4.4 GEOLOGY

4.4.1 Impact Criteria and Methodology

Based on the Marin County significance criteria and the CEQA checklist, the project is considered to have a potentially significant impact on geological resources if:

- The project were located within an Alquist-Priolo Special Studies Zone, or a known active fault zone, or an area characterized by surface rupture that might be related to a fault;
- The substrate consists of material that is subject to liquefaction or other secondary seismic hazards in the event of groundshaking;
- There is evidence of static hazards, such as landsliding or excessively steep slopes, that could result in slope failure;
- The site is in the vicinity of soil that is likely to collapse;
- Soils are characterized by shrink/swell potential that might result in deformation of foundations or damage to structures;
- The site is in a Mineral Resource Zone;
- The site is next to a water body that might be subject to tsunamis or seiche waves;
- It would increase the potential for human injury or economic loss from earthquakes, slope failure, or other geologic hazards;
- It would result in a substantial loss of soil, a substantial reduction in important farmland, or loss of access to economically significant mineral deposits; or
- It would damage or degrade an important geologic feature or landmark.

4.4.2 Riparian Alternative

Significant but Mitigable Impacts

Impact 4.4.1: Erosion of the Tidal Inlet Channel and Banks

By increasing the tidal prism, tidal inflow and outflow velocities would increase. This would cause the inlet channel bottom to scour and the banks of the inlet channel to erode, with the result that the cross-sectional area of the tidal inlet channel would increase. This is actually one of the intended results of the project. The channel is most likely to be widened by erosion of the least resistant materials, so most of the channel widening would come from erosion of the west end of the sand spit. However, increased tidal flow velocities at the inlet may also increase erosion of the beach at the base of the cliffs on the west side of the channel inlet, and could increase erosion of the cliffs themselves. Similarly, enhanced bank erosion or channel scouring could affect the embankment supporting Wharf Road where it extends along the inner portion of the inlet channel. Minor loss of beach sand is not considered a significant impact, but undermining of the coastal bluff and undermining of Wharf Road would be significant impacts, if they occurred. It is not certain that significant erosion would occur. As the inlet channel widens and deepens in response to an increase in the tidal prism, the inflow and outflow velocity in the inlet channel would decrease, until eventually, velocities and channel dimension would approach an equilibrium condition, and the erosion process would slow down. The rate of widening of the inlet channel would be controlled by the rate of increase of the tidal prism by dredging, which would increase very slowly over a period of nine years. After project buildout, tidal inflows and outflows would be more efficient, with less channel friction. This may result in a small overall increase in channel flow velocities, relative to existing conditions.

Mitigation 4.4.1: If it occurs, enhanced erosion of the bluffs on the west bank of the inlet channel could be partially mitigated by placing protection structures at the base of the bluff, including riprap, cement walls, or bluff armoring. Bluff erosion is a natural process that occurs under current conditions. Some amount of bluff erosion is inevitable and acceptable. The rate of erosion would be monitored to determine if mitigation is warranted. Currently, the embankment supporting Wharf Road is partially armored (for example, by riprap and by concrete retaining walls). Because the rate of increase of the tidal prism would be slow, it is expected that the increased rate of erosion of the west bank of the channel would be slow enough, and the amount of increase in flow velocity would be small enough, that shore protection mitigation measures could be implemented, if needed, before significant damage occurred.

Less than Significant Impacts

Enhanced Wave Attack in Lagoon Interior

At high tide levels, when the depth of water in the inlet channel is greatest, more of the incident wave energy would travel farther into the lagoon than under current conditions or the No Action Alternative and would be expended on points inside the lagoon. This may increase erosion of shoreline features inside the lagoon, including the south shore of Kent Island, the bluffs on the west side of the inlet channel, and the eastern shoreline along Highway 1. It is expected that, due to the distance from the inlet channel to Highway 1, and the geometry of the lagoon channels, wave energy would be dissipated before it reaches the shoreline of Highway 1 and that the erosion impacts from increased wave energy would be less than significant. The magnitude of any increase in wave action along the west side of the inlet channel (and Wharf Road) is likely to be minor, relative to the range of existing conditions.

4.4.3 Estuarine Alternative

The impacts of the Estuarine Alternative would be the same as those described for the Riparian Alternative.

4.4.4 No Action Alternative

Significant but Mitigable Impacts

Impact 4.4.2: Inlet Channel Narrowing or Closure

A reduction in the tidal prism of the lagoon would eventually reduce the power of tidal flows and would result in closure of the lagoon entrance channel. Narrowing or closure of the lagoon would accelerate sediment deposition in the lagoon. Freshwater inflows to the lagoon would continue, and some of the freshwater would seep through the permeable sand spit. If inflows exceeded seepage rates, the level of freshwater behind the sand spit would increase. The higher water level could cause Highway 1, houses on the sand spit, and other shoreline features to flood. This would be a significant adverse impact of the No Action Alternative.

Mitigation 4.4.2: Because the flooding that would result from closing the inlet channel would not be acceptable, a method would have to be found to release the excess water. A number of engineering options are available for releasing the water from the lagoon, and it can be assumed that some workable engineering solution could be found, if cost were not a limiting factor. (Implementing such mitigation measures under the No Action Alternative is not within the project scope and would be the responsibility of the MCOSD or others.)

The characteristics of the lagoon area would become largely dependent on the nature of the outlet. Three general classes of mitigation to control the water level in the lagoon below flood levels can be envisioned: Measures that allow tidal exchange in the lagoon to continue (that cause the tidal inlet to remain open); measures that cut off the lagoon from tidal exchange; and measures that involve temporarily opening the lagoon to tidal flows (such as breaching the sand spit when needed). Details of the design and effectiveness of potential flood mitigation options are not currently available.

An example of the type of measure that might be used to keep the inlet channel open in spite of a reduced tidal prism is construction of groins seaward of the mouth of the lagoon. The groins would be designed to direct sand that is presently carried along the shoreline of the sand spit away from the tidal inlet and into the deeper waters of Bolinas Bay. Sand would presumably continue to build up on the east side of the groin, widening the beach there, but the groin would act as a barrier, preventing the extension of the sand spit. If successful in preventing the tidal inlet from closing, the tidal prism could continue to decrease, but the tidal inlet would continue to function as an outlet for the runoff from the lagoon watershed.

Less than Significant Impacts

Fault-Related Lagoon Subsidence

Subsidence of the lagoon by natural fault-related processes could increase the tidal prism and might result in many of the same benefits that the action alternatives are designed to provide. This would be a significant impact of the No Action Alternative. But the probability of it occurring is unknown.

Keeping in mind that there is a high degree of uncertainty associated with predicting the rate of subsidence of the lagoon graben or the probability that subsidence would occur within a given time, it is nevertheless likely that the lagoon graben will continue to subside in conjunction with movement on the San Andreas Fault. It is possible that a subsidence would occur within the next 50 years, the time predicted for the mouth of the lagoon to close. The USGS estimates that the recurrence interval for an earthquake with a 7.95 moment magnitude, originating on one of the segments of the San Andreas Fault from Santa Cruz north, is about 361 years.

Subsidence of the lagoon graben may very well occur in association with such a large magnitude earthquake, even if the earthquake were not centered near the lagoon. However, the smaller the event, the nearer to the lagoon the epicenter would need to be for subsidence to result. But smaller events are more frequent. Thus, for example, the USGS has estimated that there is a 10 percent probability of a magnitude 6.7 or greater earthquake centered on the northern segment of the San Andreas Fault within the next 30 years. A magnitude 6.7 earthquake is less powerful than the 1906 earthquake by a factor of 40. None of these estimates is intended as a direct measure of the probability of lagoon subsidence; but as an indirect measure, they suggest that an event large enough to cause major subsidence of the lagoon is an infrequent occurrence, relative to the predicted timeframe for closure of the mouth of the lagoon.