3.6 GEOLOGY AND SOILS

This section of the EIR examines the regional and local geologic and soil characteristics of the project site and surrounding area. For the lagoon enhancement component, the analysis is based on the baseline geologic conditions established in *Limited Geotechnical Investigation and Input to Buena Vista Lagoon Restoration Project* (Appendix L). The baseline geologic characterization for materials disposal/reuse sites is based on the 2012 RBSP EA/Final EIR (SANDAG 2011), and the *Final Environmental Impact Statement for the Development of Facilities in San Diego/Coronado to Support the Homeporting of One NIMITZ Class Aircraft Carrier* (Navy 1995). As the geologic and soils characteristics of the project site are generally not dynamic and would not be subject to substantial change within the span of 5 to 10 years, conditions described in the report accurately reflect conditions at the time of NOP publication. Section 3.3 Oceanography/Coastal Processes addresses beach conditions and sand transport, including erosion of beach sand. Thus, these issues are not addressed in this section.

3.6.1 EXISTING CONDITIONS

The project study area is located within the Coastal Plain region of the Peninsular Ranges Geomorphic Province, which is characterized by a series of mountain ranges separated by northwest-trending valleys. The proposed Saltwater, Freshwater, and Hybrid Alternatives include lagoon enhancement activities and materials disposal and/or placement. As such, the project study area includes the lagoon and the proposed materials disposal and/or placement sites, as described below.

Regulatory Setting

A full description of the regulatory setting for this document can be found in Appendix B. The following laws, regulations, policies, and plans are applicable to this resource area:

- U.S. Geological Survey Landslide Hazard Program
- Alquist-Priolo Earthquake Fault Zoning Act
- Building Codes
- Construction General Permit
- Seismic Hazards Mapping Act of 1990

Buena Vista Lagoon

Historic Geologic Setting

Buena Vista Lagoon forms the lower reaches of Buena Vista Creek, which, like all of the major coastal drainages in the region, was carved rapidly during the mid to late Quaternary periods of

glacial advance when the global sea level reached a low of approximately 400 feet below present-day levels. During the past 18,000 years, the geologically rapid global sea level rise caused large volumes of alluvial sediment to fill all of the regional coastal drainages, thus creating estuarine/lagoonal environments.

Characterization of Soils

Quaternary Artificial Fill Soils (Qaf). Fill soils across the lagoon consist of both dredged material and land-derived graded soils. The dredge materials tend to be soft silts and clays and very fine sands, all rich in organic material. Land-derived materials within the lagoon have several sources but appear predominantly to have been cut-graded from the nearby coastal terraces, which primarily consist of Quaternary and Tertiary silty to clayey sands.

Quaternary Alluvial Soils (Qal). Natural alluvial fill soils within the lagoon channel can generally be divided into three zones, as follows:

- A thin (0 to 5 feet thick) geologically recent mantle of unconsolidated, very loose sands and soft silts and clays;
- An upper zone (generally above -20 feet in elevation) of predominantly fluvial, medium dense sands; and
- A lower zone (generally below -20 feet in elevation) of predominantly marine and estuarine, medium dense to very dense sands with abundant shells and shell fragments.

Formational Soils. The lagoon is underlain by relatively horizontally stratified sandstones and claystones of the upper-middle tertiary Santiago Formation (Tsb). Limited areas of the surface of this Eocene-age unit are exposed along the southeastern shoreline of the Coast Highway Basin, as well as the southwestern shoreline of the I-5 Basin. In addition to the fill soils described above, slopes and terraces around the perimeter of the lagoon and south of the lagoon inlet are characterized by Quaternary coastal terrace deposits (Qby). These relatively thin (generally less than 20 feet thick) but extensive terrace deposits overlie a wave-cut platform, abraded during higher global sea stands. Underlying Quaternary beach and bar deposits (Qb) exist fronting the beach near the inlet of the lagoon. These deposits consist of moderately consolidated, poorly hardened tan to reddish-brown sands and clays that include nearshore marine and beach sands and, in some areas, a cap of dune sands.

Faulting and Seismicity

The limited geotechnical investigation identified 18 faults within the study area. The closest fault to the lagoon is the offshore segment of the Newport-Inglewood Fault, located approximately 4.9

miles southwest of the lagoon. The next closest fault is the Rose Canyon Fault, located approximately 5.6 miles southwest of the lagoon. The Newport-Inglewood Fault is capable of generating an earthquake of magnitude 7.1 on the Richter Scale, while the Rose Canyon Fault is capable of generating a magnitude 7.2 earthquake. No active faults are known to underlie the lagoon that could cause the potential for ground rupture. However, due to the proximity of the active Newport-Inglewood and Rose Canyon Faults, as well as other active faults in the area, the project site is considered susceptible to the secondary effects of seismic activity, including ground-shaking, liquefaction (described below), and settlement of alluvial deposits.

Liquefaction

Liquefaction is the process in which saturated silty to cohesionless soils below the groundwater table temporarily lose strength during strong ground shaking as a consequence of increased pore pressure during conditions such as those caused by an earthquake. Earthquake waves cause water pressures to increase in the sediment and the sand grains to lose contact with each other, leading the sediment to lose strength and behave like a liquid. Sandy soils with substantial amounts of silt or clay are less likely to undergo liquefaction. Saturated soils (i.e., below the groundwater table) encountered at the lagoon during the limited geotechnical investigation were found to range from very loose to very dense. These materials were predominantly younger alluvial lagoonal deposits, with the deposits most susceptible to liquefaction confined to the upper 15 to 20 feet of sediments tested. Because of their high density, the potential for liquefaction of the deeper alluvial soils (below -20 feet in elevation) is considered low. Due to the nature of the soils up to a depth of -20 feet, the lagoon is considered moderately to highly susceptible for liquefaction of these soils. Additionally, Buena Vista Lagoon is located within an area identified by the County as having a high liquefaction risk.

Materials Disposal/Reuse Sites

Beach and Nearshore Placement Sites

Oceanside

The Oceanside placement site was formed from sand and rocks that originated from upland erosion. This site is a predominantly flat, sandy beach that consists of a relatively thin sand and cobble layer varying in width on a shallow, rock platform. Unusually large waves can expose the rock layer by moving the sand offshore or down the coast. The Oceanside site is relatively wide, although beach widths decrease south of Wisconsin Avenue as the wave sheltering effect from Oceanside Harbor no longer plays a role. Beach widths south of Oceanside Harbor, however, are currently narrower than they were historically due to the net decrease of river sand inputs and the

effect of the harbor, which prevents transport of sand from north to south. This site is located within the 12-mile stretch of beach defined by the Corps as the most critical reach for future erosion (Corps 1991).

North Carlsbad

The North Carlsbad site was formed from the same process as Oceanside and has the same geology with a thin layer of sand and cobble atop bedrock. South of Buena Vista Lagoon, the existing receiver site is relatively narrow with an abundance of cobbles. The receiver site is backed by marine terraces that reach a height of approximately 30 feet. Beach widths from Oceanside Harbor to La Jolla are narrower than they were historically as a combined consequence of a net decrease of river sand inputs and the trapping effect of the Oceanside Harbor on the littoral transport of sand from the north. This site also lies within the 12-mile length of beach area identified as having critical erosion problems (Corps 1991).

Offshore Disposal Site

LA-5

LA-5 is an offshore sediment disposal site located approximately 6 nautical miles from the San Diego coastline. The site depth ranges from 460 to 660 feet with a 6,000-foot diameter. The regional seaward features of the San Diego area are a submerged extension of the Peninsular Ranges. The irregular topography of the basins and ridges parallel the structural orientation of the onshore ranges. The mainland shelf seaward of the San Diego Harbor consists mainly of tightly folded late Beogene sandstone and shale, covered extensively with Quaternary sands and muds (EPA 1987). As described in the EIS prepared for the use of the LA-5 location for sediment disposal, samples of bottom sediment were generally sandy-silt and averaged 3 percent gravel, 52 percent sand, 33 percent silt, and 12 percent clay (EPA 1987).

3.6.2 SIGNIFICANCE CRITERIA

Pursuant to Appendix G to the CEQA Guidelines, significant impacts to geology and soils would occur if implementation of the Enhancement Project would result in any of the following:

A. Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

    a. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or

based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42);

b. Strong seismic ground shaking;

c. Seismic-related ground failure, including liquefaction; or

d. Landslides.

B. Substantial soil erosion or the loss of topsoil;

C. Location of the project 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; or

D. Location of the project on expansive soils, as defined in Section 1802.3.2 of the California Building Code (2007), creating substantial risks to life or property.

3.6.3 IMPACT ANALYSIS

Bridge and abutment improvements proposed for the railroad and I-5 would be implemented by SANDAG and Caltrans, respectively, as part of other proposed projects that would be constructed independently of this proposed enhancement project. The respective implementing agencies would perform internal quality review of engineering design to confirm that applicable regulatory safety requirements and engineering/building codes are satisfied, including those related to seismic criteria, such as liquefaction, slope stability, and expansive soils. Each agency employs qualified experts to perform design and quality assurance. Therefore, impacts to geology and soils associated with those improvements are not addressed in this section.

The project study area is located within the Cities of Oceanside and Carlsbad, neither of which contains Alquist-Priolo Earthquake Fault Zones (California Department of Conservation 2014a). Additionally, as discussed previously, no active faults are known to underlie the lagoon that could cause the potential for ground rupture. **Therefore, impacts related to fault rupture would be less than significant under each of the alternatives and for each of the materials disposal/reuse sites (Criterion A[a])**.

The following sections include analyses of impacts for the remainder of the criteria listed in Section 3.6.2.

Lagoon Enhancement

Freshwater Alternative

The Freshwater Alternative includes the dredging and excavation of soils from the lagoon; creation of deep (approximately -9 feet NGVD) fish areas in the northern portion of the Railroad

Basin and the southwestern portion of the Coast Highway Basin; construction of the Boardwalk parallel to Coast Highway/Carlsbad Boulevard extending between the Nature Center and Maxton Brown Park; removal of accumulated sediment and vegetation from the existing channel under Carlsbad Boulevard; and replacement of the existing 50-foot weir with a new 80-foot weir, which would require widening the channel at this location.

The project study area is located within the seismically active southern California region, and like all locations within the area, is subject to strong seismic ground shaking. Modern structures are designed to resist ground shaking. The Boardwalk project component would be common to each of the three build alternatives. Pilings would be set at depths extending at least 4 feet into stable ground, and design for foundations, landings, platforms, rest areas, handrails, and the walking surface of the Boardwalk would comply with the latest versions of applicable federal, state, and local codes relative to seismic criteria. No other structures would be constructed under the Freshwater Alternative that would increase the risks associated with seismic ground shaking.

As previously discussed, the project site is located in an area identified as being susceptible to liquefaction. According to the Limited Geotechnical Investigation prepared for the project site, the potential for liquefaction-induced settlements of the embankments supporting the Carlsbad Boulevard bridge is considered relatively low due to the soil density, the presence of fine-grained cohesive soils, and the relatively limited thickness of potential liquefiable soils in these areas. Construction of the Boardwalk would occur parallel to the Coast Highway/Carlsbad Boulevard right-of-way and, as discussed, would be designed in compliance with applicable federal, state, and local codes. The Limited Geotechnical Investigation further states that a potentially loose layer of sand within the I-5 embankment could be susceptible to liquefaction. However, no structures are proposed for this area under the Freshwater Alternative. No other structures would be constructed under the Freshwater Alternative that would increase the risks associated with liquefaction.

Dredging activities under the Freshwater Alternative would be limited to portions of the lagoon basins and hydraulic connections (i.e., channels) that are generally underlain by fill soils and alluvial deposits. These activities would not have the potential to induce or increase the risk of landslides. Under the Freshwater Alternative, excavation on the south side of the inlet would be required to widen the channel to accommodate the new 80-foot weir. The terrace at this location is not considered a steep slope that would be susceptible to landslides, and excavation in this area would not increase the risk for landslides on- or off-site. Structural integrity is a critical component for all structures, including the Boardwalk and replacement weir, and there are engineering standards/codes that dictate design standards and reviewing entities that ensure standards are met. The Boardwalk and replacement weir constructed as part of the Freshwater Alternative would be required to meet these engineering design standards/building codes.

SANDAG would perform internal quality reviews of engineering design to confirm that applicable regulatory safety requirements and engineering/building codes are satisfied. **With adherence to applicable building codes relative to seismic criteria, impacts resulting from strong seismic ground shaking, liquefaction, and landslides would be less than significant under the Freshwater Alternative (Criterion A[b, c, and d])**.

As discussed in Section 3.2 Hydrology, erosion control from construction activities would be addressed in the SWPPP prepared for the project, which would include BMPs to minimize scour and impacts on surface drainage patterns and existing drainage systems. The BMPs contained in the SWPPP would be developed and implemented by the contractor in compliance with existing regulations and implementation of those appropriately designed BMPs, such as riprap, other erosion control products, and/or vegetated material would reduce erosion or scour potential by protecting the susceptible soil. Over the long-term maintenance of the project, erosion could occur in and around the channels connecting the basins during large storm events under the Freshwater Alternative. However, areas identified as having the potential for erosion within lagoon channel cross sections would be protected with erosion control products and vegetated material to stabilize soils. Thus, no substantial long-term erosion would result from implementation of the Freshwater Alternative. **Therefore, neither construction nor long-term maintenance of the Enhancement Project under the Freshwater Alternative would result in substantial soil erosion or the loss of topsoil, and impacts would be less than significant (Criterion B)**.

The Limited Geotechnical Investigation performed at the project site indicates that embankment slopes are generally statically stable. With regard to seismic slope stability, slopes are susceptible to the impacts of liquefaction and lateral spreading and may become unstable during a substantial seismic event. Impacts related to liquefaction are discussed above; therefore, this discussion focuses on potential impacts related to slope stability and lateral spreading.

The existing embankment side slopes for the Carlsbad Boulevard bridge have an inclination of 0:1. It is anticipated that dredging activities would not destabilize the existing embankments if slopes no greater than 3:1 are maintained for the Carlsbad Boulevard bridge (TerraCosta Consulting Group, Inc. 2008). Dredging activities within the channels under the Freshwater Alternative would maintain the existing side slope inclinations for the Carlsbad Boulevard bridge; thus, slope stability would not be affected at this location.

Enhancement activities within the lagoon under the Freshwater Alternative would require the dredging and removal of large quantities of sediments. Approximately 562,000 cy of sediments would be removed from the lagoon basins and tidal channels. As discussed in Chapter 2, two construction approaches are proposed for the placement of dredged sediments. Approach 2

involves the creation of an overdredge pit extending up to -32 feet NGVD within the Coast Highway Basin to accommodate material not suitable for beach or nearshore placement. The overdredge pit would be specifically designed with appropriate distance from the Carlsbad Boulevard and I-5 bridge embankments so that even if the pit unexpectedly collapsed and it assumed a slope equal to its angle of repose, the embankment stability would be unaffected.

The embankments supporting the Carlsbad Boulevard bridge are anticipated to experience 2 or more feet of lateral spreading (TerraCosta Consulting Group, Inc. 2008). However, the Freshwater Alternative does not include new structures at this location, and additional protection is not anticipated to be necessary for the Carlsbad Boulevard bridge under the Freshwater Alternative.

Dredging activities under the Freshwater Alternative would be limited to portions of the lagoon basins and hydraulic connections (i.e., channels) that are generally underlain by fill soils and alluvial deposits. These activities would not have the potential to induce or increase the risk of landslides. Under the Freshwater Alternative, excavation on the south side of the inlet would be required to widen the channel to accommodate the new, 80-foot weir. The terrace at this location is not considered a steep slope that would be susceptible to landslides, and excavation in this area would not increase the risk for landslides on- or off-site. **With adherence to applicable building codes relative to seismic criteria, impacts to soil stability would be less than significant under the Freshwater Alternative (Criterion C)**.

Expansive soils are clay-based soils that tend to expand (increase in volume) as they absorb water and shrink (lessen in volume) as water is drawn away. Soils within the lagoon are, by nature, saturated soils. As such, expansion would not occur within these soils. Additionally, lagoonal soils would only have the potential to shrink once dredged materials are removed from the lagoon and allowed to dry. Grading and excavation activities under the Freshwater Alternative would not increase the risks from expansive soils. Additionally, as construction of the Boardwalk foundation would occur in saturated soils, this project component would not be susceptible to risks associated with expansive soils. **Therefore, the Freshwater Alternative would not result in impacts from expansive soils (Criterion D)**.

Saltwater Alternative

The Saltwater Alternative includes the dredging and excavation of soils from the lagoon; construction of the Boardwalk extending between the Nature Center and Maxton Brown Park; expansion of the channel under Carlsbad Boulevard to 110 feet and replacement of the existing Carlsbad Boulevard bridge; and replacement of the existing 50-foot weir with a 100-foot-wide open inlet to provide tidal exchange.

Similar to the Freshwater Alternative, the project under the Saltwater Alternative would be subject to strong seismic ground shaking. Both the Boardwalk component and the replacement and expansion of the Carlsbad Boulevard bridge would be designed and constructed in accordance with the latest versions of applicable federal, state, and local codes relative to seismic criteria. No other structures would be constructed under the Saltwater Alternative that would increase the risks associated with seismic ground shaking.

The potential for liquefaction-induced settlement of the embankments supporting the Carlsbad Boulevard bridge is considered low. Construction of the Boardwalk and the Carlsbad Boulevard bridge under the Saltwater Alternative would be designed and implemented in compliance with applicable federal, state, and local codes, which are described in Appendix B. According to the Limited Geotechnical Investigation, sand within the I-5 embankment could be susceptible to liquefaction. The Saltwater Alternative would require the expansion of the channel underlying I-5, but no structures are proposed for this area under the Saltwater Alternative. No other structures would be constructed under the Saltwater Alternative that would increase the risks associated with liquefaction. Structural integrity is a critical component for all structures, including the Boardwalk and Carlsbad Boulevard Bridge, and there are engineering standards/codes that dictate design standards and reviewing entities that ensure standards are met. Improvements proposed to Carlsbad Boulevard as part of the Saltwater Alternative would be required to meet these engineering design standards/building codes. SANDAG would perform internal quality reviews of engineering design to confirm that applicable regulatory safety requirements and engineering/building codes are satisfied. Carlsbad Boulevard is under the ownership of the City of Carlsbad, and bridge improvements would be checked for standard/code compliance by City of Carlsbad engineering staff following required review procedures to confirm that engineering/design standards/codes would be implemented.

Dredging activities under the Saltwater Alternative would be limited to portions of the lagoon basins and hydraulic connections (i.e., channels) that are generally underlain by fill soils and alluvial deposits. These activities would not have the potential to induce or increase the risk of landslides. Under the Saltwater Alternative, excavation on the south side of the inlet would be required to widen the channel to 100 feet and create an open tidal inlet. The terrace at this location is not considered a steep slope that would be susceptible to landslides, and excavation in this area would not increase the risk for landslides on- or off-site.

Removal of the weir and the opening of the inlet under this alternative would require periodic excavation to remove littoral sand accumulating in the channel and maintain the open inlet. Maintenance activities under the Saltwater Alternative would not increase the risks related to ground shaking, liquefaction, or landslides. **With adherence to applicable building codes relative to seismic criteria, impacts resulting from strong seismic ground shaking,**

liquefaction, and landslides would be less than significant for construction and long-term maintenance under the Saltwater Alternative (Criterion A [b, c, and d]).

Similar to the Freshwater Alternative, erosion control from construction activities under the Saltwater Alternative would be addressed in the SWPPP prepared for the project, which would include BMPs to minimize scour and impacts on surface drainage patterns and existing drainage systems. The BMPs contained in the SWPPP would be developed and implemented by the contractor in compliance with existing regulations and would serve to reduce erosion potential. Additionally, areas identified as having the potential for erosion within lagoon channel cross sections under the Saltwater Alternative would be protected with erosion control products and vegetated material to stabilize soils. Thus, no substantial long-term erosion would result from implementation of the Saltwater Alternative. **Therefore, neither construction nor long-term maintenance of the project under the Saltwater Alternative would result in substantial soil erosion or the loss of topsoil, and impacts would be less than significant (Criterion B)**.

Dredging activities within the channels under the Saltwater Alternative would maintain the existing side slope inclination for the Carlsbad Boulevard bridge, as the channel would remain vertical under this alternative; thus, slope stability would not be affected.

Enhancement activities within the lagoon under the Saltwater Alternative would require the dredging and removal of large quantities of sediments. Approximately 781,000 cy of sediments would be removed from the lagoon basins and tidal channels. As with the Freshwater Alternative, the overdredge pit, if used, would be specifically designed with appropriate distance from the Carlsbad Boulevard and I-5 bridge embankments so that even if the pit unexpectedly collapsed and it assumed a slope equal to its angle of repose, the embankment stability would be unaffected.

The expanded channel created for the Carlsbad Boulevard bridge may require slope protection to prevent scour of the bridge abutments and embankments. It is anticipated that stone revetment would extend up to 300 feet from the channel to the north and south on both the eastern and western sides of the embankment. Bridge improvements would be designed and constructed to comply with the latest versions of applicable federal, state, and local codes relative to seismic criteria, including those related to lateral spreading (PDF-1 and PDF-2). Adherence to applicable safety codes that address seismic criteria would ensure the bridge design would not be susceptible to geologic hazards and minimize associated risk.

Removal of the weir and the opening of the inlet under this alternative would require periodic excavation to remove littoral sand accumulating in the channel and maintain the open inlet. Maintenance activities under the Saltwater Alternative would not increase the risks related to

lateral spreading. **With adherence to applicable building codes relative to seismic criteria, impacts to soil stability would be less than significant for construction and long-term maintenance under the Saltwater Alternative (Criterion C)**.

Similar to the Freshwater Alternative, expansion of soils within the lagoon would not occur. Lagoonal soils would only have the potential to shrink once dredged materials are removed from the lagoon and allowed to dry. Grading and excavation activities under the Saltwater Alternative would not increase the risks from expansive soils. Additionally, as construction of the Boardwalk and Carlsbad Boulevard bridge foundations would occur in saturated soils, these project components would not be susceptible to risks associated with expansive soils.

Removal of the weir and the opening of the inlet under this alternative would require periodic excavation to remove littoral sand accumulating in the channel and maintain the open inlet. Maintenance activities under the Saltwater Alternative would not increase the risks related to expansive soils. **Therefore, neither construction nor long-term maintenance of the Saltwater Alternative would result in impacts from expansive soils (Criterion D)**.

Hybrid Alternative

The Hybrid Alternative includes two options (A and B). Both options include the dredging and excavation of soils from the lagoon; construction of the Boardwalk extending between the Nature Center and Maxton Brown Park; construction of a new water control structure (weir) at the I-5 bridge to maintain a freshwater hydrologic regime in the portion of the lagoon east of I-5; expansion of the channel under Carlsbad Boulevard to 110 feet and replacement of the existing Carlsbad Boulevard bridge; and replacement of the existing 50-foot weir with a 100-foot-wide open inlet to provide tidal exchange. The Hybrid Alternative, Option A also includes the construction of a channel guide connecting the tidal inlet from the ocean area through the Weir Basin and into the Railroad Basin, creating a perched water level, whereas the Hybrid Alternative, Option B would create an open inlet similar to that described under the Saltwater Alternative.

Similar to the Saltwater Alternative, the Hybrid Alternative would be subject to strong seismic ground shaking. Both the Boardwalk component and the replacement and expansion of the Carlsbad Boulevard bridge would be designed and constructed in accordance with the latest versions of applicable federal, state, and local codes relative to seismic criteria, which are described in Appendix B. No other structures would be constructed under the Hybrid Alternative that would increase the risks associated with seismic ground shaking.

The potential for liquefaction-induced settlements of the embankments supporting the Carlsbad Boulevard bridge is considered low. Construction of the Boardwalk and the Carlsbad Boulevard bridge under the Hybrid Alternative would be designed and implemented in compliance with applicable federal, state, and local codes. Sand within the I-5 embankment could be susceptible to liquefaction. A weir would be installed within the channel underlying I-5; however, this is a water control structure that would be used to maintain the proposed hydrologic regimes under the Hybrid Alternative, and would not be used by or open to the public. No other structures would be constructed under the Hybrid Alternative that would increase the risks associated with liquefaction. Structural integrity is a critical component for all structures, including the Boardwalk, Carlsbad Boulevard Bridge, channel guide (under Option A) and weir under I-5, and there are engineering standards/codes that dictate design standards and reviewing entities that ensure standards are met. Improvements proposed to Carlsbad Boulevard as part of the Hybrid Alternative would be required to meet these engineering design standards/building codes. SANDAG would perform internal quality reviews of engineering design to confirm that applicable regulatory safety requirements and engineering/building codes are satisfied. Carlsbad Boulevard is under the ownership of the City of Carlsbad, and bridge improvements would be checked for standard/code compliance by City of Carlsbad engineering staff following required review procedures to confirm that engineering/design standards/codes would be implemented.

Dredging activities under the Hybrid Alternative would be limited to portions of the lagoon basins and hydraulic connections (i.e., channels) that are generally underlain by fill soils and alluvial deposits. These activities would not have the potential to induce or increase the risk of landslides. Similar to the Saltwater Alternative, under the Hybrid Alternative, excavation on the south side of the inlet would be required to widen the channel to 100 feet and create an open tidal inlet. The terrace at this location is not considered a steep slope that would be susceptible to landslides, and excavation in this area would not increase the risk for landslides on- or off-site.

Removal of the weir and the opening of the inlet under this alternative would require periodic excavation to remove littoral sand accumulating in the channel and maintain the open inlet. Maintenance activities under the Hybrid Alternative would not increase the risks related to ground shaking, liquefaction, or landslides. **With adherence to applicable building codes relative to seismic criteria, impacts resulting from strong seismic ground shaking, liquefaction, and landslides would be less than significant for construction and long-term maintenance under the Hybrid Alternative (Criterion A[b, c, and d])**.

Similar to the Saltwater Alternative, erosion control from construction activities under the Hybrid Alternative would be addressed in the SWPPP prepared for the project, which would include BMPs to minimize scour and impacts on surface drainage patterns and existing drainage systems. The BMPs contained in the SWPPP would be developed and implemented by the

contractor in compliance with existing regulations and would serve to minimize the potential for erosion through appropriate soil and bank protection. Additionally, areas identified as having the potential for erosion within lagoon channel cross sections under the Hybrid Alternative would be protected with erosion control products and vegetated material to stabilize soils. Thus, no substantial long-term erosion would result from implementation of the Hybrid Alternative. **Therefore, neither construction nor long-term maintenance of the project under the Hybrid Alternative would result in substantial soil erosion or the loss of topsoil, and impacts would be less than significant (Criterion B)**.

Dredging activities within the channels under the Hybrid Alternative would maintain the existing side slope inclination for the Carlsbad Boulevard bridge, as the channel would remain vertical under this alternative. Thus, slope stability would not be affected.

Enhancement activities within the lagoon under the Hybrid Alternative would require the dredging and removal of large quantities of sediments. Approximately 833,000 cy of sediments would be removed from the lagoon basins and tidal channels. As with each of the other two build alternatives, the overdredge pit, if used, would be specifically designed with appropriate distance from the Carlsbad Boulevard and I-5 bridge embankments so that, even if the pit unexpectedly collapsed and it assumed a slope equal to its angle of repose, the embankment stability would be unaffected.

Similar to the Saltwater Alternative, slope protection for the I-5 structure would be designed and placed as part of the Caltrans improvements along I-5, and would not be part of the proposed Enhancement Project. Similarly, slope protection, if needed, for the railroad bridge embankment would be implemented by SANDAG as part of the LOSSAN double-tracking project. The expanded channel created for the Carlsbad Boulevard bridge may require slope protection to prevent scour of the bridge abutments and embankments. It is anticipated that stone revetment would extend up to 300 feet from the channel to the north and south on both the eastern and western sides of the embankment. Bridge improvements would be designed and constructed to comply with the latest versions of applicable federal, state, and local codes relative to seismic criteria, including those related to lateral spreading (PDF-1 and PDF-2). Adherence to applicable safety codes that address seismic criteria would ensure the bridge design would not be susceptible to geologic hazards and minimize associated risk.

Removal of the weir and the opening of the inlet under this alternative would require periodic excavation to remove littoral sand accumulating in the channel and maintain the open inlet. Maintenance activities under the Hybrid Alternative would not increase the risks related to lateral spreading. **With adherence to applicable building codes relative to seismic criteria, impacts**

to soil stability would be less than significant for construction and long-term maintenance under the Hybrid Alternative (Criterion C).

Similar to the Saltwater Alternative, expansion of soils within the lagoon would not occur. Lagoonal soils would only have the potential to shrink once dredged materials are removed from lagoon and allowed to dry. Grading and excavation activities under this alternative would not increase the risks from expansive soils. Additionally, as construction of the Boardwalk and Carlsbad Boulevard bridge foundations would occur in saturated soils, these project components would not be susceptible to risks associated with expansive soils.

Removal of the weir and the opening of the inlet under this alternative would require periodic excavation to remove littoral sand accumulating in the channel and maintain the open inlet. Maintenance activities under the Hybrid Alternative would not increase the risks related to expansive soils. **Therefore, neither construction nor long-term maintenance of the Hybrid Alternative would result in impacts from expansive soils (Criterion D)**.

No Project Alternative

Under the No Project Alternative, the proposed enhancement of the lagoon would not be completed. The existing weir would remain in place. No removal of sediment or vegetation would occur. No structures would be constructed under the No Project Alternative and no maintenance activities would occur that could increase the risks related to geology and soils. Under the No Project Alternative, the project site would be subject to the same seismic phenomena as under existing conditions and would not increase risks associated with such phenomena. **Therefore, no impacts to geology and soils would occur under the No Project Alternative (Criteria A through D)**.

Materials Disposal/Reuse Sites

As discussed in Chapter 2, two construction approaches are proposed for the placement of dredged sediments. Under both approaches, dredged materials suitable for beneficial use would be placed at the identified beach and/or nearshore sites. Those materials not suitable for beach or nearshore placement would be transported to LA-5 for offshore placement under Approach 1. Under Approach 2, an overdredge pit measuring up to -32 feet NGVD would be created to accommodate material not suitable for beach or nearshore placement.

<u>Beach and Nearshore Placement Sites</u>

Impacts would be similar for both the Oceanside and North Carlsbad placement sites. No structures would be constructed at the placement sites and no slopes exist at the sites that would increase risks associated with seismic ground shaking, liquefaction, lateral spreading, landslides,

or soil stability. **Therefore, no impacts resulting from these phenomena would occur at the placement sites (Criteria A and C)**.

Dredged materials at the Oceanside and North Carlsbad sites would be placed on and near the beach, which is an area that is constantly subjected to natural erosion and coastal processes that repeatedly disturb the on-site geologic materials. **Placement of materials at these sites would not increase erosion, and impacts would be less than significant (Criterion B)**.

As previously discussed, lagoonal soils would have the potential to shrink once dredged materials are removed from the lagoon and allowed to dry. These materials would also have the potential to expand at the placement sites once exposed to moisture. Expansion and shrinkage of dredged materials at the placement sites would not pose a geologic risk as the beach and nearshore areas are subjected to regular wetting and drying as tides change throughout the day. Furthermore, the materials suitable for the beach placement sites would be those with higher sand and lower clay content. **Therefore, placement of materials at the beach and nearshore sites would not result in significant impacts related to expansive soils (Criterion D)**.

Offshore Disposal Site

LA-5

All sediments transported to the LA-5 site would be disposed of offshore. Therefore, materials disposed of at this site would not have the potential to result in impacts to geology and soils.

No Project Alternative

No materials would be dredged or excavated that would need to be disposed of or used for littoral cell nourishment under the No Project Alternative. The project site would be subject to the same seismic phenomena as under existing conditions and would not increase risks associated with such phenomena. No changes to risks related to geology and soils would occur and **no impacts would result from the No Project Alternative (Criteria A through D).**

3.6.4 MITIGATION MEASURES

Impacts on geologic hazards from construction of the overdredge pit and weir under the Freshwater Alternative, or overdredge pit, tidal inlet and bridge for the Saltwater and Hybrid Alternatives, are less than significant due to project design features and engineering standards/codes that dictate design standards, plus appropriate reviewing entities that ensure

standards are met to avoid or minimize geologic impacts. No significant impacts to geology and soils have been identified under any of the alternatives. Therefore, no mitigation measures are required.