traces of active faults. According to the AP Zone Act, active faults have experienced surface displacement during the last 11,000 years. Potentially active faults are those that show evidence of surface displacement during the last 1.6 million years. A fault may be presumed to be inactive based on satisfactory geologic evidence; however, the evidence necessary to prove inactivity sometimes is difficult to obtain and locally may not exist.

California Building Standards Code

The State of California regulates development within the State through a variety of tools that reduce or mitigate potential hazards from earthquakes or other geologic hazards. The 2010 California Building Standards Code (California Code of Regulations [CCR], Title 24) governs the design and construction of all building occupancies and associated facilities and equipment throughout California.[5] In addition, the California Building Standards Code governs development in potentially seismically active areas and contains provisions to safeguard against major structural failures or loss of life caused by earthquakes or other geologic hazards. The California Building Standards Code includes federal building standards adapted to meet conditions and address concerns unique to those of California.

[5] California Building Standards Commission. *California Building Standards Code (Title 24, California Code of Regulations).* Effective July 1, 2014.

Seismic Hazards Mapping Act

The California Seismic Hazards Mapping Act of 1990 (California Public Resources Code Section1690-2699.6) addresses non-surface rupture earthquake hazards, including liquefaction, induced landslides, and subsidence. A mapping program is also established by this Act, which identifies areas within California that have the potential to be affected by such non-surface rupture hazards. The Seismic Hazards Mapping Act specifies that the lead agency for a project may withhold development permits until geologic or soils investigations are conducted for specific sites and mitigation measures are incorporated into plans to reduce hazards associated with seismicity and unstable soils.

Surface Mining and Reclamation Act

The Surface Mining and Reclamation Act (SMARA) was enacted in 1975 to address the need for a continuing supply of mineral resources, and to prevent or minimize the negative impacts of surface mining to public health, property, and the environment. The SMARA includes a process called "classification-designation." The purpose of this process is to provide local agencies with information about the location, need, and importance of various mineral resources within their jurisdiction, and to ensure this information is used in local land use decisions.

Local Regulations

The following are the local environmental laws and policies relevant to geology, soils, and mineral resources.

City of Antioch General Plan

The Antioch General Plan establishes the following objectives and policies applicable to geology, soils, and mineral resources.

Objective 11.3.2 Minimize the potential for loss of life, physical injury, property damage, and social disruption resulting from seismic groundshaking and other geologic events.

Policy 11.3.2.a Require geologic soils reports to be prepared for proposed development sites, and incorporate the findings and recommendations of these studies into project development requirements. As determined by the City of Antioch Building Division, a site-specific assessment shall be prepared to ascertain potential ground shaking impacts on new development. The site-specific ground shaking assessment shall incorporate up-to-date data from government sources and may be included as part of any site-specific geotechnical investigation. The site-specific ground shaking assessment shall include specific measures to reduce the significance of potential ground

shaking hazards. This site-specific ground shaking assessment shall be prepared by a licensed geologist and shall be submitted to the City of Antioch Building Division for review and approval prior to the issuance of building permits. For purposes of this policy, "development" applies to new structures and existing structures or facilities that undergo expansion, remodeling, renovation, refurbishment or other modification. This policy does not apply to second units or accessory buildings.

Policy 11.3.2.c Encourage the purchase of earthquake insurance by residents and businesses.

Policy 11.3.2.f Work with PG&E, pipelines companies, and industrial uses to implement measures to safeguard the public from seismic hazards associated with high voltage transmission lines, caustic and toxic gas and fuel lines, and flammable storage facilities.

Policy 11.3.2.g Require that engineered slopes be designed to resist seismically-induced failure.

Policy 11.3.2.h Require that parcels overlying both cut and fill areas within a grading operation be over-excavated to mitigate the potential for seismically-induced differential settlement.

Policy 11.3.2.i Limit development in those areas, which, due to adverse geologic conditions, will be hazardous to the overall community and those who will inhabit the area.

Policy 11.3.2.j Require evaluations of potential slope stability for developments proposed within hillside areas, and incorporate the recommendations of these studies into project development requirements.

Policy 11.3.2.k Require specialized soils reports in areas suspected of having problems with potential bearing strength, expansion, settlement, or subsidence, including implementation of the recommendations of these reports into the project development, such that structures designed for human occupancy are not in danger of collapse or significant structural damage with corresponding hazards to human occupants. Where structural damage can be mitigated through structural

design, ensure that potential soils hazards do not pose risk of human injury or loss of life in outdoor areas of a development site.

Policy 11.3.2.l Where development is proposed within an identified or potential liquefaction hazard area (as determined by the City), adequate and appropriate measures such as (but not limited to) designing foundations in a matter that limits the effects of liquefaction, the placement of an engineered fill with low liquefaction potential, and the alternative siting of structures in areas with a lower liquefaction risk, shall be implemented to reduce potential liquefaction hazards. Any such measures shall be submitted to the City of Antioch Building Division for review prior to the approval of the building permits.

Policy 11.3.2.m As appropriate and necessary to protect public health and safety, abandoned mines hall be placed in natural open space areas, with appropriate bugger areas to prevent unauthorized entry.

Policy 11.3.2.n Within areas of known historic mining activities, site-specific investigations shall be undertaken prior to approval of development to determine the location of any remaining mine openings, the potential for subsidence of collapse, and necessary measures to protect public health and safety, and prevent the collapse or structural damage to structures intended for human occupancy due to mine-related ground failure or subsidence. Such measures shall be incorporated into project approvals.

Policy 11.3.2.o All identified mine openings shall be effectively sealed.

Policy 11.3.2.p Construction of structures for human occupancy shall be prohibited within areas found to have a high probability of surface collapse or subsidence, unless foundations are designed that would not be affected by such surface collapse or subsidence, as determined by site-specific investigations and engineered structural design.

Policy 4.4.6.7.b Sand Creek Focus Area development shall make a substantial commitment to employment-generating uses. Up to 280 acres are to be devoted to employment generating uses within the areas shown for Business Park and Commercial/Open Space, in addition to the area shown as Mixed Use Medical Facility. Appropriate

primary land uses within employment generating areas include:

- Administrative and Professional
- Offices
- Research and Development
- Light Manufacturing and Assembly
- Hospital and related medical uses

Policy 4.4.6.7.r Sand Creek, ridgelines, hilltops, stands of oak trees, and significant landforms shall be preserved in their natural condition. Overall, a minimum of 25 percent of the Sand Creek Focus Area shall be preserved in open space, exclusive of lands developed for golf course use.

Policy 4.4.6.7.bb Mass grading within the steeper portions or the Focus Area (generally exceeding 25 percent slopes) is to be avoided.

Policy 5.4.14.a Design hillside development to be sensitive to existing terrain, views, and significant natural landforms and features.

Policy 5.4.14.b Projects within hillside areas shall be designed to protect important natural features and to minimize the amount of grading. To this end, grading plans shall conform to the following guidelines.

- *Slopes less than 25%:* Redistribution of earth over large areas may be permitted.
- *Slopes between 25% and 35%:* Some grading may occur, but landforms need to retain their natural character. Split-level designs and clustering are encouraged as a means of avoiding the need for large padded building areas.
- *Slopes between 35% and 50%:* Development and limited grading can occur only if it can be clearly demonstrated that safety hazards, environmental degradation, and aesthetic impacts will be avoided. Structures shall blend with the natural environment through their shape, materials and colors. Impact of traffic and roadways is to be minimized by following natural contours or using grade separations. Encouraged is the use of larger lots, variable setbacks and variable building

structural techniques such as stepped or post and beam foundations are required.

- Slopes greater than 50%: Except in small, isolated locations, development in areas with slopes greater than 50% should be avoided.

Policy 5.4.14.c Manufactured slopes in excess of five vertical feet (5') shall be landform graded. "Landform grading" is a contour grading method which creates artificial slopes with curves and varying slope ratios in the horizontal and vertical planes designed to simulate the appearance of surrounding natural terrain. Grading plans shall identify which slopes are to be landform graded and which are to be conventionally graded.

Policy 5.4.14.d The overall project design/layout of hillside development shall adapt to the natural hillside topography and maximize view opportunities to, as well as from the development.

Policy 5.4.14.e Grading of ridgelines is to be avoided wherever feasible, siting structures sufficiently below ridgelines so as to preserve unobstructed views of a natural skyline. In cases where application of this performance standard would prevent construction of any structures on a lot of record, obstruction of views of a natural skyline shall be minimized through construction techniques and design, and landscaping shall be provided to soften the impact of the new structure.

Policy 5.4.14.f Hillside site design should maintain an informal character with the prime determinant being the natural terrain. This can be accomplished by:

- Utilizing variable setbacks and structure heights, innovative building techniques, and retaining walls to blend structures into the terrain, and
- Allowing for different lot shapes and sizes.

Policy 5.4.14.g Buildings should be located to preserve existing views and to allow new dwellings access to views similar to those enjoyed from existing dwellings.

Policy 5.4.14.h Streets should follow the natural contours of the hillside to minimize cut and fill, permitting streets to be split into two one-way streets in steeper areas to minimize grading

and blend with the terrain. Cul-de- sacs or loop roads are encouraged where necessary to fit the terrain. On street parking and sidewalks may be eliminated, subject to City approval, to reduce required grading.

Policy 5.4.14.i Clustered development is encouraged as a means of preserving the natural appearance of the hillside and maximizing the amount of open space. Under this concept, dwelling units are grouped in the more level portions of the site, while steeper areas are preserved in a natural state.

Policy 5.4.14.j Project design should maximize public access to canyons, overlooks, and open space areas by:

- Providing open space easements between lots or near the end of streets or cul-de-sacs; and
- Designating public pathways to scenic vistas.

Policy 5.4.14.k Permit the use of small retaining structures when such structures can reduce grading, provided that these structures are located and limited in height so as not to be a dominant visual feature of the parcel.

- Where retaining walls face public streets, they should be faced with materials that help blend the wall into the natural character of the terrain.
- Large retaining walls in a uniform plane should be avoided. Break retaining walls into elements and terraces, and use landscaping to screen them from view.

Policy 5.4.14.l Lot lines shall be placed at the top of slopes to facilitate maintenance by the down slope owner, who has the greater "stake" in ensuring the continued integrity of the slope.

4.6.4 IMPACTS AND MITIGATION MEASURES

The following section describes the standards of significance and methodology utilized to analyze and determine the proposed project's potential impacts related to geology, soils, and mineral resources. A discussion of the project's impacts, as well as mitigation measures where necessary, is also presented.

Standards of Significance

Impacts related to geology, soils, and mineral resources are considered significant if the proposed project would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    - 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 based on other substantial evidence of a known fault;
    - Strong seismic ground shaking;
    - Seismic-related ground failure, including liquefaction;
    - 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 18-1B of the Uniform Building Code;
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State; or
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

Method of Analysis

The analysis for the proposed project's geology, soils, and mineral impacts is based on the *Geotechnical Exploration* prepared by ENGEO, Inc., as well as the *City of Antioch General Plan* and associated EIR. ENGEO's geotechnical analysis for the project site is comprised of a number of analytical tasks, including field exploration, geological maps, subsurface exploration (drilling and sampling of 40 borings to depths of 11.5 feet to 31.5 feet, and 23 exploratory test pits using a rubber-tired tractor-mounted backhoe), laboratory testing of soil samples to determine field classifications.

The proposed project's components are compared to the existing conditions of the project site and the Standards of Significance identified above to determine the severity of potential impacts.

Project-Specific Impacts and Mitigation Measures

As discussed in Chapter 3 of this EIR, Project Description, two development scenarios for the proposed project are currently being considered: a Multi-Generational Plan and a Traditional Plan. The following discussion of impacts is based on implementation of either of the development scenarios. Where impacts would be similar under both of the development scenarios, the discussion of impacts presented below is applicable for both scenarios. However, where impacts would differ between the two development scenarios, the impacts are discussed separately for each

scenario. It should be noted that while potential impacts related to both development scenarios are analyzed, ultimately, only one development scenario would be constructed.

4.6-1 Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, strong seismic ground shaking, seismic-related ground failure, including liquefaction, and landslides. Based on the analysis below and with implementation of mitigation, the impact would be *less than significant.*

Multi-Generational Plan and Traditional Plan

The California Division of Mines and Geology has not identified any active faults within the project site. In addition, the site is not located within an Alquist-Priolo Earthquake Fault Zone, and surface evidence of faulting was not observed during site reconnaissance. Although portions of the Great Valley Fault were identified approximately five miles from the proposed project site, the fault does not extend to the ground surface, and therefore, is not considered active by the State of California.

Based on the aforementioned factors, fault ground rupture at the project site resulting from seismic activity is unlikely. In addition, the project site is located in a low susceptibility zone for liquefaction. However, an earthquake of moderate to high magnitude generated within the San Francisco Bay Region could cause considerable ground shaking, which could increase the potential for seismic-related landslides. The degree of shaking is dependent on the magnitude of the event, the distance to earthquake's epicenter, and local geologic conditions.

The *Geotechnical Exploration* designates portions along steep-sloping banks of Sand Creek located on the northern side of the project area as having a risk of landslide hazards, including seismically induced landslides. Approximately 50 percent of the steepest slopes within the project site are located along the creek banks. According to project development plans, the proposed project would preserve the existing Sand Creek corridor as open space with an average width throughout the corridor of approximately 430 feet. Thus, with the exception of the proposed bridges across Sand Creek, the proposed project would not involve development near the banks of Sand Creek and would not be subject to landslide hazards associated with such. It should be noted that the *Geotechnical Exploration* includes project-specific recommendations for development, with the exception of the proposed bridges and off-site improvement areas. Without further assessment of the conditions and implementation of proper engineering techniques at the bridge locations, risks to people and the bridge structures associated with potential landslides along the banks of Sand Creek could potentially occur.

Outside of Sand Creek, the most substantial on-site slopes are located within the northwest and southwest portions of the project site. Accordingly, such areas could be subject to landslides, including seismically-induced landslides. The northwestern portion of the project site would be preserved as open space and would not be developed with buildings or roadways under either of the proposed development scenarios. Rather, development

within the northwest area would be limited to pedestrian and bicycle trails. While much of the hillside and ridgeline area in the southwestern portion of the project site would be preserved as open space, both project development scenarios would include some residential development (a proposed LD-1 neighborhood) in the area. However, as discussed in further detail in Chapter 4.9 of this EIR, Land Use and Planning/Population and Housing, the proposed project would be consistent with General Plan policies associated with development in hillside areas, including the City's Hillside Design policies. For example, as shown in Figure 4.6-1, the southwestern portion of the project site (within the proposed LD-1 neighborhood area) would be graded with a landform grading methodology, avoiding the top 25 percent of the hilltops and matching the existing contouring of the hillsides to the maximum extent feasible, consistent with Policies 5.4.14a, b, and c. As also shown in Figure 4.6-1, the steepest slopes to the east and west of the proposed LD-1 neighborhood would be retained as open space and left in a primarily undeveloped state, consistent with Policies 5.4.14b and d, as well as the overall intention of the City's Hillside Design policies.

In addition, the *Geotechnical Exploration* includes recommendations for the proposed structures for properly engineered stabilization of landslide areas or creation of sufficient buffers between the colluvial deposits and development areas. The *Geotechnical Exploration* further provides recommendations for maximum slope gradients, slope rebuilding, and construction of debris benches between property lines and open-space slopes as a means to reduce possible adverse impacts related to slope stability, including landslides. Compliance with the recommendations set forth in the *Geotechnical Exploration* would ensure that any potential hazards related with landslides associated with the proposed residential development would be reduced to the maximum extent feasible. Furthermore, the proposed project would be required to comply with the current California Building Code (CBC), which contains provisions to safeguard against major structural failures or loss of life caused by earthquakes or other geologic hazards. Compliance with the CBC would help to ensure that all future structures are designed and built sufficient to minimize the potential effects of an earthquake.

As mentioned above, the *Geotechnical Exploration* made recommendations for development on the project site, but did not include recommendations for the proposed bridges or off-site improvement areas. A number of the off-site improvements would occur within currently developed areas (e.g., within existing roadway rights-of-way). Accordingly, due to the currently developed nature of such areas, impacts associated with seismic activity, including ground rupture and ground shaking, liquefaction, and landslides, would not be expected to be substantial in those areas. In addition, for off-site improvement areas located in currently undeveloped areas, because the off-site improvement areas share the same soil types as the project site,[6] the same geological conditions would be expected to occur at the off-site improvement areas as the project site. As a result, the recommendations stated in the *Geotechnical Exploration* would be applicable for the off-site improvement areas, as well.

[6] ECORP Consulting, Inc. *Biological Resources Assessment, The Ranch in Antioch, Contra Costa County, California.* [pg. 20]. October 2017.

Figure 4.6-1
Preliminary Hillside Grading Plan

Nonetheless, without further assessment of the conditions and implementation of proper engineering techniques at the bridge locations, and without compliance with the recommendations stated in the *Geotechnical Exploration*, risks to people and structures associated with ground rupture, ground shaking, liquefaction or other seismic-related ground failure, and landslides could occur. Therefore, impacts would be considered ***significant.***

Mitigation Measure(s)

Implementation of the following mitigation measures would reduce the above impact to a *less-than-significant* level.

Multi-Generational Plan and Traditional Plan

4.6-1(a) *Prior to issuance of any grading permits, all recommendations set forth in the Geotechnical Exploration prepared for the proposed project shall be reflected on the project grading and foundation plans, subject to review and approval by the City Engineer.*

4.6-1(b) *Prior to issuance of any grading permits, the project applicant shall submit to the City of Antioch Engineering Department, for review and approval, a design-level geotechnical engineering report produced by a California Registered Civil Engineer or Geotechnical Engineer and identify grading and building practices necessary to achieve compliance with the latest adopted edition of the California Building Standards Code's geologic, soils, and seismic requirements. The design-level report shall also include an analysis of the geologic hazards at the proposed bridge locations, including landslides, expansive/unstable soils, and seismic-related hazards such as liquefaction, and identify measures to address construction requirements to mitigate, at a minimum, groundshaking and unstable soils, including liquefiable and expansive soils. Measures to address the aforementioned geological concerns could include the following:*

- *The use of post-tensioned concrete mat foundations or similarly stiffened foundations systems which are designed to resist the deflections associated with soil expansion and liquefaction-induced settlement.;*
- *The over-excavation of soil, where existing structure foundations or non-engineered fill exist, in order to place the soil back on-site as engineered fill; and*
- *Soil borings and/or cone penetration tests within the development areas and laboratory soil testing to provide data for the preparation of specific recommendations regarding grading, foundations, and drainage for the proposed construction.*

4.6-2 Risks to people and structures associated with expansive soils or 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 lateral spreading, or collapse. Based on the analysis below and with implementation of mitigation, the impact would be *less-than-significant.*

Multi-Generational Plan and Traditional Plan

Based on the *Geotechnical Exploration*, the project site consists of expansive near-surface soils, which are considered capable of exerting significant expansion pressures upon building foundations and concrete slabs. Accordingly, the soils that exist on the site are rated moderately to highly expansive. Thus, the proposed project may be susceptible to hazards associated with expansive soils.

The northwestern portion of Sand Creek within the project site consists of steep banks ranging up to approximately 30 feet high, thus, creating a high susceptibility to lateral spreading along the creek. Both development scenarios would place residential structures on the hillsides in the northwest and southwest corners of the project area, which are more susceptible to soil creep and lateral spreading. Thus, the proposed project may be susceptible to hazards associated with lateral spreading.

The *Geotechnical Exploration* provides recommendations for maximum slope gradients, slope rebuilding, and construction of debris benches between property lines and open-space slopes as a means to reduce possible adverse impacts related to slope stability. The *Geotechnical Exploration* includes project-specific recommendations for development of the proposed project, with the exception of the proposed bridges and off-site improvement areas. However, a number of the off-site improvements would occur within currently developed areas and, thus, impacts associated with expansive soils and lateral spreading would not be expected to be substantial in such areas. In addition, as discussed above, because the off-site improvement areas share the same soil types as the project site, the recommendations stated in the *Geotechnical Exploration* would be applicable for the off-site improvement areas, as well.

Nonetheless, without further assessment of the conditions and implementation of proper engineering techniques at the bridge locations, and without compliance with the recommendations stated in the *Geotechnical Exploration*, risks to people and structures associated with expansive soils and lateral spreading could occur. Therefore, impacts would be considered ***significant***.

Mitigation Measure(s)
Implementation of the following mitigation measure would reduce the above impact to a *less-than-significant* level.

Multi-Generational Plan and Traditional Plan

4.6-2 Implement Mitigation Measures 4.6-1(a) and 4.6-1(b).

4.6-3 Risks associated with substantial erosion or loss of topsoil. Based on the analysis below and with implementation of mitigation, the impact would be *less than significant.*

Multi-Generational Plan and Traditional Plan

Erosion refers to the removal of soil from exposed bedrock surfaces by water or wind. Although naturally occurring, erosion is often accelerated by human activities that disturb soil and vegetation. Buildout of either development scenario would require grading, excavation, and other construction-related activities, which, during the early stages of construction, prior to overlaying the ground surface with structures, would cause topsoil to be exposed, potentially resulting in wind erosion or an accelerated rate of erosion during storm events. Due to the nature of the silt soil and bedrock, graded slopes may experience more severe erosion when grading is halted by heavy rain. Buildout of the proposed project would include construction-related activities within hillside areas, where silt soil and bedrock is most prevalent.

Upon development of the site with buildings and structures, as well as landscaped ground cover, the amount of exposed soil that may be lost or displaced due to wind or stormwater would be minimized. As such, development on the project site would preclude erosion, and erosion would not be considered an issue during operation of the project.

Although topsoil exposure would be temporary during early construction activities and would cease once development of buildings and structures occurs, after grading and leveling and prior to overlaying the ground surface with structures, the potential exists for erosion to occur. To address construction-related discharges, the project applicant would be required to prepare and implement a Storm Water Pollution Prevention Plan, including Best Management Practices (BMPs), which would include measures to control erosion and sediment. Erosion control BMPs would be implemented to ensure that sediment is confined to the construction area and not transported off-site. Refer to Chapter 4.8 of this EIR, Hydrology and Water Quality, for further discussion.

Therefore, short-term, construction-related impacts associated with soil erosion and the loss of topsoil would be considered ***significant***.

Mitigation Measure(s)
Implementation of the following mitigation measure would reduce the above impact to a *less-than-significant* level.

Multi-Generational Plan and Traditional Plan

4.6-3 *Prior to issuance of any grading permits, the project applicant shall submit, for review and approval by the City Engineer, an erosion control plan that uses standard construction practices to limit the erosion effects during construction of the proposed project. Measures shall include, but are not limited to, the following:*

- *Hydro-seeding;*
- *Placement of erosion control measures within drainageways and ahead of drop inlets;*
- *The temporary lining (during construction activities) of drop inlets with "filter fabric" (a specific type of geotextile fabric);*
- *The placement of straw wattles along slope contours;*
- *Directing subcontractors to a single designation "wash-out" location (as opposed to allowing them to wash-out in any location they desire);*
- *The use of siltation fences; and*
- *The use of sediment basins and dust palliatives.*

4.6-4 Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State or of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan. Based on the analysis below, the project would have *less-than-significant* impact.

Multi-Generational Plan and Traditional Plan

As discussed above, the former mining town of Judsonville is located on the western border of the project site, along Empire Mine Road, with two former mines located to the south. Although former coal mines with relatively unknown underground workings exist within the vicinity of the site, the former mines are not located directly within the project site and therefore, the proposed structures would not be located within identified former mining zones.

In addition, all areas identified in the City's General Plan as available for new development do not contain any known mineral resources. The Contra Costa County General Plan identifies the nearest areas with important mineral resources as being located in Concord, Port Costa, and Byron in the southeastern area of the County, the closest of which is located 8.3 miles from the project site. Therefore, the proposed project site does not contain any known mineral resources, and development of the project on the site would not result in the loss of availability of any mineral resources. Therefore, a ***less-than-significant*** impact would occur related to such as a result of the proposed project.

Mitigation Measure(s)
None required.

Cumulative Impacts and Mitigation Measures

The continuing buildout of developments in the City of Antioch and surrounding areas would be expected to increase the need for surface grading and excavation, and, therefore, increase the potential for impacts related to soil erosion, unforeseen hazards, and exposure of people and property to earthquakes.

The following discussion of impacts is based on the implementation of the proposed project in combination with other proposed and pending projects in the region. Other proposed and pending projects in the region under the cumulative context would include buildout of the City of Antioch General Plan, as well as development of the most recent planned land uses within the vicinity of the project area.

4.6-5 Cumulative increase in the potential for geological related impacts and mineral resource impacts. Based on the analysis below, the impact is *less than cumulatively considerable*.

Development of the proposed project would increase the number of structures that could be subject to the damaging effects of expansive soils, landslides, and lateral spreading. Site preparation would also result in temporary and permanent topographic changes that could affect erosion rates or patterns. However, potentially adverse environmental effects associated with geologic or soils constraints, topographic alteration, and erosion, are usually site-specific and generally would not combine with similar effects that could occur with other projects in Antioch and the surrounding region. Furthermore, all projects would be required to comply with the CBC, and other applicable regulations. In addition, all project would be required to comply with the City of Antioch Municipal Code Section 9-4.513 and the City of Antioch General Plan Policy 11.3.2, which require the preparation of site-specific geology and soils reports for all new developments, and require that the findings and recommendations of these studies be incorporated into project development. Consequently, the proposed project would generally not be affected by, nor would the proposed project affect, other development approved by the City of Antioch.

As discussed above, all areas identified in the City's General Plan as available for new development do not contain any known mineral resources. Accordingly, cumulative development within the City, similar to the proposed project, would not result in the loss of availability of any mineral resources.

Based on the above, the project's contribution to cumulative impacts related to geology, soils, and mineral resources would be considered ***less than cumulatively considerable***.

Mitigation Measure(s)
None required.