4.7 GEOLOGY AND SOILS

This section addresses several issues involving geologic and soils conditions, wave action, currents, and sedimentation. This information will also be utilized in assessing the impacts of the proposed disposition in connection with several other resource areas: marine biology, marine water quality, recreation, and hazards. A number of geology and soils issues typically associated with project impact analysis are not analyzed herein because of the kind of project being proposed, and its location in the nearshore and offshore environments. These issues include seismic shaking; exposure of people to seiche, tsunami, or volcanic hazard; land subsidence; expansive soils or other unstable soil conditions from grading, excavation, or fill; effects on groundwater movement and quantity; and exposure of people to floods.

4.7.1 Description of Resource/Environmental Setting

Geology

The SONGS site is located on the coast of southern California within the Peninsular Ranges Province. Northwesterly trending mountain ranges and valleys, in general, characterize this Geomorphic Province. Differential uplift resulting from faulting has occurred along the eastern margin of the province and along the San Jacinto and Elsinore fault zones (Ehlig 1977). The subject site is located within the southwesterly portion of the province, which extends from the Los Angeles basin southwesterly into Mexico.

The existing offshore conduits are situated on the San Onofre Shelf portion of the California Continental Borderland. The San Onofre Shelf between Dana Point and Oceanside is about 3 to 5 miles (5 to 8 km) wide and extends seaward to about 295 feet (90 m) in depth. The buildings at SONGS are located on the coastal terrace itself, which is underlain by Miocene-age marine bedrock capped by Pleistocene-age marine and non-marine sediments (terrace deposits).

The major drainages in the region of SONGS consist of the Santa Ana River drainage north of the site and the Santa Margarita River drainage south of SONGS.

The San Onofre and Santa Marguerita mountains, part of the Peninsular Range, are located inland from the site and trend northwesterly to end at the San Juan Creek drainage, which enters the ocean at Dana Point. Broad Pleistocene marine terraces are well developed along this section of the coast and, in the area of SONGS, separate the San Onofre Mountains from the beach. The lowest terrace has an average width of approximately 0.5 mile (0.8 km) and is generally continuous except where dissected by drainage courses.

The coastal plain is terminated at the beach by a line of relatively straight coastal bluffs. The coastal bluffs have been eroded at the toe and cut by sea wave erosion, exposing sandstone bedrock in some areas within the lower bluff face just above the beach surface. Bedrock is overlain by poorly consolidated marine and non-marine sediments, which form the upper cliff face and the coastal plain surface beyond. Where the cliff face is relatively low, the entire face exposes these terrace deposits and bedrock is not exposed above the beach surface.

Most of the bedrock underlying the project area and exposed along the seafloor in the vicinity of the project area is the San Mateo Formation. The Pliocene-age San Mateo Formation consists of a non- to slightly cemented, relatively friable, semi- to well-consolidated, arkosic, marine sandstone (San Onofre sandstone). This formation is predominantly massive, coarse grained, light yellow brown to light gray, with scattered lenses of conglomerate and occasional interbeds of fine silty sandstone. The San Onofre sandstone is predominantly dense and forms near-vertical slopes in coastal bluff exposures.

Marine terrace deposits form the low marine terrace (coastal plain) adjacent to SONGS. These materials consist of fine-grained materials and gravels, which are considered to be Pleistocene in age. Their deposition is related to glacially induced fluctuations in sea level (Ehlig 1977).

The majority of the seafloor in the project vicinity is covered with a layer of sand, silt, and cobbles that overlie the San Mateo Formation, but portions of the seafloor bottom consist of exposed bedrock (Anderson et al. 1995). An unconsolidated hard cobble surface is known to locally underlay the sand veneer. Areas overlain by sand are generally less than 10 feet (3 m) thick.

The existing conduits extend seaward to water depths ranging from approximately 10 to 30 feet (3 to 9 m) over the top of pipeline. The seafloor consists of more than 90 percent sand cover, generally 5 to 10 feet (2 to 3 m) in thickness (SCE 1997a).

Offshore of the conduits, between Dana Point and Oceanside, there are dune-like, elongated deposits of fine sands that extend perpendicular to the shore. The elongated sand dunes tend to be stable in volume and coverage, but their position and configuration change over time as they migrate southward, driven by the predominantly southerly longshore current.

Currents and Sediment Movement

The longshore currents in the project vicinity tend to be consistent with the prevailing wind direction. The result is a southward-flowing current along the shoreline and nearshore environment that predominates in every season, with the strongest southerly flow occurring in the summer months (Daly et al. 1993); see Figure 4.1-1. These currents, along with large storm waves, are the primary forces that suspend and transport sediments (Cacchione et al. 1987; Wiberg and Smith 1983; Cacchione and Drake 1982).

As discussed above in Section 4.3, surface current velocities have been estimated at 0.3 to 0.4 knots, with current velocities near the seafloor estimated at 0.2 knots. The depth-averaged mean annual current velocity is estimated at 0.22 knots (BGI 2003). In general, the current velocities involved with the longshore current are sufficient only to suspend and transport small-sized sediment, i.e., coarse sand size and smaller, in any substantial volume.

The volume of sediment available to form beaches and available within the area of the conduits for conduit infill material can vary from year to year. According to Kuhn and Shepard (1984), the predominant longshore current since at least 1950 has been from north to south. During the 1980s, the net longshore drift had been virtually balanced (Seymore 1980-1982). Kuhn and Shepard (1984) reported observations that during particularly stormy years, the beaches in the coastal area that includes the project site were markedly widened. It was concluded that during years of unusually stormy seasons, the available sediment was increased in proportion to the observable erosion of bluffs and canyons, as well as material generated by coastal bluff landslides.

The seabed sediments in the project vicinity are typically medium-grained sands with a mean grain size of 0.02 inches (0.05 cm) (Elwany 2000). The character of the ocean bottom in the region of the project is the result of both natural processes and man-induced changes. The major natural sources of sediment to this system include, from north to south, San Juan Creek, San Onofre Creek, San Mateo Creek, Santa Margarita River, San Luis Rey River, and San Dieguito River, as well as material eroded from coastal bluffs. A limited amount of fine sediment in the littoral cell is transported shoreward from deep ocean sources. In addition, sediment generated from the dredging necessary to expose the terminal structures and manhole risers will contribute in the short term to the sediment load available to backfill the dredged areas as well as fill the conduit.

Historic human impacts to the littoral cell sediment budget in the project vicinity include the construction of the seawalls and fortifications at SONGS; the placement of railroad tracks at the base of the coastal bluff north of SONGS; the addition of artificial beach fill to the beach and littoral system; the construction of the fortifications along the railroad tracks and at the base of coastal bluffs; and the construction of Dana Point Harbor and Oceanside Harbor, north and south, respectively, of the project site.

Earthquake Faults

Several active and recently active faults are located in the region. The Christianitos Fault is the only major fault in the project vicinity. The nearest segment of the Christianitos Fault Zone occurs about 3 miles (5 km) east of the project area, and the Newport-Inglewood-Rose Canyon Fault Zone is located about 3 to 5 miles (5 to 8 km) west of the project area. The Christianitos Fault is a major structural feature in the project vicinity. This fault has not shown displacement since the formation of the lowest marine terrace.

While the various segments of the Christianitos Fault exhibit no evidence of movement during the past 1.6 million years and are not considered to be highly active, the Newport-Inglewood-Rose Canyon Fault Zone contains numerous recently active segments. The most recent earthquakes on that fault zone occurred in 1933 near Newport Beach, about 25 miles (40 km) northwest of the project area, and measured up to 7.8 on the Richter Scale (Jennings 1994).

Beaches

The onshore areas adjacent to the project site include the beaches along MCB Camp Pendleton. The beach berms in this area are typically 9.5 feet to 13 feet (2.9 to 4 m) AMSL. The amount of sand available to the beach and hence the size of the beach generally varies with the season as winter storm and surf conditions tend to remove sand to offshore bars, diminishing the width of a beach. Unless intercepted by subterranean canyons, these materials are returned to restore the beach during summer months. Man-made structures such as jetties and harbor structures can interfere with this natural process.

4.7.2 Regulatory Setting

The laws and regulations regarding soils and geologic conditions that would apply to the Proposed Project were addressed in Section 4.1, Marine Biological Resources, and Section 4.3, Marine Water Quality.

4.7.3 Significance Criteria

The proposed disposition activities would be considered to have a significant impact on geology, soils, and nearshore sediment deposition and erosion if any of the following would occur:

- substantial conflict with relevant regulations, e.g., regulations for protection or maintenance of marine resources would result;
- injury or loss of life would occur from an existing geological hazard;
- an existing geologic hazard would be aggravated by the proposed project or alternatives; or
- people or structures would be exposed to potential substantial adverse effects, the risk of loss, injury, or death.

4.7.4 Impact Analysis and Mitigation

The geology and soils impact analysis was based upon a review of existing information from readily available sources and a third-party review based upon readily available published and unpublished reports and literature concerning soil and geologic conditions within the project site vicinity. The analysis included a review of previously performed geophysical and bathymetric surveys and a seismicity evaluation for the project site and adjacent regions, including review of historical photographs.

Impact GEO-1: Sedimentation Effects

Dredging during the Proposed Project would cause sedimentation effects in downcoast areas (Class II)

To dismantle the terminal structures and manhole risers, it has been determined that use of a mechanical dredge would be required to remove the sediments and any existing cap rock. The engineering study prepared by BGI (2003) determined for practical purposes this material would be sidecast a distance of approximately 50 to 100 feet (15 to 30 m) away from the conduits. Based upon the estimated longshore current velocity (generated from existing NOAA buoy data), the estimated maximum surface current velocity is 1.5 knots. The depth-averaged mean annual current velocity is 0.22 knots, a velocity more likely to be observed near the seabed and affecting sediment transport.

Based on Table 6.8 of the BGI report, and assuming that the final project specifications would include the release of dredged sediment from a closed cap dredge bucket as close to the seafloor as possible, it is estimated that the horizontal extent of the sediment plume created by the dredging will range from 10 to 50 feet (3 to 15 m) from point of placement. The prevalent longshore current would carry most of the sediment plume in the direction of the dredged area.

Overall, the sedimentation effects during dredging would be potentially significant (Class II).

<u>Mitigation Measures for Impact GEO-1: Sedimentation Effects</u>

MM WAT-1-a, WAT-1b, WAT-1c, and WAT-1d would apply to this impact.

Impact GEO-2: Effects on Beaches

Removal terminal structures and manhole risers could lead to a loss of material available for beach replenishment or cause pieces of concrete to break off during disposition and move onto the beach from wave action or ocean currents (Class III)

The oceanographic processes that affect beach width and sand deposition would not be adversely affected as a result of the proposed disposition project. Although there may be a relatively small short-term and minor loss of material available for beach replenishment, middle to long-term effects on the volume of material available for beaches would not be significantly affected by the abandonment of the conduits. Once the conduits have been filled, the abandoned, below-seafloor structures would not affect longshore current velocity or direction, and would have no impact on sand disposition on the beach (Class III). No mitigation is required.

The concrete materials removed from the terminal structures and manhole risers would be substantial in size. Review of the engineering study (BGI 2003) indicates that removal of the terminal structures and manhole risers would not result in a significant amount of smaller pieces of material that would break off as the concrete sections are removed. The methods of removal of the terminal structure and manhole risers, as described in the *Seafloor Debris Removal Plan* (Appendix E) would preclude any significant concrete debris of any significant size being left on the seafloor (Class III). No mitigation is required. There is no realistic potential that the concrete materials removed from the terminal structures or manhole risers would move onto the beach from wave action or ocean currents during periods of storm surge.

Table 4.7-1 summarizes the geology and soils mitigation measures.

Table 4.7-1. Summary of Geologic Impacts and Mitigation Measures

Impact	Mitigation/Preventative Measures
GEO-1: Sedimentation Effects	**WAT-1a.** Use closed-cap dredge bucket and SSV **WAT-1b.** Minimize sediment drop height to 10 feet (3 m) maximum **WAT-1c.** Minimize spoil placement distance from excavation; create heightened spoil profile **WAT-1d.** Minimize anchor dragging
GEO-2: Effects on Beaches	No mitigation required

4.7.5 Impacts of Alternatives

4.7.5.1 Complete Removal of Conduits Alternative

The Complete Removal Alternative would remove a larger volume of material from below the seafloor and, as a result, would create a larger trench than the Proposed Project.

Impact GEO-ALT-1: Sedimentation Effects

Dredging would cause sedimentation effects in downcoast areas (Class II)

The Complete Removal Alternative would entail a much larger volume of sediment required to expose the conduit trenches and to backfill the open trench, and would require and a longer period to achieve equilibrium.

<u>Mitigation Measures for Impact GEO-ALT-1: Sedimentation Effects</u>

MM WAT-1a, WAT-1b, WAT-1c, and WAT-1d

Impact GEO-ALT-2: Effects on Beaches

Removal of conduits could lead to a loss of material available for beach replenishment or cause pieces of concrete to break off and move onto the beach from wave action or ocean currents (Class III)

As with the Proposed Project, with implementation of the Seafloor Debris Removal Plan this alternative would have no significant impact on beaches (Class III).

4.7.5.2 Removal of Nearshore Components Alternative

The Removal of Nearshore Portions of Conduits Alternative would involve a similar scope as the Complete Removal Alternative; however, the conduits would only be removed to a distance of approximately 300 feet (91 m) offshore. The Gerwick report (2003) described two subalternatives. One subalternative would remove the terminal structures; the second subalternative would leave both vertical structures in place.

Impact GEO-ALT-3: Sedimentation Effects

Dredging would cause sedimentation effects in downcoast areas (Class II)

The Removal of Nearshore Components Alternative would entail a larger volume of sediment to backfill the open trench than the Proposed Project; however, the volume required would be less than with the Complete Removal Alternative. A short-term effect on the beach configuration within the immediate area may occur until natural processes fill the excavation (Class II).

<u>Mitigation Measure for Impact GEO-ALT-3: Sedimentation Effects</u>

MM WAT-1a, WAT-1b, WAT-1c, and WAT-1d

Impact GEO-ALT-4: Effects on Beaches

Removal of conduits could lead to a loss of material available for beach replenishment or cause pieces of concrete to break off and move onto the beach from wave action or ocean currents (Class III)

As with the Proposed Project, with implementation of the Seafloor Debris Removal Plan this alternative would have no significant impact on beaches (Class III).

4.7.5.3 Crush Conduits and Remove Terminal Structures Alternative

The activities associated with this alternative would be similar to those from the Complete Removal Alternative. However, instead of removing the conduits, the crawler crane working from the onshore trestle would crush the conduits in place using a drop chisel-shaft.

Impact GEO-ALT-5: Sedimentation Effects

Dredging would cause sedimentation effects in downcoast areas (Class III)

The Crush Conduits and Remove Terminal Structures Alternative would not remove the conduits and therefore would not create a deep trench. Because there would be no removal of the conduits, there would be reduced sedimentation impacts in downcoast areas (Class III). No mitigation is required.

Impact GEO-ALT-6: Effects on Beaches

Removal of conduits could lead to a loss of material available for beach replenishment or cause pieces of concrete to break off and move onto the beach from wave action or ocean currents (Class III)

This alternative could result in a significant volume of smaller-sized concrete debris. Storm surge could pick up concrete debris in the nearshore zone and place it on the beach in the area of the conduits. However, implementation of the *Seafloor Debris Removal Plan*, as described in Appendix E, would prevent a significant impact to beaches (Class III). No mitigation is required.

4.7.5.4 Artificial Reef Alternative

This alternative would be similar to the Proposed Project; however, the cut up sections of concrete from the terminal structures would remain permanently on the seafloor. This would create a larger artificial reef around the existing rock riprap, and no concrete debris would be taken to the recycling facility.

Impact GEO-ALT-7: Sedimentation Effects

Dredging would cause sedimentation effects in downcoast areas (Class III)

The Artificial Reef Alternative would not create any dredging or sedimentation impacts as no excavation would occur. Sedimentation impacts would be less than significant (Class III). No mitigation is required.

Impact GEO-ALT-8: Effects on Beaches

Removal of conduits could lead to a loss of material available for beach replenishment or cause pieces of concrete to break off and move onto the beach from wave action or ocean currents (Class III)

This alternative would cut up sections of concrete and allow them to remain permanently on the seafloor. The cut up sections of concrete would be large enough to resist ocean currents, and they would remain at their current location. No impacts to beaches would occur (Class III). No mitigation is required.

4.7.5.5 No Project Alternative

The No Project Alternative would leave the existing conduits and their associated terminal structures in their current state. There would be no short- or long-term effects associated with the No Project Alternative.

4.7.6 Cumulative Projects Impact Analysis

Because none of the cumulative projects identified in Section 4.0 would affect the seabed or offshore geologic processes, there would be no significant cumulative geotechnical impacts.

4.7.7 References

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