C.5 Geology and Soils

This section describes the existing conditions and geologic hazards related to geology and soils within the proposed action (Project) area. This analysis focuses on the potential exposure of people or structures to geologic hazards as well as the potential for the proposed action to cause or be affected by unstable soil conditions.

C.5.1 Affected Environment

Baseline data were collected from several sources, including: U.S. Geological Survey (USGS), USDA Natural Resources Conservation Service (NRCS), Department of Conservation California Geological Survey (CGS), and Palmdale Water District (PWD).

C.5.1.1 Regional Setting

The Project study area includes Littlerock Reservoir and dam, the potential sand and gravel pits and PWD disposal areas, and the haul route between the reservoir and the disposal areas, as shown in Figure B-1. The Project area is located on the north-central edge of the Transverse Range's physiographic province, an east-west-trending group of mountain ranges and valleys in Southern California. The reservoir and disposal sites are located along the boundary between the north-facing foothills of the San Gabriel Mountains and the Antelope Valley. The reservoir and upstream contributing area are located in the Angeles National Forest, and are bounded by Mount Emma Ridge and Pacifico Mountain to the west; Kratka Ridge, Mount Hillyer, and Waterman Mountain to the south; and Mount Williamson, Pallett Mountain, and Pleasant View Ridge to the east. The disposal sites are located on the valley floor north of the reservoir. The mining pits are located within the alluvial fan formed by Little Rock Wash, and the PWD property lies to the west of the drainage.

The San Gabriel Mountains were formed by north-south compression of the Earth's crust combined with uplift along east-west trending faults, including the Sierra Madre fault system. The active San Andreas Fault, which runs roughly perpendicular to Little Rock Wash between the reservoir and the disposal sites, represents the northerly boundary of the Transverse Ranges province and the San Gabriel Mountains.

C.5.1.2 Geology

The mountains near the reservoir are formed by an igneous rock complex of Precambrian to Mesozoic age (URS, 2008; USGS, 2005). The valley north of the reservoir near the disposal sites contains Mesozoic-age granitics, Pliocene-age sedimentary rocks, and Holocene fan deposits. The Littlerock Reservoir is underlain by Late Triassic quartz monzonite and monzodiorite. Bedrock beneath the dam and reservoir is mapped as Mesozoic-age Lowe granodiorite. An outcropping of Middle Proterozoic anorthosite and gabbro borders the reservoir to the southwest. As the haul route leaves the quartz formation associated with the reservoir, it traverses Pliocene to Holocene alluvium, Miocene to Pleistocene sandstone and conglomerate, and Mesozoic granodiorite and quartz monzonite. The PWD disposal site is underlain by Mesozoic granodiorite and quartz monzonite, and Pliocene to Holocene alluvium. The mining pits are underlain entirely by Pliocene to Holocene alluvium.

C.5.1.3 Seismicity

The seismicity of Southern California is dominated by the intersection of the north-northwest trending San Andreas Fault system and the east-west trending Transverse Ranges fault system. The closest known active fault to the Project area is the Mojave segment of the San Andreas Fault, located approximately two miles north of the reservoir. The San Andreas is a right-lateral strike-slip fault that runs over 700 miles from the Gulf of California to Cape Mendocino. Ground rupture associated with the 1857 earthquake on the San Andreas occurred along the segment of the fault that is adjacent to the Project site, and the modern trace has been the site of recurring Holocene ground rupture (URS, 2008).

Neither the Littlerock Reservoir nor the potential disposal sites fall within an Earthquake Fault Zone as defined by CGS. However, the haul route crosses the Earthquake Fault Zone associated with the San Andreas Fault. Although neither the reservoir nor the disposal sites would be subject to surface fault rupture, the entire project area could experience strong ground shaking from both the San Andreas and Transverse Range fault systems (CGS, 2014).

C.5.1.4 Soils

The area surrounding the reservoir and disposal sites is dominated by Entisols, with small areas of Alfisols and Inceptisols interspersed (NRCS, 2014). The reservoir and downstream wash are underlain by riverwash that is composed primarily of sand, gravel, cobbles, and some boulders. Both sides of the reservoir are surrounded by the Trigo family of dry-Lithic Xerorthents. The PWD property disposal site is underlain by Hanford, Ramona, and Vista coarse sandy loam. The mining pits disposal site is surrounded by Arizo gravelly loamy sand and loamy fine sand, and Hesperia fine sandy loam.

The soils surrounding the reservoir are highly susceptible to erosion and have an average slope gradient of 65 percent. Therefore, the potential for landslide in the area surrounding the reservoir is high. The soils surrounding the disposal sites are less susceptible to erosion and lie on the generally flat valley floor. There is no risk of landslide in the areas surrounding the disposal sites.

Liquefaction is the phenomenon in which saturated granular sediments temporarily lose their shear strength during periods of earthquake induced, strong groundshaking. The susceptibility of a site to liquefaction is a function of the depth, density, and water content of the granular sediments and the magnitude and frequency of earthquakes in the surrounding region. Saturated, unconsolidated silts, sands, and silty sands within 50 feet of the ground surface are most susceptible to liquefaction. The potential for liquefaction in the upper loose layers of sands within Littlerock Reservoir is high (URS, 2008). The depth of potential liquefiable sands is approximately 20 feet.

C.5.2 Regulatory Framework

This section provides an overview of the regulatory framework for geology and soils, specifically as they relate to geologic hazards and unstable soil conditions. Table C.5-1 provides a list of plans and policies that are applicable to geology and soils, and includes a discussion of the Project's consistency with each plan or policy.

C.5.2.1 California Department of Conservation

- **Alquist-Priolo Earthquake Fault Zoning Act of 1972.** This Act (formerly the Special Studies Zoning Act) regulates development and construction of buildings intended for human occupancy to avoid the hazard of surface fault rupture. This Act helps define areas where fault rupture is most likely to occur and groups faults into categories of active, potentially active, and inactive in order to assess the potential for damage to structures or injury to people from fault rupture.
- **Seismic Hazards Mapping Act of 1990.** This Act (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, California Geological Survey (CGS) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and

to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use seismic hazard zone maps developed by CGS in their land-use planning and permitting processes.

C.5.2.2 County of Los Angeles

- **County** of **Los Angeles General Plan.** The County of Los Angeles General Plan Safety Element contains goals and policies to minimize injury, loss of life, and property damage due to seismic and geologic hazards, including earthquakes and landslides.
- **Antelope Valley Areawide General Plan.** The Antelope Valley Areawide General Plan includes policies to protect people and structures from the risk of seismic hazards. Special development standards are required for projects within the Seismic Safety Management Areas, which are based on the Alquist-Priolo Earthquake Fault Zones.

C.5.2.3 City of Palmdale

City of Palmdale General Plan. The City of Palmdale General Plan Safety Element contains a goal to minimize danger and damage to public health, safety, and welfare resulting from natural hazards, including seismic hazards. This goal is implemented through review (and modification when necessary) of development within or adjacent to geologic hazards.

Table C.5-1. Consistency with Applicable Geology and Soil-Related Plans and Policies

Plan/Policy	Consistency	Explanation
Alquist-Priolo Earthquake Fault Zoning Act and Seismic Hazards Mapping Act	Yes	Earthquake Fault Zones, Liquefaction zones, and Landslide zones have been reviewed and identified in Section C.5.1. No structures would be placed within a geologic hazard zone.
County of Los Angeles General Plan, Antelope Valley Areawide General Plan, and City of Palmdale General Plan Seismic and Geologic Hazard Policies.	Yes	Seismic and geologic hazards have been identified in Section C.5.1. The Project will be designed and operated so as to minimize risks associated with seismic and geologic hazards.

C.5.3 Issues Identified During Scoping

Table C.5-2 below provides a list of geology and soil-related issues raised during the public scoping period for the EIS/EIR [see Appendix E (Summary of Scoping Process)]. Issues are listed by agency or members of the public providing comment. The table also includes a brief discussion the applicability of each issue to the environmental analysis and where that issue is addressed in the EIS/EIR.

Table C.5-2. Scoping Issues Relevant to Geology and Soils

Comment	Consideration in the EIS/EIR
Lahontan Regional Water Quality Control Board	
The Draft EIS/EIR should evaluate and consider reducing concentrations of inorganic mercury in reservoir sediment through stabilization of soils.	Soils will be stabilized by the grade control structure to prevent upstream incision and erosion of the stream channel. Soils downstream of the grade control structure will be excavated and disposed of at an appropriate site. Clean sediment will be deposited at one of two disposal sites identified in Figure B-1. Any sediment that is found to be contaminated will be disposed of in an appropriate hazardous waste facility, thereby reducing concentrations of inorganic mercury in reservoir sediment. Soils within the reservoir downstream of the grade control structure will not be stabilized for the purposes of isolating inorganic mercury.

Table C.5-2. Scoping Issues Relevant to Geology and Soils

Comment	Consideration in the EIS/EIR
The Draft EIS/EIR should identify an alternative and define mitigation measures to ensure that the concentrations of Hg and PCBs in sediments are not increased by the Project and are decreased to the extent feasible.	Reservoir management alternatives (such as pH adjustment, nutrient addition, oxygenation, and stocking practices) to reduce methylmercury production are not part of the proposed action. Concentrations of Hg and PCBs in sediments would not be increased by the Project. Because contaminated sediment that is encountered during excavation would be removed and be disposed of in an appropriate hazardous waste facility, the concentrations of Hg and PCBs in sediments within the reservoir may be decreased under the proposed action.

C.5.4 Environmental Consequences

Significance Criteria. Appropriate criteria have been identified and utilized in order to base the significance conclusions on the CEQA Appendix G Environmental Checklist and to make them relevant to this analysis based on local conditions and the project description. Geologic conditions were evaluated with respect to Project impacts on local geology, as well as the impacts local geologic conditions may have on the Project. For purposes of the CEQA analysis in this report, impacts related to geology and soils are considered significant if the Project would:

- Criterion GEO1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known Alquist-Priolo earthquake fault, landslides, strong seismic ground shaking, or seismic-related ground failure, including liquefaction.
- Criterion GEO2: Cause or be affected by substantial soil erosion, slope instability, or slope failure.

Impact Assessment Methodology. This impact analysis is based on an assessment of baseline conditions relevant to the site, including geologic formations, soil types and properties, and known or potential geologic hazards, which are presented in Section C.5.1. These baseline conditions were evaluated based on their potential to be affected by, or to affect, construction activities as well as operation and maintenance activities related to the Project and alternatives. Potential impacts were then identified based on the predicted interaction between construction, operation, and maintenance activities with the affected environment, using appropriate technical analysis and the impact significance criteria. Standard project commitments, described in Appendix A, were considered as project features in the impact analysis.

Impacts are described in terms of location, context, and intensity, and identified as being either short- or long-term, and direct or indirect in nature. Beneficial as well as adverse impacts are identified, with a discussion of the effect and risk to public health and safety, and potential violation of environmental laws. Mitigation measures are developed to avoid, minimize or rectify impacts, and described in terms of need and mitigating effect on the impact.

C.5.4.1 Proposed Action/Project

This section describes the direct and indirect effects of the proposed action (Project) on geology and soils and the exposure of people or structures to seismic and geologic hazards.

Direct and Indirect Effects Analysis

Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving, rupture of a known Alquist-Priolo earthquake fault, landslides, strong seismic ground shaking, or seismic-related ground failure, including liquefaction (Criterion GEO1)

Impact G-1: The Project would expose people or structures to potential substantial adverse effects due to seismic or geologic hazards.

Neither the Littlerock Reservoir nor the proposed disposal sites are located within an Alquist-Priolo Earthquake Fault Zone. Additionally, no structures would be constructed under the proposed action. However, the San Andreas Fault runs east-west between the reservoir and the disposal sites, approximately 1.7 miles north of Littlerock Dam. In the event of a large earthquake along this fault, the entire Project area would experience strong seismic ground shaking. This ground shaking would not expose structures to adverse effects because no structures would be constructed under the proposed action. Although construction workers could be exposed to strong seismic ground shaking, they would not experience any direct adverse effects because Project work (excavation, hauling, and disposal of sediment) would occur in an open overhead environment with no risk of injury due to falling objects or collapsing structures.

The greatest risks under the proposed action associated with Criterion GEO1 are landslide and liquefaction. Structures would not be exposed to adverse effects, as no structures would be constructed under the proposed action. Construction workers could be exposed to risk of injury due to landslide or liquefaction. Although the area surrounding Littlerock Reservoir has not been evaluated by the California Geological Survey, the reservoir is surrounded by steep slopes that could be subject to earthquake-induced landslides. A landslide on the surrounding hillsides could affect the Project area and cause injury or death to construction workers. The loose, often saturated sands and silt within the reservoir could be subject to liquefaction during a seismic event. In the event of liquefaction, the ground would become unstable and construction workers could be injured by falling or coming into contact with falling equipment.

Implementation of SPC GEO-1, provided in Appendix A, would reduce the risk of injury or death due to seismic and geologic hazards to a negligible level.

SPCs Applicable to Impact G-1

SPC GEO-1 (Geotechnical Investigation)

CEQA Significance Conclusion

Any potential risk of injury or death due to seismic or geologic hazards would be minor. Landslides or liquefaction would likely only occur during an earthquake, and therefore would be limited to short periods. This risk would be further reduced through implementation of SPC GEO-1. Impacts would be less than significant (Class III).

Production of or exposure to substantial soil erosion, slope instability, or slope failure (Criterion GEO2)

Impact G-2: The Project would cause or be affected by substantial soil erosion, slope instability, or slope failure.

The Project includes construction of a subterranean grade control structure within the reservoir, excavation of accumulated sediment to restore 1992 design water storage and flood control capacity, ongoing annual sediment removal to maintain reservoir design capacity, and maintenance or improvement of the roadbed along the sediment disposal haul route to prevent or repair damage to affected roadways. The excavation of accumulated sediment is by definition a soil-disturbing activity. Soil disturbance can lead to increased erosion and sedimentation, and can mobilize pollutants that may have attached to the sediment. All excavation work would occur during the dry season and within the reservoir. Any loose or stockpiled soil that is not immediately removed to a disposal site would be naturally redistributed along the bed of the reservoir. This sediment would be confined by Littlerock Dam. Disposal of clean sediment would occur at the PWD property or in abandoned mining pits shown on Figure B-1. Although one small, ephemeral stream crosses the PWD property, SPC HYDRO-1 (refer to Appendix A) would ensure that sediment be placed and graded so that it not enter the stream channel through subsequent erosion and sedimentation. Sediment disposed in the abandoned gravel mining pits would be substantially below the surrounding grade, and no sediment would leave the site or enter any waterbody.

SPC HYDRO-1 would ensure that excavated material to be stockpiled on the PWD alternate disposal site would not obstruct or divert flow in the ephemeral watercourse that crosses that property. Implementation of a Stormwater Pollution Prevention Plan as required by the Clean Water Act would further reduce the potential for sediment eroded by stormwater runoff to leave the disposal site. No Project-related erosion in this watercourse is expected. Sedimentation from the stockpile will be minor due to compliance with existing regulations.

Construction of the grade control structure would also result in soil disturbance. However, this disturbance would also occur only within the reservoir, and any loose or stockpiled soil would similarly be confined by Littlerock Dam. Road maintenance and improvement along the sediment disposal haul route could also lead to soil disturbance. However, the haul routes follow paved roads, and any soil disturbance related to maintenance or improvement of the roadways would be minimal and short-term. No new roads would be created, and no paved surfaces would be converted to bare soil conditions.

Destabilization of natural or constructed slopes could occur as a result of construction activities due to excavation and grading operations. Slope failures are more likely to occur in areas with a history of previous failure, in weak geologic units exposed on unfavorable slopes and in areas of fault-sheared rock. Instances of triggered slope failure from excavation activities could cause damage to construction equipment and could potentially result in injury to workers. However, as discussed above under Impact G-1, a design level geotechnical investigation would be performed prior to construction and would include evaluation of slope stability issues in areas of planned grading and excavation, and provide recommendations for development of grading and excavation plans. Based on the results of the geotechnical investigations, appropriate support and protection measures would be designed and implemented to maintain the stability of slopes adjacent to work areas during and after construction.

SPCs Applicable to Impact G-2

SPC GEO-1 (Geotechnical Investigation)

SPC HYDRO-1 (Fill From Reservoir Excavation Will Not Be Placed in Stream Channels)

CEQA Significance Conclusion

Any potential impacts to geology and soils related to erosion or slope failure would be minor. Implementation of SPCs GEO-1 and HYDRO-1 would ensure that slopes within the Project area are properly stabilized prior to and during construction. Impacts would be less than significant (Class III).

C.5.4.2 Alternative 1: Reduced Sediment Removal Intensity Alternative

Direct and Indirect Effects Analysis

Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving, rupture of a known Alquist-Priolo earthquake fault, landslides, strong seismic ground shaking, or seismic-related ground failure, including liquefaction (Criterion GEO1)

Impact G-1: The Project would expose people or structures to potential substantial adverse effects due to seismic or geologic hazards.

Project activities under this alternative related to Impact G-1 would be very similar to those described under the proposed action. The only difference is that fewer disposal trucks would be utilized, but over a longer period each season for a greater number of years. Fewer workers would be exposed to risks associated with landslide and liquefaction, but over a longer period of time. These risks would remain the same as under the Project, and would be minor.

CEQA Significance Conclusion

SPC GEO-1 would be implemented to avoid any potential risk to people or structures. Impacts for Alternative 1 are the same as those described for the Project, less than significant (Class III).

Production of or exposure to substantial soil erosion, slope instability, or slope failure (Criterion GEO2)

Impact G-2: The Project would cause or be affected by substantial soil erosion, slope instability, or slope failure.

Project activities under this alternative related to Impact G-2 would be very similar to those described under the proposed action. The only difference is that fewer disposal trucks would be utilized, but over a longer period each season for a greater number of years. Fewer workers would be exposed to risks associated with unstable slopes, but over a longer period. These risks would remain the same as under the proposed action, and would be minor. Soil disturbance under this alternative would be potentially less than under the proposed action, but would occur over a longer period.

CEQA Significance Conclusion

Implementation of SPCs GEO-1 and HYDRO-1 would ensure that slopes within the area of proposed activity are properly stabilized prior to and during construction. Impacts for Alternative 1 are the same as those described for the Project, less than significant (Class III).

C.5.4.3 Alternative 2: No Action/No Project Alternative

Direct and Indirect Effects Analysis

Under the No Action Alternative, sediment removal activities would not occur and sediment would continue to accumulate upstream of Littlerock Dam at the annual average rate of 38,000 cubic yards per year, reducing the capacity of the Reservoir by approximately 23.6 acre-feet annually. This lost capacity could be addressed either by breaching the dam and allowing the natural flow of Little Rock Creek to overtop the dam, or by demolishing the dam and removing approximately 2.8 million cubic yards of sediment and dam concrete. Demolition of Littlerock Dam and removal of the accumulated sediment could expose construction workers to risks associated with liquefaction and landslide. This alternative would involve much more earth movement and could involve working on or near steeper slopes. The geotechnical safeguards for this potential demolition and excavation work are unknown, and therefore the No Action/No Project Alternative could result in a direct, adverse impact.

Under the No Action Alternative, sediment removal activities would not occur and sediment would continue to accumulate upstream of Littlerock Dam at the annual average rate of 38,000 cubic yards per year, reducing the capacity of the Reservoir by approximately 23.6 acre-feet annually. This lost capacity could be addressed either by breaching the dam and allowing the natural flow of Little Rock Creek to overtop the dam, or by demolishing the dam and removing approximately 2.8 million cubic yards of sediment and dam concrete. Whether the dam was breached or demolished, it is likely that substantial downstream erosion and sedimentation would result. It is unknown what project commitments would be included in this alternative, or if they would be adequate to protect downstream resources from erosion and sedimentation. Therefore, this alternative would result in a direct and adverse impact.

CEQA Significance Conclusion

Impacts to seismic or geologic hazards and substantial soil erosion, slope instability, or slope failure would be significant and unavoidable (Class I).

C.5.5 Impact Summary

Impact G-1 for the Project and Alternative 1 is adverse, but not significant (Class III). Impact G-1 is significant and unavoidable under the No Action Alternative. Impact G-2 for the Project and Alternative 1 is adverse, but not significant (Class III). Impact G-2 is significant and unavoidable under the No Action Alternative. Table C.5-3 summarizes impact significance.

Table C.5-3. Summary of Impacts and Mitigation Measures – Geology and Soils

Impact	Impact Significance				Mitigation Measures/SPC
	Proposed Action	Alt. 1	Alt. 2: No Action	NFS Lands[1]	
G-1: The Project would expose people or structures to potential substantial adverse effects due to seismic or geologic hazards.	Class III	Class III	Class I	Yes	SPC GEO-1 (Geotechnical Investigation)
G-2: The Project would cause or be affected by substantial soil erosion, slope instability, or slope failure.	Class III	Class III	Class I	Yes	SPC GEO-1 (Geotechnical Investigation) SPC HYDRO-1 (Fill From Reservoir Excavation Will Not Be Placed in Stream Channels)

Notes:
1 - Indicates whether this impact is applicable to National Forest System lands.