3.5 Geology, Soils, and Paleontological Resources

3.5.1 Introduction

This section describes the regulatory and environmental setting for geology, soils, and paleontological resources in the vicinity of the Project. It also describes the potential impacts related to geology, soils, and paleontological resources that would result from the operation and/or construction of the Project and mitigation measures that would reduce significant impacts, where feasible and appropriate. Some impacts related to geology and seismicity are not included in this section; they are discussed in Chapter 4, *Other CEQA-Required Analysis*. Cumulative impacts on geology, soils, and paleontological resources, in combination with planned, approved, and reasonably foreseeable projects, are discussed in Section 3.11, *Cumulative Impacts*.

3.5.2 Regulatory Setting

3.5.2.1 Federal Regulations

Federal Railroad Administration

In the event of a natural disaster, such as an earthquake or landslide, 49 Code of Federal Regulations (CFR) Part 213, Section 213.239, *Special Inspections,* requires that the Federal Railroad Administration and the rail operator conduct a special inspection of the track involved as soon as possible after the occurrence and, if possible, before the operation of any train over the track.

Paleontological Resources Preservation Act

The federal Paleontological Resources Preservation Act of 2002 was enacted to codify the generally accepted practice of limiting the collection of vertebrate fossils and other rare and scientifically significant fossils to qualified researchers. These researchers must obtain a permit from the appropriate federal or state agency and agree to donate any materials recovered to recognized public institutions, where they will remain accessible to the public and other researchers.

3.5.2.2 State Regulations

International Building Code 2021 and American Society of Civil Engineers 7

International Building Code 2021 and American Society of Civil Engineers 7, codes and standards that provide minimum design loads for buildings and other structures, would be used for the design of the Project's maintenance facilities and stations. Sections in these codes and standards also provide minimum requirements for geotechnical investigations, levels of earthquake ground shaking, minimum standards for structural design, and inspection and testing requirements.

California Building Standards Code

California Code of Regulations (CCR) Title 24, the California Building Standards Code, governs the design and construction of buildings, associated facilities, and equipment and applies to most buildings in California. Standards cover general building design and construction requirements related to fire and life safety, structural safety, and access compliance.

California Environmental Quality Act and California Environmental Quality Act Guidelines for Protection of Paleontological Resources

The California Environmental Quality Act (CEQA; California Public Resources Code [PRC] 21000 et seq.) and CEQA Guidelines (Title 14 CCR § 15064.7) provide specific guidance for determining the significance of impacts on historic and unique archaeological resources. Under CEQA, these resources are called historical resources whether they are of historic or prehistoric age.

The CEQA Guidelines define procedures, types of activities, persons, and public agencies required to comply with CEQA. Section 15064.7(b) prescribes that project effects that would "cause a substantial adverse change in the significance of an historical resource" are significant effects on the environment. Substantial adverse changes include physical changes to both the historical resource and its immediate surroundings.

Appendix G of the CEQA Guidelines provides an environmental checklist of questions that a lead agency should normally address if relevant to a project's environmental impacts. One of the questions to be answered in the Environmental Checklist (§ 15023, Appendix G, Section V, part c) is: "Would the project directly or indirectly destroy a unique paleontological resource or site?" Although CEQA does not define what constitutes a unique paleontological resource or site, PRC Section 21083.2 defines unique archaeological resources as any archaeological artifact, object, or site about which it can be clearly demonstrated that, without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

- Contains information needed to answer important scientific research questions and show that there is a demonstrable public interest in that information.
- Exhibits a special and particular quality, such as being the oldest of its type or the best available example of its type.
- Is directly associated with a scientifically recognized important prehistoric or historic event or person.

This definition is equally applicable to recognizing a unique paleontological resource or site. CEQA Section 15064.7(a)(3)(D) provides additional guidance, indicating that "generally, a resource shall be considered historically significant if it has yielded, or may be likely to yield, information important in prehistory or history."

The CEQA lead agency having jurisdiction over a project is responsible for ensuring that paleontological resources are protected in compliance with CEQA and other applicable statutes. PRC Section 21081.6, Mitigation Monitoring Compliance and Reporting, requires that the CEQA lead agency demonstrate project compliance with mitigation measures developed during the environmental impact review process.

California Public Resources Code

Section 5097.5 of the PRC protects artifacts at paleontological sites, including fossilized footprints, that are situated on public lands, except with the permission of the public agency with jurisdiction over the lands. Public lands are defined as lands owned by the state, any city, county, district, authority, or public corporation. Disturbing paleontological resources on public lands under this section of the PRC is a misdemeanor.

3.5.2.3 Regional and Local Regulations

Madera County General Plan

The *Madera County, California, General Plan – Section 4, Recreational and Cultural Resources* (County of Madera 1995) contains the following goals, policies, and implementation programs relevant to geology, soils, and paleontological resources that could be impacted by the Project.

> Goal 4.D: To identify, protect, and enhance Madera County's important historical, archaeological, paleontological, and cultural sites and their contributing environment.

> Policy 4.D.1: The County shall solicit the views of the local Native American community in cases where development may result in disturbance to sites containing evidence of Native American activity and/or to sites of cultural importance.

> Policy 4.D.2: The County shall coordinate with the cities and advisory councils in the county to promote the preservation and maintenance of Madera County's paleontological, archaeological, and historical resources.

> Policy 4.D.3: The County shall require that discretionary development projects identify and protect from damage, destruction, and abuse, important historical, archaeological, paleontological, and cultural sites and their contributing environment.

> Implementation Program 4.5: The County shall develop preservation incentive programs for owners of important cultural and paleontological resources, using such mechanisms as the Mills Act, the Historic Preservation Easement program, the Certified Local Government program, and the Heritage Tourism program.

The *Madera County, California, General Plan – Section 6, Health and Safety* (County of Madera 1995) contains the following goals, policies, and implementation programs relevant to geology, soils, and paleontological resources that could be impacted by the Project.

> Policy 6.A.1: The County shall require the preparation of a soils engineering and geologic-seismic analysis prior to permitting development in areas prone to geological or seismic hazards (i.e., groundshaking, landslides, liquefaction, critically expansive soils).

> Policy 6.A.2: In landslide hazard areas, the County shall prohibit avoidable alteration of land in a manner that could increase the hazard, including concentration of water through drainage, irrigation, or septic systems; removal of vegetative cover; and steepening of slopes and undercutting the bases of slopes. Areas of known landslides should be designated for open space uses.

> Policy 6.A.3: The County shall limit development in areas of steep or unstable slopes to minimize hazards from landslides. Development will be prohibited in areas with slopes of 30 percent or more unless it can be demonstrated by a registered engineer or registered engineering geologist that such development will not present a public safety hazard.

Policy 6.A.4: The County shall continue to support scientific geologic investigations that refine, enlarge, and improve the body of knowledge on active fault zones, unstable areas, severe groundshaking, and other hazardous conditions in Madera County.

Madera County Local Hazard Mitigation Plan Update (2017)

The *Madera County Local Hazard Mitigation Plan Update* (County of Madera 2017) was developed by Madera County and three participating jurisdictions: the Cities of Chowchilla and Madera and the North Fork Rancheria of Mono Indians to make the County and its residents less vulnerable to future hazard events. The Plan Update was designed to identify hazards, including natural and human-made hazards, to which the County is exposed and develop strategies to help reduce or eliminate long-term risk to people and property as identified in the Disaster Mitigation Act of 2000.

3.5.2.4 Industry Design Standards and Guidelines

The design and construction of the Project would conform to industry-wide engineering design guidelines and standards. These guidelines and standards define the parameters for the design and construction of facilities that protect the users of the facilities and others that may be affected by public use of the facility. Each improvement associated with the Project would be designed to handle normal operating loads from the weight of the structure or train, as well as loads from environmental conditions, such as seismic shaking and wind forces. At locations where geologic conditions present a hazard, the guidelines and standards identify minimum requirements for characterizing the geologic conditions and then addressing the design issue, such as the stability of slopes, corrosion of materials, and best management practices (BMPs) for water and wind, erosion, stream sedimentation, or dust control.

These guidelines and standards provide requirements for evaluating soil conditions, defining seismic loads, and evaluating the response of the foundation systems. Minimum performance requirements are also provided. The guidelines and standards also provide direction when minimum performance requirements are not met. Primary guidelines and standards that would be incorporated as part of the Project to reduce risks associated with geology and soils are highlighted in this section.

American Association of State Highway and Transportation Officials Bridge Design Standards

The American Association of State Highway and Transportation Officials' (AASHTO) *Load and Resistance Factor Design Bridge Design Specifications* (2012) and *Guide Specifications for Load and Resistance Factor Seismic Bridge Design* (2011) provide guidance for characterization of soils, as well as methods to be used in the design of bridge foundations and structures, retained cuts and retained fills, at-grade segments, and buried structures. These design specifications would provide minimum specifications for evaluating the seismic response of soils and structures.

Federal Highway Administration Guidance

Federal Highway Administration circulars and reference manuals provide detailed guidance on the characterization of geotechnical conditions at sites, methods for performing foundation design, and recommendations on foundation construction. These guidance documents include methods for designing retaining walls used for retained cuts and retained fills, foundations for elevated structures, and at-grade segments. Some of the documents include guidance on methods of design to reduce the risk of geologic hazards that are encountered during design.

American Railroad Engineering and Maintenance-of-Way Association Manual

The American Railway Engineering and Maintenance-of-Way Association's *Manual for Railway Engineering* (AREMA 2019) deals with rail systems. Although these guidelines cover many of the same general topics as AASHTO, they are more focused on BMPs for rail systems. The manual includes principles, data, specifications, plans, and economics pertaining to the engineering, design, and construction of railways.

ASTM International

American Society for Testing and Materials (ASTM) is a standards organization that develops and publishes voluntary consensus technical international standards for a wide range of materials, products, systems and services. The *Annual Book of ASTM Standards,* ASTM International (2024) has developed standards and guidelines for all types of material testing, from soil classifications to pile-load testing or compaction testing to concrete strength testing. ASTM standards also include minimum performance requirements for materials. Most of the guidelines and standards cited in the preceding sections use ASTM or a corresponding series of standards from AASHTO to achieve the required and intended quality in the constructed project.

Society of Vertebrate Paleontology

The Impact Mitigation Guidelines Revisions Committee of the Society of Vertebrate Paleontology (SVP) has published *Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources* (2010) that include procedures for the investigation, collection, preservation, and cataloguing of fossil-bearing sites. The Standard Guidelines are widely accepted among paleontologists and are followed by most investigators.

3.5.3 Environmental Setting

This section describes the environmental setting related to geology, soils, and paleontological resources that could be impacted by the Project.

Information presented in this section related to geology, soils, and paleontological resources was obtained from the following sources.

- Geographic Information Systems (GIS) data from the U.S. Department of Agriculture's (USDA) Soil Survey Geographic Database (SSURGO), California Department of Conservation, California Geological Survey (CGS), and U.S. Geological Survey (USGS).
- Data referenced in the 2*024 Madera High Speed Rail Station Full-Build Project (Phase 3) Initial Study* (SJJPA 2024) (Appendix E), is included by reference.

3.5.3.1 Geology

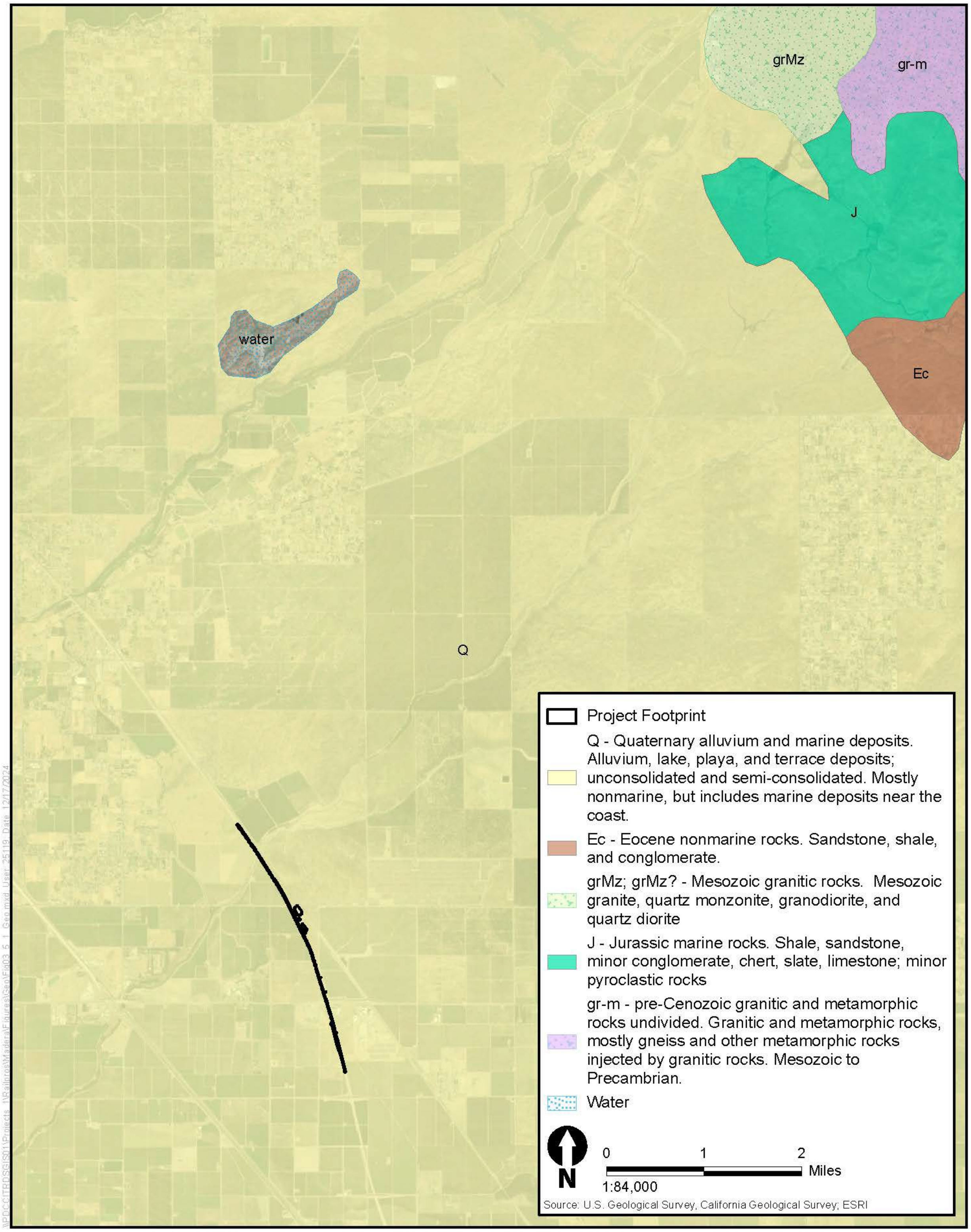
The Project Footprint is located in Madera County. Geological units underlying the Project Footprint consist exclusively of Quaternary alluvium and marine deposits (**Figure 3.5-1**). The Project Footprint varies in elevation by approximately 1 foot east to west and approximately 20 feet north to south over a distance of more than 2 miles. The Project Footprint is not situated on a geological unit nor soils that are prone to geological hazards, such as landslides or liquefaction.

3.5.3.2 Soils

Soil type is one criterion used to evaluate potential impacts of development on the environment. Depending on type, some soils are susceptible to erosion or expansive behavior, whereas others are more suitable for construction. Soil type mapping, emphasizing a soil's agricultural and engineering properties, is conducted typically on a countywide (or geographic) basis, using nomenclature that changes with time.

Figure 3.5-2 depicts soil survey units underlying the Project Footprint (USGS 2019). Soil types present onsite predominately include San Joaquin–Whitney sandy loams, 0- to 3-percent slopes (ScB), Hanford fine sandy loam, 0- to 1-percent slopes (HaA), Alamo Clay, 0- to 1-percent slopes (AsA), and Delhi sand, moderately deep and deep over hardpan 0- to 3-percent slopes (DfA). **Table 3.5-1** displays the number of acres of each soil type found within the Project Footprint (USGS 2019).

Figure 3.5-1: Geologic Unit Mapping



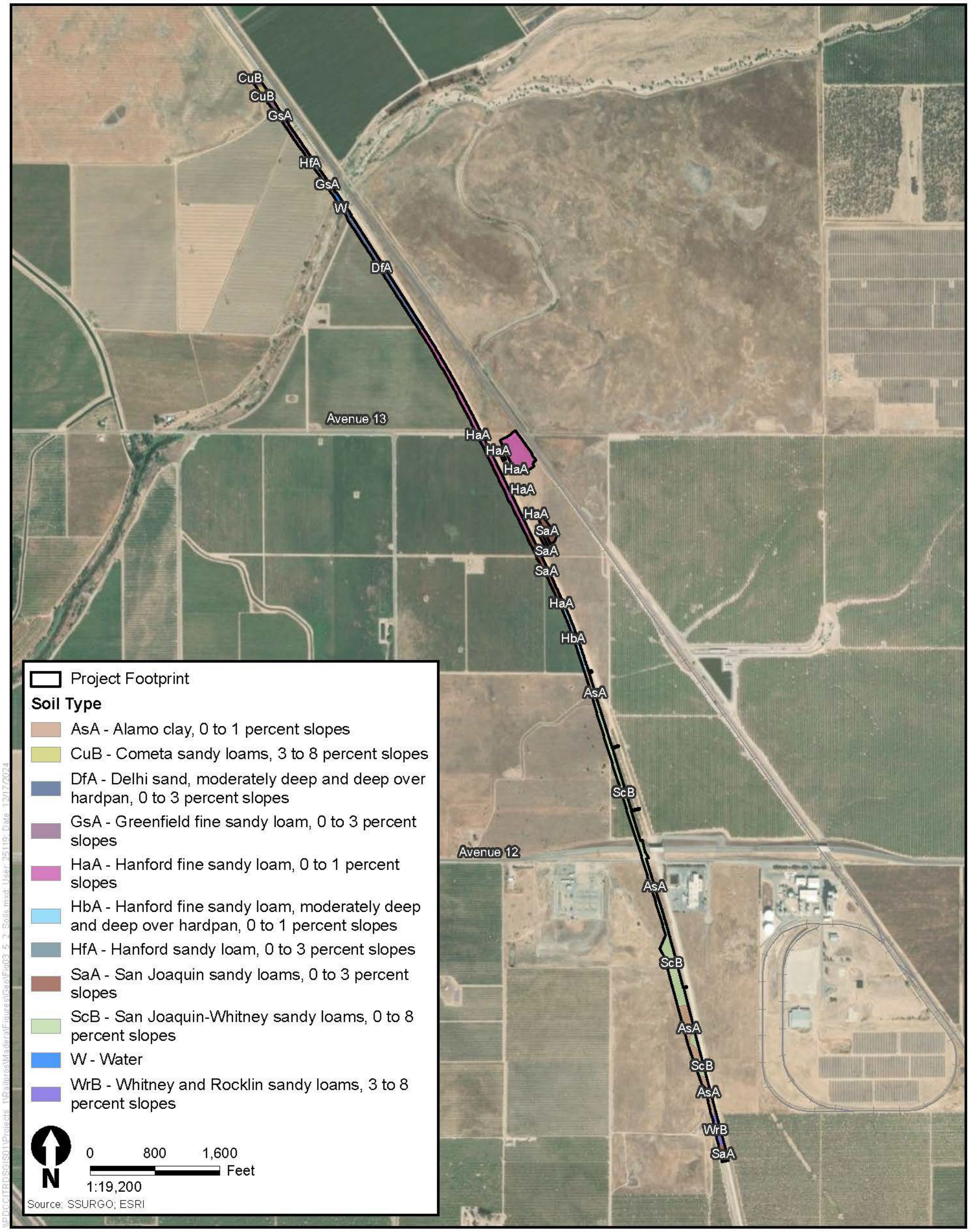
Source: (USGS, 2019)

Table 3.5-1: Soil Types Present within the Project Footprint

Soil Type	Acres
Alamo clay, 0–1% slopes	14.63
Cometa sandy loams, 3–8% slopes	0.89
Delhi sand, moderately deep and deep over hardpan, 0–3% slopes	12.16
Greenfield fine sandy loam, 0–3% slopes	9.38
Hanford fine sandy loam, 0–1% slopes	27.65
Hanford fine sandy loam, moderately deep and deep over hardpan, 0–1% slopes	6.56
Hanford sandy loam, 0–3% slopes	1.76
Hanford sandy loam, moderately deep and deep over hardpan, 0–3% slopes	1.71
Pachappa fine sandy loam, 0–1% slopes	0.38
San Joaquin sandy loams, 0–3% slopes	10.05
San Joaquin–Whitney sandy loams, 0–8% slopes	36.61
Water	1.32
Whitney and Rocklin sandy loams, 3–8% slopes	2.26
Total	**125.37**

Source: (USGS, 2019)

Figure 3.5-2: Soil Type Mapping



Source: (USGS, 2019)

Soil Conditions

Expansive Soils

Shrink-swell potential reflects the ability of some soils with high clay content to change in volume with a change in moisture content. Plasticity Index (PI) can serve as an indicator for the potential for soils to swell when wetted and shrink when dried. Expansive soils are subject to shrinking and swelling with seasonal changes in moisture content. Soil expansion and contraction can cause damage or failure of foundations, utilities, and pavements. Soils below the depth of the permanent water table or that are inundated are not subject to shrinking and swelling. The Natural Resources Conservation Service (NRCS) has determined the PI for each soil unit. A low PI generally corresponds to a low shrink-swell potential, and a high PI generally corresponds to a high shrink-swell potential.

According to the USDA's NRCS Web Soil Survey, the Project Footprint is underlain by Alamo clay (AsA), San Joaquin sandy loam (SaA), and San Joaquin Whitney sandy loam (ScB; USDA 2023). There is a lesser area underlain by Hanford fine sandy loam (HbA). SSURGO identified the presence of additional soil types within the Project Footprint, including but not limited to Cometa sandy loams (CuB), Greenfield fine sandy loam (GsA), Hanford fine sandy loam (HaA), Hanford sandy loam (HfA), Hanford sandy loam (HgA), and Pachappa fine sandy loam (PaA; **Figure 3.5-2**)[1]. The San Joaquin sandy loam soil unit is composed of 90-percent San Joaquin soils, with the remainder (i.e., 10 percent) of a variety of minor soil types. San Joaquin Valley soils are characterized by moderate drainage, slow water movement, very low water availability to a depth of 2.1 inches, and high shrink-swell potential.

Except for Alamo clay, these soils are all classified as moderately to well drained and consist of loam, sand, and sandy loams. Most of the soils in the upper 5 feet of the soil profile within the Project Footprint were generally found to have moderate-to-high shrink-swell potential. The soils of the older, low alluvial terraces contain expansive clays, giving these soils a high shrink-swell potential.

The typical soils profile of Alamo clay is clay layers and compacted soil to approximately 30 inches in depth and sandy loam beyond. According to the California Department of Water Resources, groundwater monitoring–service levels taken in March and October of 2022 and March 2023 from the two nearest water wells located approximately 2 miles from the Project Footprint had depths to groundwater of 170 and 190 feet below ground surface (bgs; DWR, 2023). In general, the groundwater table in the Project Footprint has fluctuated between 150 and 300 feet bgs (DWR, 2020).

Corrosive Soils

Soil corrosivity measures the potential for corrosion of concrete and steel caused by contact with some types of soil. Knowledge of potential soil corrosivity is often critical for the effective design parameters associated with cathodic protection of buried steel and concrete mix design for plain or reinforced concrete buried project elements. Several factors—including soil composition, soil and pore water chemistry, moisture content, and pH—affect the response of concrete and steel to soil corrosion. Soils with high moisture content, high electrical conductivity, high acidity, and high dissolved-salts content are most corrosive. In general, sandy soils have high resistivity and are the least corrosive. Clayey soils, including those that contain interstitial saltwater, can be highly

[1] Acronyms presented above will not be used in place of their definitions in the main text.

corrosive. The Project Footprint is located on soils that are almost entirely classified as sandy loam. These soils have high resistivity and are not very corrosive. Alamo clay is also located throughout the Project Footprint and would be the most corrosive soil found onsite.

Collapsible Soils

Collapsible soils are soils that undergo volume reduction or settlement on the addition of water, which weakens or destroys soil particle bonds of loosely packed structure, reducing the bearing capacity of the soil. Other mechanisms for soil collapse include the sudden closure of voids in a soil, whereby the sudden decrease in volume results in loss of the soil's internal structure, causing the soil to collapse. Specific soil types, such as loess and other fine-grained aeolian soils, are most susceptible to collapse, although certain coarser-grained, rapidly deposited alluvial soils can also be susceptible. Location-specific data on the collapsible soils are generally collected during geotechnical investigations. The Project Footprint is almost entirely composed of sandy loam and clay, which are not an immediate threat to collapse. Laboratory testing of soils may take place in order to identify soils susceptible to collapse.

Erodible Soils

The potential for erosion by water or wind is a function of the cohesiveness of the soil particles. The NRCS has quantified the potential for erosion by water with the K factor, with lower K factor values indicating soils resistant to detachment and not easily susceptible to movement by water (i.e., erosion), and high K factor values indicating soils that are more easily detached by water and, therefore, more erodible. Soils on steep slopes are often erodible, especially during heavy rain events. The wind erodibility index is a numerical value indicating the susceptibility of soils to wind erosion: the higher the wind erodibility index, the higher susceptibility to wind erosion.

The Project Footprint is flat, and the elevation changes in the site and surrounding area are minimal. According to the USDA's NRCS Web Soil Survey, the erodibility of onsite soils both for water- and wind-related erosion ranges from very low to high, depending on the soil classifications. Soils with a higher clay content and a reduced capacity for drainage, such as the Alamo series, would be more susceptible to erosion. Approximately 14 percent of the overall Project Footprint contains Alamo clay, whereas the balance of the onsite soils has a low potential for erodibility (USDA 2023).

Liquefaction

Liquefaction is the process by which water-saturated materials lose strength and may fail during strong ground shaking, when granular materials are transformed from a solid state into a liquefied state as a result of increased pore-water pressure. The susceptibility of an area to liquefaction is determined largely by the depth to groundwater and the properties (e.g., grain size, density, and degree of consolidation) of the soils and sediment within and above the groundwater. The sediments most susceptible to liquefaction are saturated, unconsolidated sand and silt within 50 feet of the ground surface (CGS, 2008:35–36). Soil types in Madera County generally are not conducive to liquefaction because they are either too coarse in texture or too high in clay content, soil types that reduce the potential for liquefaction. The Project Footprint is also located a substantial distance from known active fault zones, and the intensity of any anticipated ground shaking and the underlaying soils and depth to groundwater further reduce the potential for liquefaction.

Lateral Spreading

Lateral spreading is a finite, lateral displacement of gently sloping ground that occurs from liquefaction or pore-pressure buildup in a shallow underlying deposit during an earthquake. Lateral spreading generally occurs on mild slopes of 0.3 to 5.0 percent that are underlain by loose soil deposits and a shallow water table. The Project Footprint is mostly flat and not underlain by unstable soils. However, the Project Footprint is located in a low-to-moderately active seismic region and is susceptible to earthquakes. Given this, the Project Footprint is considered to have low-to-moderate risk pertaining to liquefaction and lateral spreading.

Seismically Induced Landslides

Landslides triggered by earthquakes have historically been a significant source of damage in California. Areas that are most susceptible to earthquake-induced landslides are steep slopes in poorly cemented or highly fractured rocks, areas underlain by loose, weak soils, and areas on or adjacent to existing landslide deposits. According to the U.S. Landslide Inventory (USGS, 2023), the Project Footprint is not located within an area with potential risk of landslide(s). The Project Footprint varies in elevation by approximately 1 foot east to west and approximately 20 feet north to south, over a distance of more than 2 miles. The surrounding areas are flat and do not contain slopes that would be susceptible to landslides, such as steep terrains and hillsides. Given this, the Project Footprint is considered to have low risk of seismically induced landslides.

3.5.3.3 Paleontological Resources

Paleontological resources, commonly referred to as fossils, are the remains, traces, imprints, or life history artifacts (e.g., nests) of prehistoric plants and animals found in ancient sediments, which may be either unconsolidated or lithified (i.e., either poorly or well cemented). Fossils, considered nonrenewable scientific and educational resources, include the bones and teeth of animals, the casts and molds of ancient burrows and animal tracks, and very small remains, such as the bones of birds and rodents. They also include plant remains, such as logs, prehistoric leaf litter, and seeds. The area surrounding the Project Footprint is known to have yielded paleontological resources in the past at a depth of 40 feet bgs.

The determination of paleontological sensitivity is a qualitative assessment, based on the paleontological resource potential of the stratigraphic units present, the local geology and geomorphology, and other factors relevant to fossil preservation and potential yield. According to the SVP (2010), standard considerations for determining sensitivity are: (1) the potential for a geological unit to yield abundant or significant vertebrate fossils or to yield a few significant fossils, large or small, of vertebrate, invertebrate, or paleobotanical remains; and (2) the importance of recovered evidence with respect to new and significant taxonomic, phylogenetic, paleoecological, or stratigraphic data.

Unlike archaeological sites, which are narrowly defined, paleontological sites are defined by the entire extent (i.e., both areal and stratigraphic) of a unit or formation. In other words, once a unit is identified as containing vertebrate fossils or other rare fossils, the entire unit is considered to be paleontologically sensitive. For this reason, the paleontological sensitivity of geologic units is described and analyzed broadly below, in **Table 3.5-2**.

Table 3.5-2: Paleontological Sensitivity Ratings

Potential	Definition
High	Rock units from which vertebrate or significant invertebrate, plant, or trace fossils have been recorded are considered to have high potential with respect to containing additional significant paleontological resources. Paleontological potential considers both: (1) the potential for yielding abundant or significant vertebrate fossils or a few significant fossils, large or small, of vertebrate, invertebrate, plant, or trace fossils; and (2) the importance of recovered evidence with respect to new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data.
Undetermined	Rock units for which little information is available concerning their paleontological content, geologic age, and depositional environment are considered to have undetermined potential. Further study is necessary to determine if these rock units have high or low potential with respect to containing significant paleontological resources.
Low	Reports in the paleontological literature or field surveys by a qualified professional paleontologist may lead to a determination that some rock units have low potential for yielding significant fossils. Such rock units will be poorly represented by fossil specimens in institutional collections or, based on general scientific consensus, will preserve fossils only in rare circumstances. The presence of fossils is the exception, not the rule.
None	Some rock units, such as high-grade metamorphic rocks (e.g., gneisses and schists) and plutonic igneous rocks (e.g., granites and diorites), have no potential to contain significant paleontological resources. Rock units with no potential require neither protection nor mitigation measures relative to paleontological resources.

Source: (SVP, 2010:1–2)

The Project is in an area that has moderate to high paleontological sensitivity and is underlain by mid- to late-Pleistocene deposits. These areas consist of three stratigraphic units from top to bottom: the Modesto, Riverbank, and Turlock Lake formations, the last of which is highly sensitive for paleontological resources. Fossils have been recovered from the Turlock Lake Formation elsewhere in Madera County at depths of 40 feet bgs.

3.5.4 Impact Analysis

3.5.4.1 Methods for Analysis

Geology and Soils

Geology and soils impacts are analyzed qualitatively, based on a review of published geologic and soils information for the Project Footprint and on professional judgment, in accordance with the current standard of care for geotechnical engineering and engineering geology. The analysis focuses on the potential of the Project, during construction and operation, to increase the risk of personal injury, loss of life, and damage to property given the existing geologic conditions in the Project Footprint.

Paleontological Resources

To address potential impacts to paleontological resources, an evaluation was undertaken of existing conditions and previous disturbances in the Project Footprint, geology of the Project Footprint, and anticipated depths of grading.

3.5.4.2 Thresholds of Significance

CEQA Guidelines Appendix G (Title 14 CCR § 15000 et seq.) identifies criteria for determining the significance of impacts on geology, soils, and paleontological resources. Construction or operation of the Project would result in significant impacts due to any of the following:

1. 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
2. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (International Conference of Building Officials, 1994), creating substantial risks to life or property
3. Directly or indirectly destroy a unique paleontological resource or site or unique geological feature

3.5.4.3 Impacts and Mitigation Measures

Project Construction

Impact GEO-1	Construction of the Project would not 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.
Level of Impact	**Less than Significant with Mitigation Incorporated**

The Project would be constructed in an area that is relatively flat, with little to no slope, and where existing groundwater is generally 150 to 300 feet bgs (DWR, 2020). The Project Footprint is not located in proximity to any active faults or unstable geologic units, nor situated on soils that are prone to landslides or liquefaction.

Land subsidence is the gradual settling or sinking of an area with little or no horizontal motion because of changes taking place underground. Although it is a natural process, land subsidence can also occur and be accelerated as a result of human activities, such as groundwater pumping, oil and gas extraction from underground reservoirs; dissolution of limestone aquifers (sinkholes); collapse of underground mines, drainage of organic soils, and initial wetting of dry soils. The Project would be constructed above existing groundwater levels and does not propose groundwater withdrawals, nor does it include any elements or uses (e.g., residential, commercial, industrial) that would result in a substantial increase in groundwater withdrawal from local aquifers. Similarly, the Project does not propose extraction of oil and/or gas from underground reservoirs that could exacerbate the potential for subsidence. The Project Footprint has not been used for mining, nor are there mines near the Project Footprint that could increase the potential for subsidence to occur.

However, there is potential for soils to collapse near-surface soils that vary in composition, both vertically and laterally. Although the Project is not located near any active faults, strong ground shaking from earthquakes are a regular occurrence throughout California and can cause non-uniform compaction of the soil strata, resulting in movement of the near-surface soils and collapse. Therefore, Project construction would result in a significant impact related to being located on a geologic unit or soil that is unstable.

To reduce potential impacts resulting from soil conditions that could cause the Project Footprint to be susceptible to landslide, lateral spreading, subsidence, liquefaction, or collapse, Mitigation Measure (MM) GEO-1 would be implemented to ensure a geotechnical report is prepared in accordance with California Building Code (CBC) (CCR Title 24). Implementation of MM GEO-1 and adherence to all applicable regulations would reduce impacts associated with potential landslide, lateral spreading, subsidence, liquefaction, or collapse. After implementation of MM GEO-1, impacts would be less than significant during Project construction.

MM GEO-1: Implement and follow the Recommendations of a Geotechnical Report

A geotechnical report will be prepared for the Project and identify onsite soils, depth to groundwater, and other conditions that could cause the site to be susceptible to landslide, lateral spreading, subsidence, liquefaction, or collapse. The geotechnical report will include required elements of the California Building Code (CCR Title 24) and prescribe appropriate design features and construction measures to minimize potential adverse effects related to seismic-related ground failure, including liquefaction. Potential strategies would include but are not limited to: simple spans with large and elongated bearing seats, enhanced derailment containment, seismic isolation and dissipation devices, and ductile and thickened reinforced mat concrete foundations. The geotechnical study will include requirements and measures that would be incorporated into the Project design and engineering.

Impact GEO-2	Construction of the Project would not create substantial risks to life or property relative to being located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994).
Level of Impact	**Less than Significant with Mitigation Incorporated**

As noted above, the Project Footprint is on relatively flat land in the San Joaquin sandy loam soil unit. San Joaquin Valley soils are characterized by moderate drainage, slow water movement, very low water availability to a depth of 2.1 inches, and high shrink-swell potential.

The earth loads associated with at-grade segments of the track alignment would not be sufficient to overcome swell potential due to soils in the area with shrink-swell potential. This impact is considered to have substantial intensity because it would result in loss of life or substantial property damage due to unacceptable swell potential in soils, and the potential for the failure of facilities, if not adequately addressed during design and construction, which would result in a significant impact.

Expansive soils are generally associated with silt and clay soils, which are subject to shrinking and swelling due to the large pore volume and the fact that large changes in moisture content during dry and wet periods can affect their ability to support overlying structures. Expansive soils need not be located throughout a site because variations in subsurface soils beneath different parts of a structure resulting in shrinking and swelling of soils can cause damage or failure of portions of foundations, utilities, and pavements in localized areas. More specifically, during periods of high moisture content, expansive soils under foundations can heave and result in structures lifting. In dry periods, the same soil can lose strength, collapse, and result in settlement of structures. According to the USDA's NRCS Web Soil Survey, a portion of the Project Footprint is located within an area mapped as Alamo clay, which is poorly drained. The balance of the soil within the Project Footprint is well-to-very-well drained (USDA 2023). As previously stated, the earth loads associated with at-grade segments of the track alignment would not be sufficient to overcome swell potential due to soils in the area with shrink-swell potential. Potential impacts resulting from expansive soils would be significant during construction activities.

To reduce potential impacts associated with soil expansion, MM GEO-1 would be implemented that would require the preparation of a site-specific evaluation in the geotechnical report evaluating soil conditions prior to construction activities. The site-specific evaluation would identify recommendations for ground preparation and earthwork specific to the Project Footprint and would become an integral part of the Project design. The geotechnical report would be prepared to identify site-specific areas and magnitudes where expansive soils could occur, and appropriate building techniques (e.g., treating soil with lime to reduce expansive characteristics, excavating expansive soil and replacing with clean fill dirt) would be proposed to prevent damage to foundations related to this hazard. Additionally, the Project would be constructed to meet Madera County's design standards for grading and comply with the CBC. After implementation of MM GEO-1, impacts would be less than significant during Project construction.

Impact GEO-3	Construction of the Project would directly or indirectly destroy a unique paleontological resource or site or unique geological feature.
Level of Impact	**Less than Significant with Mitigation Incorporated**

There are no unique geologic features within the Project Footprint. Therefore, the Project would result in no impact on unique geologic features. As noted above, the Project is in an area that has moderate to high paleontological sensitivity and is underlain by mid-to-late Pleistocene deposits. The area in the vicinity of the Project Footprint is known to have yielded paleontological resources in the past at a depth of 40 feet bgs.

Construction activities associated with the Project would result in excavation for foundations, footings, retaining walls, and borings for structure support. Although excavation depths anticipated for this part of the Project would not likely affect resources at a depth of 40 feet bgs. However, the Project is located in an area with high paleontological sensitivity, and unknown paleontological resources have a high likelihood to be encountered during construction activities, which would result in a significant impact.

In areas determined to have high or undetermined potential for significant paleontological resources, implementation of MM GEO-2, GEO-3, and GEO-4 would reduce the potential impacts to unknown paleontological resources by ensuring a qualified paleontologist would oversee surveying, monitoring, salvage, identification, cataloguing, curation, and provision for repository storage, and reporting. After implementation of MM GEO-2 through MM GEO-4, impacts would be less than significant during Project construction.

MM GEO-2 Paleontological Monitoring During Construction.

At least 120 days prior to construction, a paleontological resources monitor will be designated for the Project and will be responsible for determining where and when paleontological resources monitoring should be conducted. The paleontological resources monitor will be selected based on their qualifications, and the scope and nature of their monitoring will be determined and directed based on the Paleontological Resource Monitoring and Mitigation Plan (PRMMP). The paleontological resources monitor will be responsible for developing and implementing the Worker Environmental Awareness Program (WEAP) training. All management and supervisory personnel and construction workers involved with ground-disturbing activities will be required to take this training prior to beginning work on the Project and will be provided with the necessary resources for response in case paleontological resources are found during construction. The paleontological resources monitor will document any discoveries, as needed, evaluate the potential resource, and assess the significance of the find under the criteria set forth in CEQA Guidelines Section 15064.5.

MM GEO-3 Prepare and Implement a Paleontological Resources Monitoring and Mitigation Plan (PRMMP)

Paleontological resources monitoring and mitigation measures are restricted to those construction-related activities that will result in the disturbance of paleontologically sensitive sediments. The PRMMP will include a description of when and where construction monitoring will be required; emergency discovery procedures; sampling and data recovery procedures; procedures for the preparation, identification, analysis, and curation of fossil specimens and data recovered; preconstruction coordination procedures; and procedures for reporting the results of the monitoring and mitigation program. In general, the monitoring program will reflect site-specific construction of the selected option. The PRMMP will be consistent with SVP guidelines for the mitigation of construction-related impacts on paleontological resources. The PRMMP will also be consistent with the SVP conditions for receivership of paleontological collections and any specific requirements of the designated repository for any fossils collected.

MM GEO-4 Halt to Construction when Paleontological Resources are Found

If fossil or fossil-bearing deposits are discovered during construction, regardless of the individual making a paleontological discovery, construction activity in the immediate vicinity of the discovery will cease. This requirement will be spelled out in both the PRMMP and the Worker Environmental Awareness Program. Construction activity can continue elsewhere provided that it continues to be monitored as applicable. If the discovery is made by someone other than a paleontological resources monitor, the paleontological resources monitor will immediately be notified. A qualified paleontologist will be retained to evaluate the resource and to prepare a recovery plan. The recovery plan will include a field survey, construction monitoring, sampling and data recovery procedures, museum storage coordination for any specimen recovered, and a report of finding. Recommendations in the recovery plan determined to be necessary and feasible will be implemented before construction activities can resume at the site where the paleontological resources were discovered.

Project Operations

Using unsuitable materials for fill and/or foundation support would have the potential to create future heaving, subsidence, spreading, or collapse problems leading to building settlement and/or utility line and pavement disruption. However, suitable materials for fill and/or foundation support would be provided in accordance with regional and CBC standards. Therefore, impacts associated with the exposure of people or structures to hazards associated with unstable geologic units or soils would be less than significant during operations.

The soils underlying the Project Footprint generally consist of sandy loam soil unit and Alamo clay. The expansive soil potential is considered high for the Project Footprint. The Project components would be designed in accordance with all standard requirements for improvements on expansive soil, reducing the potential effects from and resulting impacts due to expansive soil. With adherence to existing regulation, impacts related to expansive soils would be less than significant.

Operational activities associated with the Project would not involve ongoing ground disturbance in geologic units sensitive to paleontological resources. Therefore, the Project would not impact scientifically significant paleontological resources, and no impact would occur during operations.