6.8 Geology, Soils, and Seismicity

6.8.1 Introduction

This section discusses the regulatory setting regarding geology, soils, and seismicity, and it describes impacts under CEQA that would result from construction and operation of the CEQA Alternatives.

6.8.2 Regulatory Setting

6.8.2.1 State

Alquist-Priolo Earthquake Fault Zoning Act

The primary purpose of the Alquist-Priolo Earthquake Fault Zoning Act (Alquist-Priolo Act; Public Resources Code Sections 2621–2630) is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The law requires the state geologist to establish regulatory zones (known as Earthquake Fault Zones or Alquist-Priolo Zones) around the surface traces of active faults and issue locational maps to all affected cities, counties, and state agencies for their use in safe construction. Before a project may be permitted in an Earthquake Fault Zone, a geologic investigation is required to demonstrate that proposed buildings would not be constructed across active faults. An evaluation and written report of a specific site must be prepared by a licensed geologist. A structure for human occupancy must be set back from the surface trace of an active fault, generally by 50 feet (California Department of Conservation 2015a). The act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards.

Seismic Hazards Mapping Act of 1990

The California Seismic Hazards Mapping Act of 1990 (Public Resources Code Sections 2690 et seq.) addresses earthquake hazards other than surface fault rupture, including liquefaction and seismically induced landslides. The state establishes city, county, and state agency responsibilities for identifying and mapping seismic hazard zones and mitigating seismic hazards to protect public health and safety. The act requires the California Department of Conservation, Division of Mines and Geology, to map seismic hazards and establishes specific criteria for project approval that apply within seismic hazard zones, including the requirement for a geological technical report.

California Building Code

The California Code of Regulations, Title 24 (California Building Code) applies to all structures for which building permits are required. The California Building Code (also called the California Building Standards Code) has incorporated the International Building Code,

which is updated approximately every 3 years. The current version of the California Building Code (2013) became effective on January 1, 2014.

Local agencies must ensure that development in their jurisdictions complies with the California Building Code. Cities and counties can, however, adopt building standards more stringent those provided in the code.

6.8.2.2 Local

City of San Jose General Plan Hazards Chapter

The *Envision San Jose 2040 General Plan* (City of San Jose 2011) provides the following soil and geology goal and policy to minimize risk through design and mitigation. Geotechnical studies are required for the development of proposals.

> **Soils and Geologic Conditions Goal: Protect the community from the hazards of soil erosion, soil contamination, weak and expansive soils and geologic instability.**
>
> Soils and Geologic Conditions Policy 6 – Development in areas subject to soils and geologic hazards should incorporate adequate mitigation measures.

City of Santa Clara General Plan and Building Code

The *City of Santa Clara 2010–2035 General Plan* (City of Santa Clara 2010) recognizes seismic hazards and provides policies to address safety as it relates to earthquake activity and geologic conditions. The general plan includes the following policies with respect to seismic hazards.

> Policy 5.10.5-P5 regulates development, including remodeling or structural rehabilitation, to ensure adequate mitigation of safety hazards, including flooding, seismic, erosion, liquefaction and subsidence dangers.
>
> Policy 5.10.5-P6 requires that new development is designed to meet current safety standards and implement appropriate building codes to reduce risks associated with geologic conditions.
>
> Policy 5.10.5-P7 requires implementation of all recommendations and design solutions identified in project soils reports to reduce potential adverse effects associated with unstable soils or seismic hazards.

In addition, the City of Santa Clara has adopted the California Building Code with local amendments. The City Building Code includes provisions to address appropriate design and construction in seismically active areas. It also includes provisions to ensure that the foundation and building design are appropriate to site soil conditions.

6.8.3 CEQA Methods of Analysis

This section describes the potential geologic, soils, and seismic impacts that could result from implementation of the BART Extension or BART Extension with transit-oriented development (TOJD), as well as mitigation measures to reduce such impacts. The analysis in this section is based on VTA's *BART Silicon Valley—Phase II Extension Project Geotechnical Memorandum* prepared by PARIKH Consultants, Inc. in February 2014. Because geologic conditions do not change over the course of a few years, the setting and

conclusions stated in the 2014 report are still considered valid for the purposes of this SEIS/SEIR.

6.8.4 CEQA Thresholds of Significance

In accordance with Appendix G of the State CEQA Guidelines, a project would have a significant impact if it would result in any of the conditions listed below.

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: (1) 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; (2) strong seismic ground shaking; (3) seismic-related ground failure, including liquefaction; and (4) 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 an onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse.
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.
- 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.
- 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.
- Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.

6.8.5 Environmental Consequences and Mitigation Measures

This section identifies the impacts under CEQA relating to geology, soils, and seismicity and mitigation measures necessary to reduce the level of potentially significant impacts.

6.8.5.1 No Build Alternative

The No Build Alternative consists of the existing transit and roadway networks and planned and programmed transportation improvements (see Chapter 2, Section 2.2.1, *NEPA No Build Alternative*, for a list of these projects) and other land development projects planned by the Cities of San Jose and Santa Clara.

The No Build Alternative projects could result in effects on geology, soils, and seismicity typically associated with transit, highway, bicycle, and pedestrian facilities, and roadway

projects, as well as land development projects. Structures associated with these projects would be designed in accordance with seismic design standards in the California Building Code.

All individual projects planned under the No Build Alternative would undergo separate environmental review to identify effects on geology, soils, and seismicity. Review would include an analysis of impacts and identification of mitigation measures to reduce potential impacts.

6.8.5.2 BART Extension Alternative

Impact BART Extension GEO-1: Expose people or structures to potential seismic hazards

Potential hazards in the alignment are surface fault rupture, ground shaking, and liquefaction. This section analyzes the potential of these geologic phenomena to affect the BART Extension.

Fault Rupture

Construction

The BART Extension is not within an Earthquake Fault Zone as defined by the Alquist-Priolo Act. The Silver Creek Fault, which is a potentially active fault, runs northwest to southeast and lies within the alignment between the proposed Downtown San Jose (East and West Options) and Alum Rock/28th Street Stations.

Although there may be potential for fault rupture impacts along the Silver Creek Fault near Alum Rock/28th Street Station, the BART Extension would be constructed to comply with the California Building Code and the pertinent BART Facilities Standards. The California Building Code and the BART Facilities Standards provide standards intended to permit structures to withstand seismic hazards. They include standards for excavation, grading, construction earthwork, fill embankments, expansive soils, foundation investigations, liquefaction potential, and soil strength loss. Therefore, impacts related to fault rupture would be *less than significant*. No mitigation is required.

Operation

As described above, a potentially active fault lies within portions of the alignment. However, the BART Extension would be designed and constructed in accordance with California Building Code and the pertinent BART Facilities Standards requirements that would ensure that all facilities are constructed to withstand the maximum credible earthquake. Therefore, during operation of the BART Extension, persons or property would not be exposed to potential seismic hazards related to fault rupture, and impacts would be *less than significant*. No mitigation is required.

Ground Shaking

Construction

The BART Extension would be in a seismically active region surrounded by numerous faults. The San Andreas, Hayward, and Calaveras Faults have the greatest potential to release earthquakes that produce strong ground shaking along the alignment. The potential for strong ground shaking to occur along the alignment is moderate to high. The proximity of the faults mentioned above and other nearby active faults, such as Silver Creek Fault, which are capable of generating large magnitude earthquakes means that strong ground shaking would eventually subject the alignment and structures to strong seismic accelerations. Structures could be damaged or destroyed and people could be harmed during a major seismic event originating on any of the nearby faults.

The BART Extension would be designed and constructed to meet or exceed standards set forth by the California Building Code and the pertinent BART Facilities Standards, Release 1.2. These codes and standards are designed to reduce major structural damage and avoid major injury and loss of life in the event of an earthquake. The seismic performance goals generally expect that some property damage would be incurred in a moderate to large earthquake, but that damage would generally be reparable and not life threatening. Because the BART Extension would comply with California Building Code requirements and the pertinent BART Facilities Standards, Release 1.2, impacts related to strong seismic shaking during construction would be *less than significant*. No mitigation is required.

Operation

As described above, the alignment would be in a seismically active region and near several active faults. However, the BART Extension would be designed and constructed in accordance with California Building Code requirements and pertinent BART Facilities Standards, Release 1.2, which would ensure that all facilities are constructed to withstand strong seismic shaking. Therefore, during operation of the BART Extension, persons or property would not be exposed to potential seismic hazards related to ground shaking, and impacts would be *less than significant*. No mitigation is required.

Ground Failure Including Liquefaction

Construction

All of the stations and the Newhall Maintenance Facility would be in areas with moderate liquefaction potential. Approximately 100 and 700 feet northeast of Diridon Station (South and North Options), the alignment would cross two approximately 100-foot-wide stream channels (Los Gatos Creek and Guadalupe River, respectively), where the liquefaction potential is characterized as being very high. The approximately 500-foot-long segment of the alignment near Diridon Station (South and North Options) between the two stream channels is rated as having moderate liquefaction potential. Liquefaction potential is moderate to high and may damage project facilities along the alignment and in station areas.

The BART Extension would be designed and constructed to meet or exceed standards set forth by the California Building Code and the pertinent BART Facilities Standards. The BART Extension would also be designed and constructed using the site-specific measures provided in Mitigation Measure GEO-CNST-A (see Chapter 5, Section 5.5.9, *Geology, Soils, and Seismicity*. Because the BART Extension would comply with California Building Code requirements and pertinent BART Facilities Standards and VTA would implement Mitigation Measure GEO-CNST-A, impacts as a result of liquefaction would be *less than significant*.

Operation

As described above, portions of the alignment would be in areas with soils having moderate or very high liquefaction potential. However, the BART Extension would be designed and constructed in accordance with California Building Code requirements and the pertinent BART Facilities Standards, as well as site-specific mitigation measures prescribed in Mitigation Measure GEO-CNST-A. Therefore, during operation of the BART Extension, persons or property would not be exposed to potential seismic hazards related to ground failure including liquefaction, and impacts would be *less than significant* after mitigation.

Landslides

Construction and Operation

The alignment would be on nearly flat terrain and is not identified as being susceptible to earthquake-induced landslides. There would be *no impact* from potential landslides.

Impact BART Extension GEO-2: Cause soil erosion

Construction and Operation

Construction activities associated with the BART Extension could exacerbate erosion conditions by exposing soils. Additionally, the creation of new impervious surfaces that would generate runoff, along with landscaping irrigation, would add water to the soil during BART Extension operation. However, the BART Extension would be required to include best management practices (BMPs) stipulated in the Stormwater Pollution Prevention Plan in accordance with the state Stormwater National Pollutant Discharge Elimination System (NPDES) Construction General Permit. BMPs employed during construction would include sediment and erosion control measures to prevent pollutants from leaving the site. In addition, post-construction BMPs such as bioswales and raingardens and using soil-water separators and other filters would be incorporated into the design to filter out sediment and other pollutants from runoff and prevent it from being discharged into nearby drainages. Please see Section 6.15, *Water Resources, Water Quality, and Floodplains*, for details.

Additionally, VTA would implement a Phase II Small Municipal Separate Storm Sewer System as part of the NPDES project-specific control measures to reduce the discharge of stormwater pollutants to the maximum extent practicable. Therefore, both potential

short-term construction and long-term operational impacts related to soil erosion would be *less than significant*. No mitigation is required.

Impact BART Extension GEO-3: Be located on a geologic unit that is unstable or that would become unstable

Surface Settlement and Lateral Ground Movement

Construction and Operation

During preliminary engineering, additional analyses were conducted regarding the potential for surface settlements and lateral ground movements during construction of the tunnel and cut-and-cover stations. The purpose of these analyses was to assess the magnitude and likelihood of settlement and ground movement, physical damage to structures or utilities caused by potential settlement or ground movement, and functional significant impacts related to any physical damage on performance of structures or utilities that may be caused by tunnel boring and cut-and-cover construction. The analyses also recommended appropriate mitigation measures.

Along the tunnel alignment, the maximum surface settlement induced during tunnel boring under the Twin-Bore or Single-Bore Options is predicted to be in a range categorized as between negligible and slight. Minor cracking that can easily be patched, and sticking windows or doors, would characterize slight damage. For the Twin-Bore Option, any settlement would be distributed in a trough running parallel to and centered over the twin tunnel bores, with the maximum settlement of approximately 0.5 inch occurring at the centerline of the trough between the two bores. Maximum settlement with the Single-Bore Option is 1 inch.

For cut-and-cover construction, surface settlement varies with distance from the excavation, with a maximum being at the face of the excavation wall to zero at the *limit of influence*, a horizontal distance around the excavation equal to twice the depth of excavation. The maximum surface settlement adjacent to the open cut excavations during construction is predicted to be approximately 1.4 inches. However, the potential for ground settlement during construction is greatly reduced through the use of soil-cement mix or slurry diaphragm walls.

Although surface settlements and ground movements may cause damage to structures, settlement does not necessarily result in damage. Depending on the predicted degree of effect, probability of exceedance, and structural sensitivity to movement, the BART Extension would include ground treatment measures, strengthening of structures, and underpinning of structures on a case-by-case basis prior to tunnel boring or cut-and-cover construction. The BART Extension also would utilize Tunnel Boring Machines to minimize the risk of surface settlements and lateral ground movements. In addition to these design requirements, Mitigation Measures GEO-CNST-B through GEO-CNST-F would be implemented to reduce the magnitude and likelihood of surface settlements and ground

movements, physical damage, or functional effects. The impact would be *less than significant* after mitigation.

Excavation Bottom Stability or Disturbance

Construction and Operation

Soft to medium-stiff clay and loose to medium-dense sand may be encountered at the bottom of excavations for stations. Where these soil conditions occur, excavation bottom instability may result from bottom heave, piping, or blow-out. Bottom heave is typical for excavations in soft clays. Piping may be a concern if the force of the upward flow of water exceeds the buoyant weight of the soil at the excavation bottom. Blow-out is another mode of failure in which a pervious sand layer is located below the clay layer at excavation bottom and is not drained in advance. Blow-out occurs when hydrostatic pressures at the base of the clay layer exceed the shear strength and weight of the clay plug.

If excavation bottom fails due to bottom heave, piping or blow-out, Mitigation Measure GEO-CNST-F would be implemented to reduce impacts to a *less-than-significant* level.

Soft and loose, saturated native soil deposits could be encountered at the excavation bottom. If clay and saturated sand deposits are sufficiently disturbed during construction activities at the bottom of an excavation, the deposits could become soft and loose. Consequently, working conditions at the bottom of the excavation may become difficult and cause the loss of equipment mobility. Adequate measures should be taken to minimize the disturbance of the sensitive deposits at the excavation subgrade. The disturbance of sensitive deposits or the existence of soft or loose ground conditions may be minimized by constructing a working platform as described in Mitigation Measure GEO-CNST-G. With implementation of this mitigation, the impact would be *less than significant*.

Impact BART Extension GEO-4: Be located on expansive soil, creating risks to life or property

Construction

Expansive soils are a concern for the proposed structures for system facilities, parking, and vehicular and pedestrian access at the stations. Some of the soils at station locations and the Newhall Maintenance Facility have high plasticity indices of between 21 and 40, meaning that the soils have moderate to high expansion potential.

The BART Extension would be designed and constructed to meet or exceed standards set forth by the California Building Code, the pertinent BART Facilities Standards and using site-specific mitigation measures described in Mitigation Measure GEO-CNST-H. Because the BART Extension would comply with California Building Code requirements, pertinent BART Facilities Standards and because VTA would implement Mitigation Measure GEO-CNST-H, impacts related to expansive soils would be *less than significant*.

Operation

As described above, portions of the alignment would be in areas with soils having moderate to high expansion potential. However, the BART Extension would be designed and construction in accordance with applicable General Plan policies and California Building Code requirements, pertinent BART Facilities Standards as well as site-specific mitigation measures prescribed in Mitigation Measure GEO-CNST-H. Therefore, during operation of the BART Extension, the existing expansive soils would not create a substantial risk to persons or property, and impacts would be *less than significant*.

Impact BART Extension GEO-5: Reduce availability of a mineral resource

Construction and Operation

The BART Extension would be in areas designated as Mineral Resource Zone (MRZ) 1, which are "areas where adequate information indicates that no significant minerals are present or where it is judged that there is little likelihood exists of their presence" (Surface Mining and Reclamation Act, Public Resources Code Sections 2710–2796). Also, according to the Department of Conservation's Division of Oil, Gas, and Geothermal Resources' Well Finder, there are no active or abandoned oil or gas wells in the alignment (Department of Conservation 2015b). Because no active oil or gas wells or other mineral resource areas have been identified in the alignment, there would be *no impact* on the availability of mineral resources. No mitigation is required.

Impact BART Extension GEO-6: Destroy a unique paleontological resource or unique geologic feature

Construction

The BART Extension would be constructed in areas of San Jose and Santa Clara that have been previously developed. Consequently, any paleontological resource or site or unique geologic feature in these areas would likely have been discovered during previous development. However, because of excavation depths involved in construction of the BART Extension, there is a potential for discovery of previously unknown resources. In the event that construction activities encounter a unique paleontological resource or unique geologic feature, implementation of Mitigation Measure GEO-CNST-I would reduce potential impacts to a *less-than-significant* level.

Operation

There would be *no impacts* on paleontological resources during BART Extension operation. No mitigation is required.

6.8.5.3 BART Extension with TOJD Alternative

Impact BART Extension + TOJD GEO-1: Expose people or structures to potential seismic hazards

Potential hazards related to surface fault rupture, ground shaking, and liquefaction under the BART Extension with TOJD Alternative are similar to those discussed under the BART Extension Alternative. Construction and operations impacts related to fault rupture, ground shaking, and landslides under the BART Extension with TOJD Alternative would be *less than significant*, and no mitigation is required.

Ground Failure Including Liquefaction

All of the stations and the Newhall Maintenance Facility would be in areas with moderate liquefaction potential. Approximately 50 and 650 feet northeast of the Diridon Station South Option, and approximately 100 and 700 feet northeast of the Diridon Station North Option, the alignment would cross two approximately 100-foot-wide stream channels (Los Gatos Creek and Guadalupe River, respectively), where the liquefaction potential is characterized as being very high. The approximately 500-foot-long segment of the alignment near Diridon Station (South and North Options) between the two stream channels is rated as having moderate liquefaction potential.

The BART Extension with TOJD Alternative would be designed and constructed to meet or exceed standards set forth by the California Building Code and the pertinent BART Facilities Standards. The BART Extension with TOJD Alternative would also be designed and constructed using the site-specific measures provided in Mitigation Measure GEO-CNST-A. Because the BART Extension with TOJD Alternative would comply with California Building Code requirements and pertinent BART Facilities Standards and VTA would implement Mitigation Measure GEO-CNST-A, construction- and operations-related impacts as a result of liquefaction would be *less than significant*.

Impact BART Extension + TOJD GEO-2: Cause soil erosion

Impacts related to soil erosion under the BART Extension with TOJD Alternative would be similar to those discussed under the BART Extension Alternative. Both potential short-term construction and long-term operational impacts related to soil erosion would be *less than significant*. No mitigation is required.

Impact BART Extension + TOJD GEO-3: Be located on a geologic unit that is unstable or that would become unstable

Impacts and mitigation measures related to surface settlements, ground movements, and excavation bottom stability or disturbance under the BART Extension with TOJD Alternative would be similar to those described under the BART Extension Alternative. Implementation of Mitigation Measures GEO-CNST-B through GEO-CNST-G would reduce impacts to *less-than-significant* levels.

Impact BART Extension + TOJD GEO-4: Be located on expansive soil, creating risks to life or property

Construction and operations impacts and mitigation measures related to expansive soil under the BART Extension with TOJD Alternative would be similar to those described under the BART Extension Alternative. Implementation of Mitigation Measure GEO-CNST-H would reduce these impacts to *less-than-significant* levels.

Impact BART Extension + TOJD GEO-5: Reduce availability of a mineral resource

As under the BART Extension Alternative, there would be *no impact* on the availability of mineral resources under the BART Extension with TOJD Alternative. No mitigation is required.

Impact BART Extension + TOJD GEO-6: Destroy a unique paleontological resource or unique geologic feature

As discussed under the BART Extension Alternative, construction impacts related to paleontological resources and unique geologic features under the BART Extension with TOJD Alternative would be *less-than-significant* with implementation of Mitigation Measure GEO-CNST-I. There would be *no operational impact* related to paleontological resources and unique geologic features under the BART Extension with TOJD Alternative, and no mitigation is required.

6.8.6 CEQA Conclusion

Implementation of Mitigation Measures GEO-CNST-A through GEO-CNST-I and adherence to both the California Building Code requirements and pertinent BART Facilities Standards would minimize the potential effects related to liquefaction, expansive soils, surface settlement and lateral ground movement, and excavation bottom failure or disturbance, along with potential impacts on paleontological resources or geologic features, to *less-than-significant* levels for the BART Extension Alternative and the BART Extension with TOJD Alternative.

For the BART Extension Alternative and the BART Extension with TOJD Alternative, potential impacts related to fault rupture, ground shaking, and erosion would be *less than significant* with adherence to California Building Code requirements and pertinent BART Facilities Standards.

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