RINCON PHASE 2 DECOMMISSIONING PROJECT - POTENTIAL CAUSEWAY ALTERNATIVE DECOMMISSIONING IMPACTS

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INTRODUCTION AND SCOPE OF REPORT

Rincon Island and the approximately 2,800-foot-long causeway connecting the Island to landfall at Punta Gorda (Study Location), is about seven miles northwest of the city of Ventura along a stretch of coastline referred to as the Rincon coast (Figure 1). The island and causeway were constructed in 1959 by Atlantic Richfield Company (ARCO) in order to enable offshore drilling and then oil and gas production. The causeway landfall includes an abutment structure that is surrounded by a riprap revetment. Rincon Island and the associated nearshore and onshore components were historically leased to ARCO and subsequently Rincon Island Limited Partnership from the California State Lands Commission (CSLC). The lease was quitclaimed in 2017 to the State Lands Commission, which is now evaluating different options for removing the island, the causeway and the shoreline abutment and protective revetment. An assessment of the environmental impacts of the various options is an important part of that evaluation. This report is a component of that evaluation process and includes the following components:

1] A review of the regional shoreline setting of the Punta Gorda area in relation to the Santa Barbara Littoral Cell.

2] An evaluation of historic littoral drift rates along the Punta Gorda shoreline based on published work on the Santa Barbara Littoral Cell as they affect beach formation and shoreline configuration.

3] A comparison of the present coastline configuration at Punta Gorda/Mussel Shoals on the Ventura County coast with historic configuration based on aerial photographic and satellite imagery in order to determine if and how Punta Gorda/Mussel Shoals morphology and the beaches has changed over time. This includes the time period before and after shoreline abutment/revetment, causeway and island construction.

4] A discussion of the conclusions of the above analyses including an evaluation of how each of the three alternative approaches for decommissioning the causeway connecting Rincon Island would potentially affect the shoreline and beaches at the site. These alternatives include:

• Removal of the entire causeway, but retention of the abutment & revetment
• Partial removal of the causeway (length to be determined) and retention of the abutment & revetment
• Removal of the entire causeway and abutment

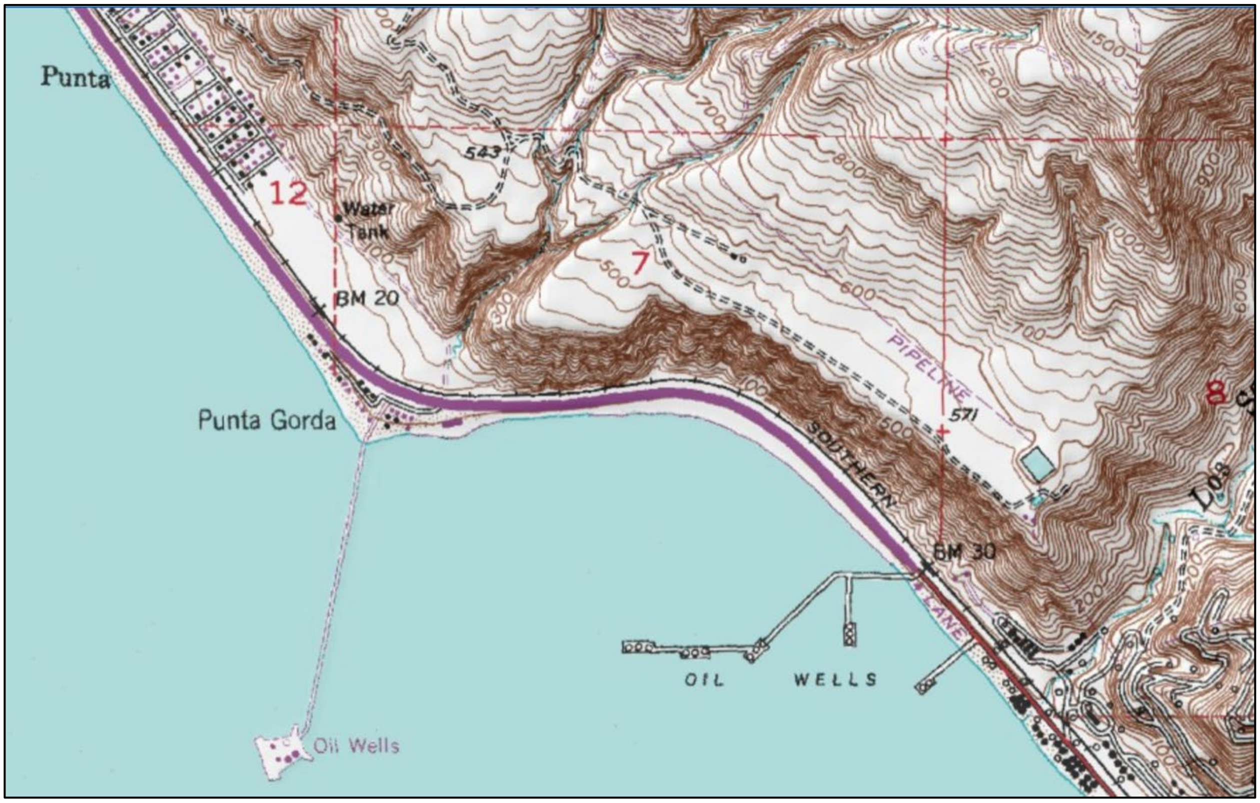

Figure 1. Site Location Map (USGS Punta Gorda Quadrangle, 2018)

AN OVERVIEW OF BEACH SAND MOVEMENT, LITTORAL DRIFT AND LITTORAL CELLS/BEACH COMPARTMENTS

Sand is in constant motion along the shoreline due primarily to the action of waves. At any particular location, sand is moving both on and offshore seasonally due to differences in the summer and winter waves (Patsch and Griggs, 2006a). Summer beaches tend to be wider and higher while winter beaches are lower and narrower. Sand also moves alongshore as a result of most waves breaking at some angle to the shoreline. This alongshore movement of sand is called littoral drift, littoral transport, or a longshore current (Figure 2). Along the Rincon coast the dominant wave direction is from the west down the Santa Barbara Channel (the offshore ocean between the shoreline and the Channel Islands – see Figure 3), which drives sand to the east or downcoast. Based on long-term dredging volumes from the Santa Barbara Harbor (~16 miles upcoast to the west), we know that the long-term average annual littoral drift of sand along the Rincon coast is approximately 300,000 yds^3/year.

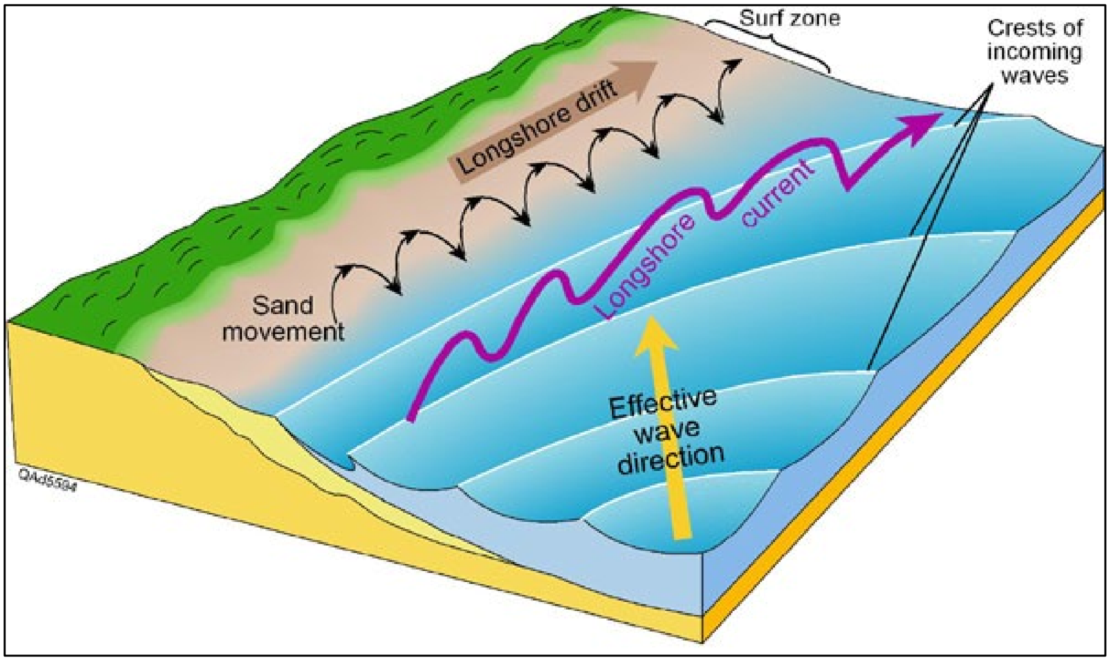

Figure 2. The development of a longshore current from waves approaching the shoreline at an angle, that then transports sand downcoast as littoral or longshore drift.

Many years of study of the shoreline and beaches of central California have shown that the coast can be divided into a series of essentially self-contained *littoral cells* or *beach compartments* (Figure 3 – Patsch and Griggs, 2006a and 2006b). Sand enters these cells or compartments primarily from river and stream discharge, and to a lesser degree, from bluff or cliff erosion. Littoral transport by waves then moves this sand alongshore or downcoast through each littoral cell where it can be either be transported onshore by wind to form sand dunes or is transported offshore into one of the many offshore submarine canyons that approach the shoreline (Patsch and Griggs, 2006a and 2006b).

Figure 3. Major littoral cells or beach compartments along the southern California coast. The Santa Barbara Channel is the offshore area from Pt. Conception to Oxnard and from the shoreline to the Channel Islands.

COASTAL LITTORAL CELL SETTING AND LITTORAL DRIFT IN THE PUNTA GORDA-MUSSEL SHOALS AREA

The Study Location (Punta Gorda/Mussel Shoals) lies in the middle of the 144-mile-long Santa Barbara littoral cell that extends from the mouth of the Santa Maria River to the Mugu Submarine Canyon (Figure 4; Patsch & Griggs, 2008). The sand budget for this cell or beach compartment is well known and includes beach sand sources, littoral drift rates and sinks or losses (Patsch & Griggs, 2006 A & B). Sand supplied by the Santa Maria and Santa Ynez Rivers is transported south and west, around Point Conception, where it is augmented by modest amounts of sand provided the smaller creeks between Point Conception and Santa Barbara. The littoral drift is then impounded by the Santa Barbara Harbor breakwater, which forms an essentially complete trap (Figure 5), since harbor construction was completed in 1933. Due to the formation of this sand trap, dredging has been required for the last 88 years. The average annual volume of sand dredged from the harbor is approximately 300,000 yds^3/year (Patsch and Griggs, 2021).

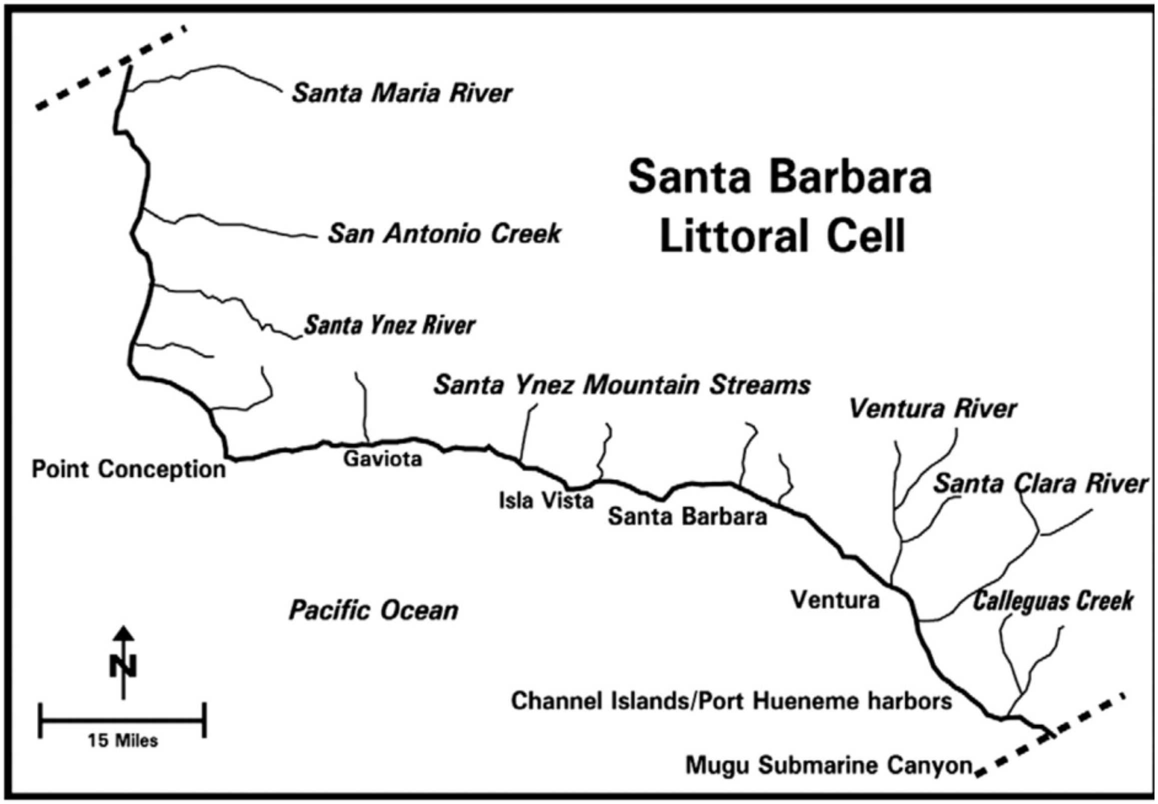

Figure 4. Boundaries and main features of the Santa Barbara Littoral Cell.

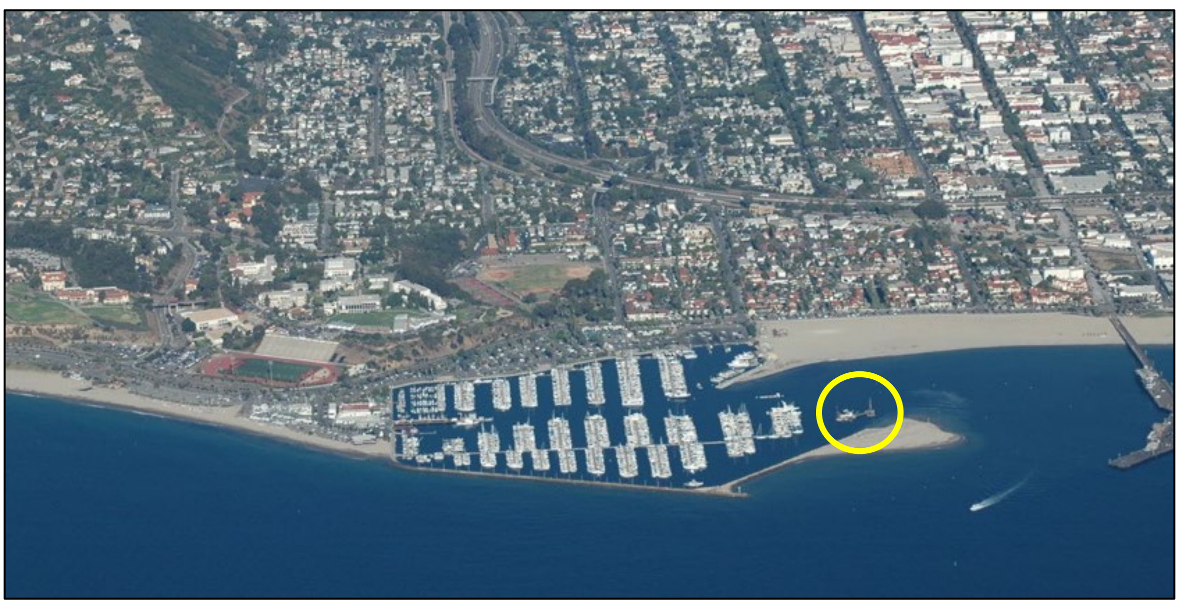

Figure 5. The Santa Barbara Harbor with sand spit and dredge (circle). Littoral drift moves from left (west) to right (east or downcoast*).*

The dredged sand is piped from the end of the breakwater (Figure 5) to the adjacent downcoast shoreline (East Beach) where it is naturally transported downcoast to the east along the shoreline by the longshore currents. There are a few small streams along this stretch of coastline that contribute small amounts of additional sand, and it is believed that bluff erosion adds a small amount of sand to the system between the harbor and Punta Gorda. Since there are no identified sinks, such as submarine canyons or dune fields along this 16-mile section of coastline that would lead to sand losses, the ~300,000 yds^3/year dredging volume at Santa Barbara is believed to be a reliable proxy for the volume of littoral drift of sand that would arrive at Punta Gorda in a typical year.

Ten miles further downcoast from the Project Location at Punta Gorda, the Ventura River discharges large volumes of sand to the shoreline. Three miles east of the river mouth, the combined littoral drift, which now includes the sand dredged from the Santa Barbara Harbor and that contributed by the Ventura River, is dredged from the Ventura Marina at an average rate of nearly 600,000 yds^3/year (Figure 6; Patsch and Griggs, 2021). It is clear from long-term dredging records that the section of shoreline, that includes Punta Gorda, is characterized by large volumes of littoral sand transport.

Figure 6. Ventura Marina, 10 miles east of Punta Gorda, where an average of about 600,000 yds^3 is dredged annually. Littoral drift of sand moves from left to right.

HISTORIC SHORELINE AND BEACH CONFIGURATION PRIOR TO RINCON ISLAND, CAUSEWAY AND ABUTMENT/REVETMENT CONSTRUCTION

Beaches occur along the California coast where the right combination of sand supply, coastal configuration, sand retention structures (natural or artificial) and wave climate (conditions) occur. Those locations where littoral drift is trapped are often where there is some natural feature, such as a headland, point or stream delta, or an artificial structure, such as a groin, breakwater or jetty, that will retain or trap littoral sand. An embayment along the coast or where the orientation of the shoreline is parallel to the angle of wave approach, are other locations where littoral drift can be impounded and a beach can form. Good examples along the Santa Barbara and Ventura County coastlines of barriers that have created significant beaches include Devereux Point, Campus Point at UCSB, the Santa Barbara Harbor breakwater, Sand Point, Rincon Point, Punta Gorda, Faria, the groin field in the city of Ventura, and the jetty and breakwater at the Ventura Marina.

It is many of these same features along this shoreline and elsewhere along California's coast that form some of the best surf breaks because of the waves refracting or bending as they approach the shoreline. Mavericks at Half Moon Bay, Steamer Lane and Pleasure Point in Santa Cruz, Rincon Point and Malibu, are a few examples.

The Study Location at Punta Gorda is a significant point along an otherwise nearly linear coastline that extends into the nearshore zone and traps the eastward or downcoast moving littoral drift of sand to form a long upcoast beach (Figure 7). The point exists in part because of the resistant bedrock that outcrops along the shoreline visible in both aerial photographs and also on the ground (Figure 8), but also because this is an alluvial fan delta (like Rincon) formed by many decades of coarse sediment discharged by the large drainage immediately landward (Figure 7).

The United States Geological Survey has recently completed a large-scale seafloor mapping program along most of the California coast, including the Ventura County coast, using a variety of different geophysical, geological and photographic methods. While their vessels are limited in how close to the beach they can actually work, the area immediately offshore of Punta Gorda has been identified as "hard, consolidated sedimentary-bedrock outcrop" (Figure 9; Endris et al., 2013). An additional map in this USGS study labels the bedrock outcrop along the shoreline and in shallow water at Punta Gorda as Tp or Pico Formation, a mixture of interbedded claystone, siltstone and sandstone; locally pebbly (Johnson, S.Y., et al., 2013). This rock type is resistant to wave erosion as evidenced by the outcrops along the shoreline at Punta Gorda (Figure 8) and also the outcrops on the seafloor evident in the recent multibeam bathymetric survey of the area (Figure 10). These subtidal outcrops are most certainly the reason why this area has also been called Mussel Shoals.

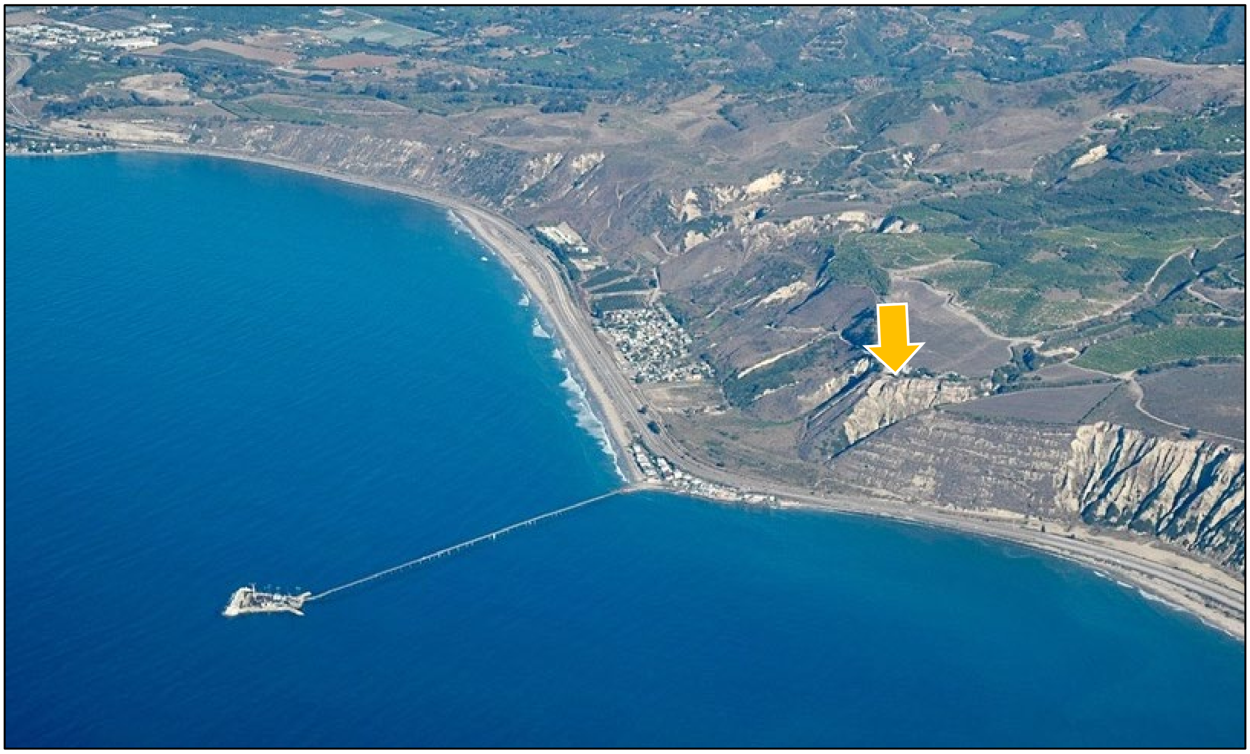

Figure 7. 2006 aerial view of Rincon Island, the Rincon coast, and Punta Gorda with a long sandy beach upcoast. Large drainage at arrow has created the alluvial fan and delta at Punta Gorda (Photo: Bruce Perry CSULB).

Figure 8. Nearshore bedrock outcrops forming Punta Gorda adjacent to left side of abutment (2013 photo from California Coastal Records Project, Kenneth and Gabrielle Adelman).

An additional factor creating a resistant area of coastline at this location is the historic sediment discharge of the immediately onshore drainage system. This drainage extends about 1.5 miles inland from the shoreline and has cut a large canyon about 250 feet deep into the terraced hills (Figures 7 and 11) and has built a large alluvial fan at the base of the hills (Figure 12). While the initial grading and construction and later widening of State Highway 101 would have altered or controlled the discharge point of this drainage, the amount of coarse material discharged to the shoreline during heavy rainfall and runoff events over many decades would have armored the shoreline and created both a large historic delta (Figures 7 and 11) but also a smaller delta immediately downcoast of Punta Gorda (Figure 13). Punta Gorda and Mussel Shoals have been in this location for at least hundreds of years by virtue of the rock outcrop and the delta formation.

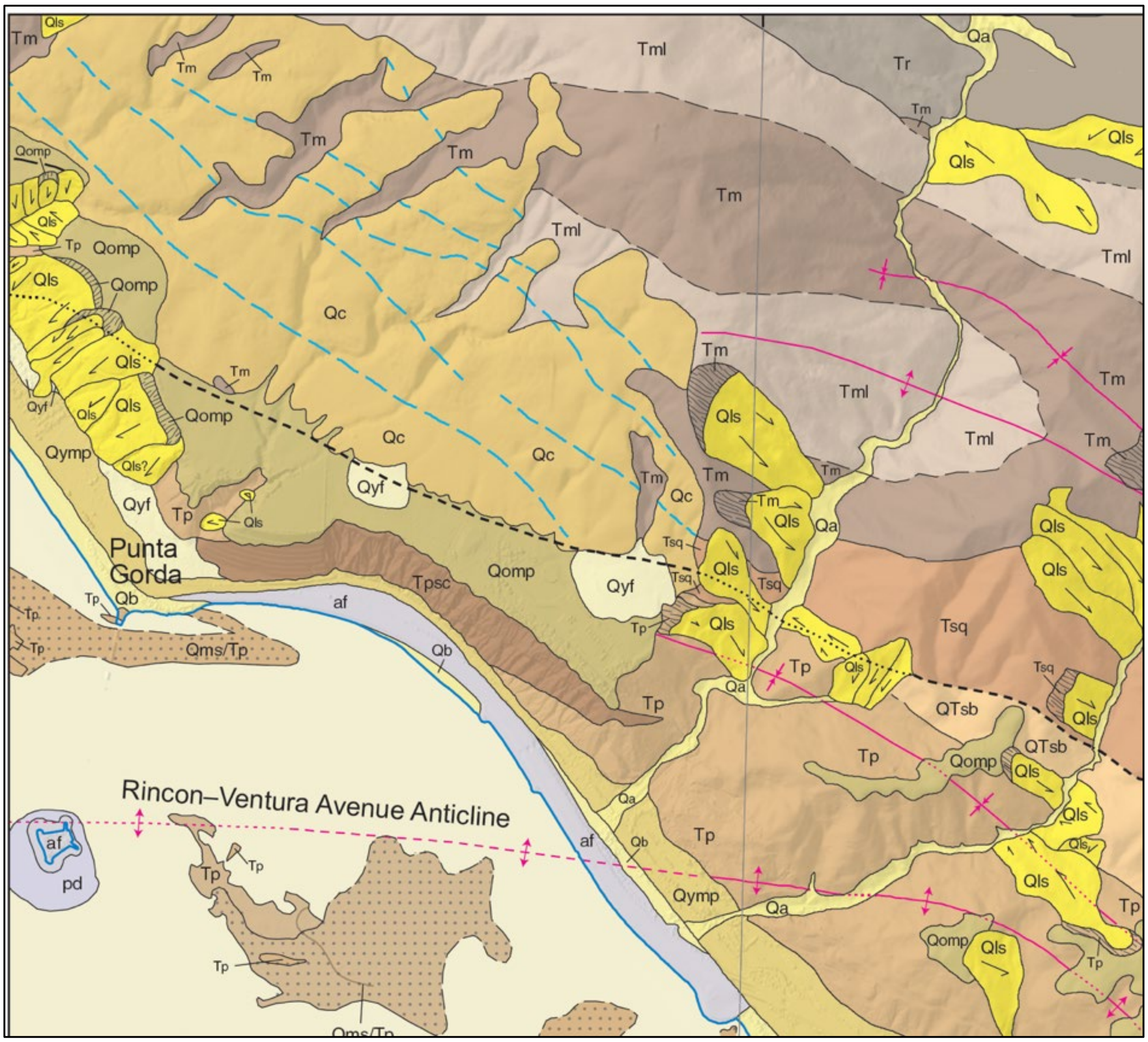

Figure 9. Geologic units along the coast and offshore (from USGS). Tp represents outcrops of the Pico Formation, which make up Punta Gorda and the offshore seafloor. Qms represents sand deposits on the seafloor.

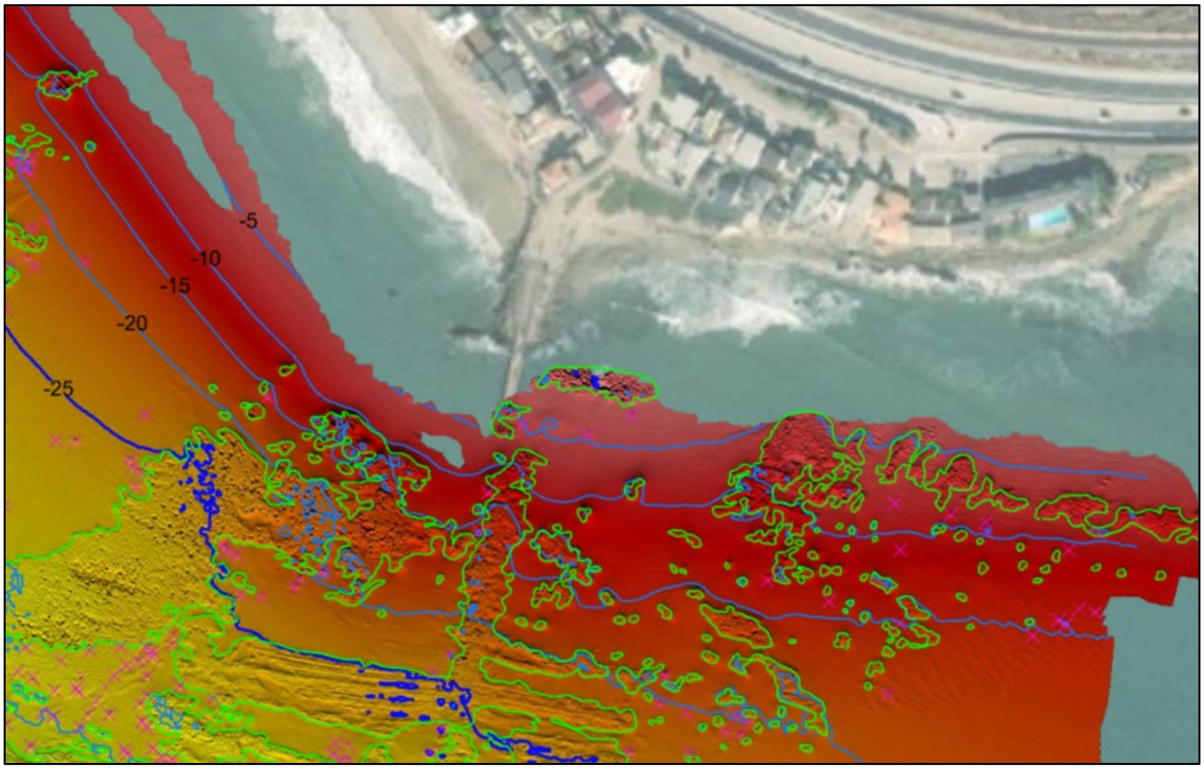

Figure 10. Multibeam bathymetry of area directly offshore from Punta Gorda (from LONGITUDE 123 INC). Colors indicate depth below NAVD88, with red being shallowest (<~20 ft.), orange & yellow (20-30 ft.). Chartreuse (light green) color indicates seafloor rock outcrops.

Figure 11. Terraced hills of Rincon Mountain showing deep arroyo and large drainage area (arrow) directly onshore from Punta Gorda where the arroyo would have discharged its sediment load (Photo: Bruce Perry-CSULB*).*

Figure 12. Alluvial fan (at arrow) formed at mouth of arroyo immediately inland from Punta Gorda. (Photo: California Coastal Records Project – Kenneth & Gabrielle Adelman).

Figure 13. 1945 aerial photograph showing a smaller delta (bulge in shoreline) at the mouth of the arroyo just downcoast from Punta Gorda at the mouth of the large arroyo.

A regional aerial view provides a good perspective of the extent of arroyo erosion in the erodible materials making up the terraced hillsides onshore along Rincon Mountain (see Figure 11). Rincon Point, 2.3 miles upcoast of Punta Gorda, has also been formed by the armoring of the shoreline by the coarse material brought to the shoreline by another drainage system, Rincon Creek (Figure 14). Downcoast, the bulges in the shoreline, which has led to home construction at Dulah and Faria, were also due to deltas forming at the mouths of the onshore arroyos/streams.

Figure 14. Rincon Point is the delta formed by the coarse sediment discharge of Rincon Creek.

The outcrop pattern of the sedimentary rock of the Pico Formation in the surf zone at Mussel Shoals is evident in many of the pre-1959 causeway and island construction aerial photographs and this has created a natural groin that has retained the littoral drift of sand from upcoast or the west (Figure 15). The result is a sandy beach that extends approximately 1.6 miles upcoast to where the coastline and Highway 101 changes orientation and heads more westerly towards Rincon Point (Figure 7). Wave refraction or bending around Rincon Point produces a world-famous surf break but also a strong longshore current along this northeast-southwest oriented shoreline (Figure 16). Where the shoreline turns almost 90 degrees to the southeast, wave refraction is minimal and littoral sand begins to accumulate to form the long beach upcoast of Punta Gorda.

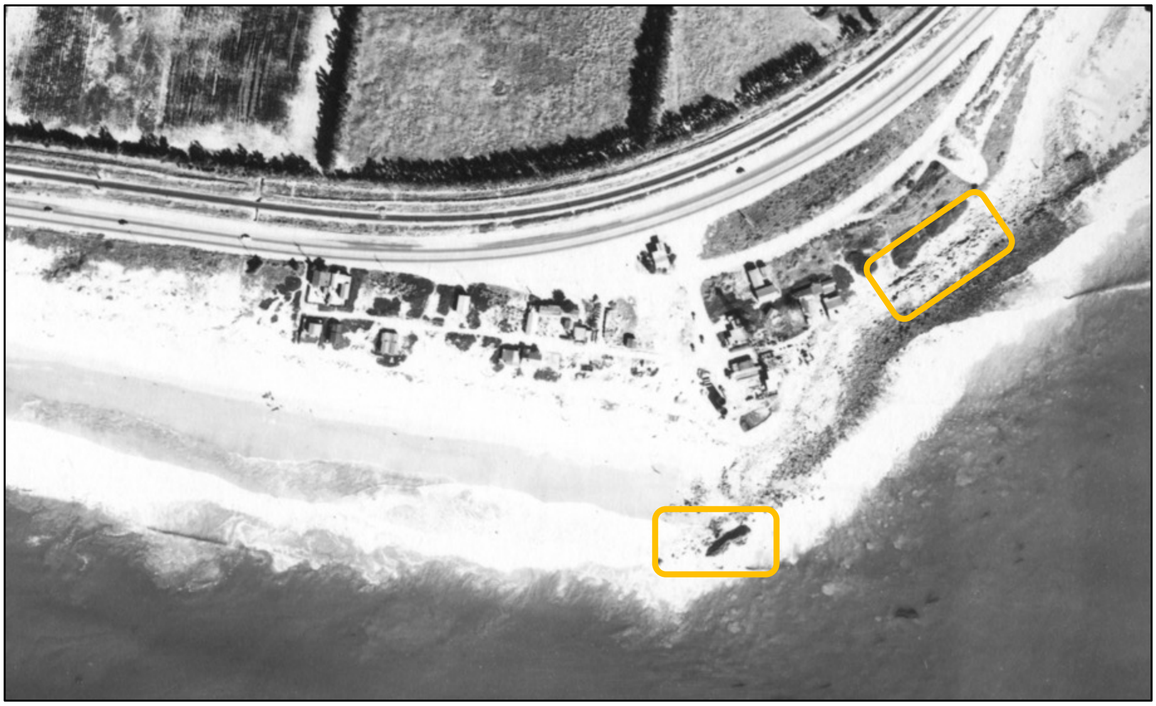

Figure 15. 1944 aerial photograph of Punta Gorda showing Pico Formation outcrop on beach (outlined in yellow) that acts as a groin to trap longshore transport of sand. Additional outcrop occurs on the back beach down coast.

Figure 16. Rincon Point in August 2014 showing wave refraction around point and narrow beach immediately downcoast.

The beach upcoast of Punta Gorda is present on all historic aerial photographs of this stretch of coast going back nearly a century, as far as 1927. The beach varies in width seasonally, as do all of California's beaches, but generally ranges from about 50 to 150 feet wide (Figure 17). This beach was wide and stable enough that dunes have formed, covered with vegetation in places.

Figure 17. Wide sandy beach upcoast from Punta Gorda (October 1945).

Approaching Punta Gorda, the beach widens as sand has accumulated against the natural bedrock groin. Based on the vertical aerial photographs from 1927, 1936, 1939 and 1945, the beach next to Punta Gorda has varied in width from about 230 to 400 feet. It was this wide, relatively stable beach resulting from the bedrock groin at Punta Gorda that led to the construction of the first beach houses here. By as early as 1927, there were already about fifteen homes that had been constructed on this wide back beach/dune area (Figure 18).

The area immediately east of the point had a triangular-shaped, rocky beach that existed throughout these pre-1959 years and extended 250 to as much as 500 feet downcoast.

Figure 18. Punta Gorda (January 1927) with some houses built on the back beach and dunes.

The front edge of this beach in all of the older (pre-1959) photographs looks to be partially covered with boulders that extend a considerable distance (~750 feet) downcoast from the point. The shoreline also has a bulge in this area, which combined with the boulders and the large drainage immediately landward is a good indication for this area being the original delta produced by the historic coarse sediment discharge from the onshore arroyo or watershed.

CHANGES TO THE SHORELINE AND BEACHES FOLLOWING 1959 CONSTRUCTION OF THE ISLAND, CAUSEWAY ABUTMENT AND REVETMENT

In 1959, the offshore island, the coastal abutment and rock revetment, and the causeway connecting these were constructed at Punta Gorda (Figure 7). The vertical aerial photographs taken prior to the construction that were discussed above (from 1927, 1936, 1939, 1944 and 1945), have been compared to the numerous aerial photographs (both vertical and oblique) taken in the years following construction to determine the extent of any shoreline and beach changes that have occurred in the subsequent years.

Although a concrete abutment was built extending out from the shoreline and armored on both sides and at the tip by riprap in 1959, this only extended seaward as far as the existing bedrock outcrop in the surf zone (Figure 8). The shoreline construction didn't significantly lengthen or extend the original natural bedrock groin forming Punta Gorda. The bedrock outcrop of Pico Formation is clearly visible on all pre-installation aerial photographs from 1927 to 1945 (Figure 19.


Figure 19. Punta Gorda in November 1945 showing Pico Formation bedrock trapping sand and forming the point.

It was this natural bedrock groin that trapped the southeastward movement of littoral sand and determined the width of the adjacent upcoast beach. While this beach does change in width seasonally and from year to year due to differences in wave climate, there has not been any consistent increase or decrease apparent in the adjacent beach width in the 63 years since abutment and riprap construction. The first 850 feet of beach immediately upcoast of the abutment has been significantly reduced in width, however, due to the construction of homes on the back beach and dunes and the emplacement of riprap along the shoreline to protect those 19 homes (Figure 20).

Because of the equilibrium or uniform profile between the exposed beach and the nearshore seafloor, it can reasonably be concluded that there have also been no significant long-term changes in the offshore area upcoast of the point since the causeway abutment was constructed. Additionally, the littoral drift or longshore transport of sand along this stretch of shoreline, as indicated by the dredging history of the upcoast Santa Barbara Harbor - 16 miles to the northwest – hasn't changed significantly over the nearly 90 years since harbor construction and dredging was initiated (Patsch and Griggs, 2021).

Any changes to the shoreline and nearshore zone immediately downcoast of the causeway abutment are also important to evaluate as they would potentially affect the wave conditions. Comparing the pre-1959 aerial photographs with the photographs taken after construction can provide the most useful comparison of any significant shoreline change.

Figure 20. Beach upcoast of Punta Gorda showing encroachment of homes on the shoreline that reduced beach width (outlined in yellow), and downcoast rocky shoreline. Note Pico Formation bedrock outcropping along the back beach extending into the subtidal (outlined in white)(Google Earth August 2019).

Punta Gorda forms a prominent point on the otherwise more-or-less linear or smooth shoreline in this area (Figure 7). The upcoast and downcoast sides of this point are different, however. Upcoast is a 1.6-mile-long, linear sandy beach formed by sand deposition or accretion against the natural groin formed by the nearshore bedrock outcrop. The downcoast side is a rocky shoreline backed by a low bluff with a shore face and intertidal area covered with boulders and cobbles that extend about 1,000 feet eastward where the bulge formed by Punta Gorda merges with State Highway 101 (Figure 20). While it is not possible to determine the source of all of the cobbles and boulders on the beach, they are from one of two different sources:

1] Outcrops of Pico Formation bedrock are exposed on the beach, in the nearshore zone and also in the subtidal (Figures 20 & 21). Rocks of the Pico Formation are also shown clearly on the multibeam bathymetry recently collected just offshore and were almost certainly the reason behind the Mussel Shoals name for this feature.

2] The riprap that has been added completely around the concrete abutment and also in front of the homes downcoast of the abutment. Rip rap was also placed beginning about 130 feet downcoast of the abutment that extends approximately 900 feet fronting and protecting the 12 homes and motel that were built on the low bluff. Rip rap then continues downcoast protecting Highway 101.

Figure 21. Outcrops of the Pico Formation adjacent to the causeway.

An October 2022 site visit reveals that the larger rocks on the beach at present are the same type of rock that was used to armor the abutment and also to protect the homes east of the abutment, which appears to be a very hard volcanic clastic rock. Some of the rock scattered across the downcoast beach and into the surf zone and beyond appears to be “fugitive” boulders that were loosened and then removed from the original riprap placement in 1959 by storm waves in the subsequent years (Figure 22).

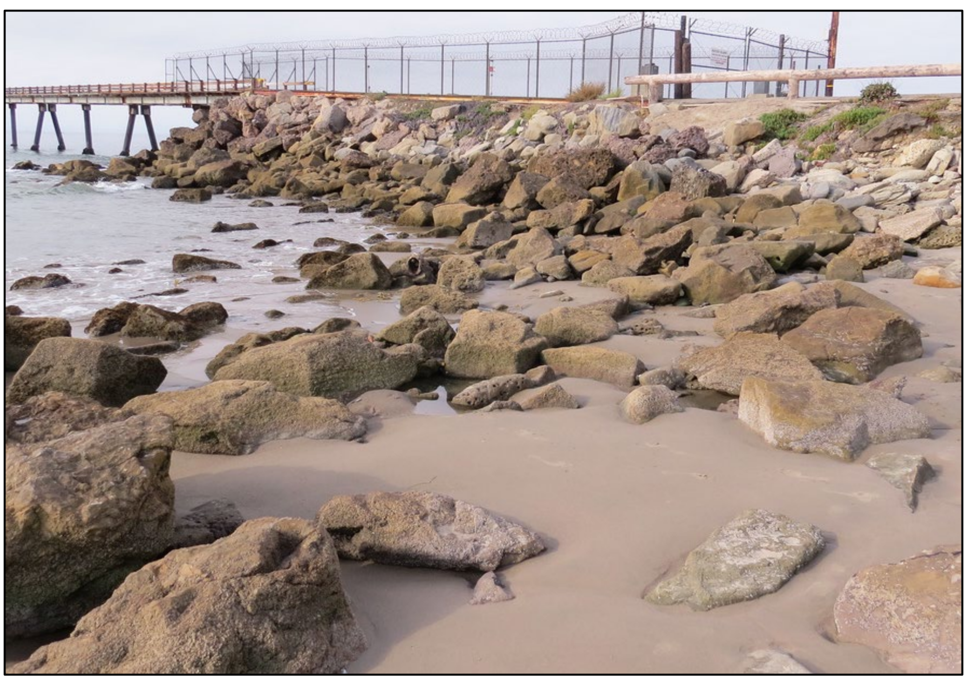

Figure 22. Boulders along the present shoreline downcoast from the abutment.

By 1987, the upcoast homes all have been armored, and the downcoast shoreline also appears to have had some riprap emplaced. A higher resolution photo from 2002 show where riprap was placed downcoast (Figure 23).

Figure 23. 2002 photo showing where riprap has been placed downcoast from the abutment.

The shoreline immediately downcoast of Punta Gorda has changed in configuration from a generally convex seaward shape prior to causeway construction to a concave configuration following construction of the causeway abutment (Figure 24). The pre-installation photographs show a sandy back beach area fronted by a rocky shoreline. This may be due to wave reflection off of the abutment focusing energy in this area, leading to scour of the beach, which is a common effect where groins have been spaced too far apart along a shoreline. It also may be due to continued erosion of the former active delta as the sediment supply was cut off, or a combination of the two.

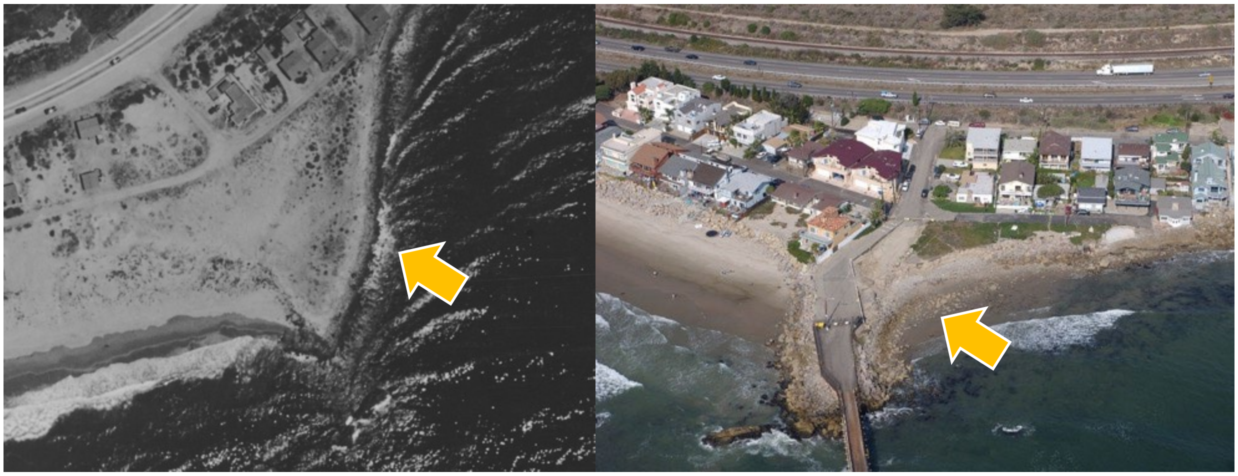

Figure 24. Comparison of 1927 image and 2004 image showing difference in shoreline area immediately downcoast of the abutment.

POTENTIAL EFFECTS OF THE RINCON CAUSEWAY & ABUTMENT REMOVAL ON THE SHORELINE AND BEACHES

Each of the three alternative approaches for decommissioning the causeway connecting Rincon Island to the shoreline and the associated concrete abutment, and potential effects on the shoreline and beaches are evaluated below. Demolition of the concrete abutment would involve first removal and temporary stockpiling of the surrounding riprap, followed by removal of the concrete abutment, and finally, replacing the riprap around and over Punta Gorda. The three causeway alternatives include:

A. Removal of the entire causeway but retention of the abutment
B. Partial removal of the causeway and retention of the abutment & revetment
C. Removal of the entire causeway and abutment

When discussing potential effects, it should be noted that any historic shoreline or beach change taking place along the Study Location could be due to either natural processes or anthropogenic factors, or a combination of the two. Potential natural processes and anthropogenic factors are described below:

1) *Natural processes*, which could include changes in wave climate (direction of wave approach, size of waves or frequency of large storms); coincidence of large waves at times of elevated water levels (high astronomical tides or El Niño events), amount of sand delivered to the shoreline by stream runoff or bluff or dune erosion; or short-term tectonic events (uplift or subsidence during an earthquake).
2) *Anthropogenic factors,* which could include construction or removal of some upcoast or adjacent coastal engineering structure (groin, jetties, breakwater, seawall or revetment); augmentation or reduction of sand supply through inland barriers such as dams or debris basins or shoreline barriers (groins, etc.); changes in stability of cliffs or

bluffs due to surface or groundwater alterations, or cliff loading; and any alterations to Highway 101 (widening, realignment, etc.).

Shorelines and beaches also experience both 1) short-term changes, taking place over days, weeks or months, and also 2) longer-term changes, taking place over years to decades or longer. No shoreline or beach will remain the same for long, as wave climate changes, offshore and onshore sand moves around, coasts erode and retreat, and sea level rises. In response, the waves breaking on the shoreline will change over time as well.

OPTION A: REMOVAL OF THE ENTIRE CAUSEWAY BUT RETENTION OF THE ABUTMENT & REVETMENT

In this option, which was previously labeled the Reefing Alternative, the entire approximately 2,800 feet of causeway extending from the shoreline abutment to Rincon Island, would be removed. The causeway pilings and wooden pile stubs (used in the original construction of the causeway), as applicable would be removed to five feet below the seafloor. The existing causeway abutment and surrounding riprap revetment would be left in place.

Would this removal option have any effect on the shoreline and beach? There are two approaches to resolving this question: a. What effect, if any, did the initial construction of the causeway have on the shoreline configuration and beach? and b. Would there be any significant change in the nearshore wave conditions with this decommissioning option that might affect the shoreline and beach?

The changes that occurred along the Punta Gorda shoreline as observed in the pre-installation (pre-1959) and then post-installation aerial photos were evaluated and discussed earlier in this report. Study of the many pre- and post-installation images indicate no significant or systematic change in the long sandy beach upcoast (west) of the causeway or abutment, other than the narrowing of the first 1,000 feet of beach west of the abutment due to the placement of homes and riprap on the back beach and dunes.

Because the dominant waves along the Rincon coast approach from the west (NV5, 2021) and move eastward down the Santa Barbara Channel (Figures 25 & 26), and the causeway is downcoast from where the waves break on the sandy beach, the causeway has no impact on wave action at this location. As discussed earlier on pages two and three, waves are the major driver of nearshore beach processes, whether seasonal differences in wave climate (height, period and steepness) that produce changes in the beach profile, or longshore transport of sand driven by the angle that waves approach and break on the shoreline (see Figure 2). Essentially all of the waves breaking on the sandy shoreline upcoast or west of Punta Gorda are completely unaffected by the causeway, which is downcoast. Removal of the causeway would therefore have no effect on the shoreline and the sandy upcoast beach.

Figure 25. May 2015 Google Earth image showing wave fronts approaching from the WNW (from approximately 280°) and striking the upcoast sandy beach before reaching the causeway.

Figure 26. April 2018 image showing waves approaching from the WSW (from approximately 250°) and breaking on the upcoast beach before reaching the causeway (Google Earth).

The coast immediately downcoast from Punta Gorda differs from the upcoast shoreline in having a rocky beach backed by a low eroded bluff with rocks of the Pico Formation exposed in the bluff, along the beach and on the nearshore seafloor (Figure 27). The evaluation of the changes along the coastline downcoast from Punta Gorda from the construction of the abutment, causeway and island were discussed earlier. There were no significant shoreline changes evident in the post-1959 photographs in contrast to the pre-1959 photographs other than in the area adjacent to the abutment and riprap (see Figure 22). The convex seaward sandy shoreline backed by dunes in the 1927 aerial photo) had already begun to erode by the time of the 1945 photo (see Figure 13). This erosion continued in the subsequent years with the dunes and most of the sandy beach gradually being removed, leaving a rocky shoreline with a concave seaward shape (Figure 28).

Waves approaching this stretch of shoreline typically pass through the causeway. The pilings for the causeway are of a very small diameter and also widely spaced (see Figure 29), however, such that they have no significant effect on the waves passing through the causeway. An earlier coastal engineering study on the Decommissioning Project (NV5, 2021: p.15) also concluded that "the impact of the causeway removal on the nearshore processes is negligible because the size of the causeway piles is negligible compared to the wavelength(of the waves) and scale of the nearshore area". Additionally, aerial photos that capture waves approaching the shoreline do not indicate any obvious effect of the causeway on the waves passing through the pilings (Figures 30 and 31).

Figure 27. Comparison of shoreline up and downcoast from Punta Gorda with resistant rock outcrops marked with arrows (2006 California Coastal Records Project – Kenneth and Gabrielle Adelman).

Figure 28. Close-up of the shoreward end of the causeway showing concave shape (2010 – California Coastal Records Project – Kenneth and Gabrielle Adelman).

Figure 29. View of the causeway from downcoast showing wide spacing and small diameter of pilings.

This section of the Santa Barbara Channel shoreline isn't characterized by frequent large waves, however, simply due to the sheltering effects of the offshore Channel Islands, so not surprisingly, few of the aerial photographs show larger well-formed wave fronts.

The best aerial photographs of waves passing through the causeway and approaching the shoreline were taken by commercial surf photographer Anthony Ghiglia on December 21, 2006 (during what was labeled as the biggest swell in a decade), and Jason Wolcott (Figures 32 and 33). In both of these photographs, wave crests are completely unchanged as they pass through the causeway and show that complete removal of the causeway would have no significant effect on the waves and therefore the shoreline up or downcoast from Punta Gorda.

Figure 30. Wave trains from the WSW (from approximately 250°) passing unchanged through the causeway in August 2019.

Shorelines and beaches do change over both the short and long-term, due to both natural processes and human interventions. The most pronounced and most easily observed short-term changes are those between winter and summer beaches due to the differences in wave climate: wave height, steepness, period and direction of approach (see Figures 1a & b). Changes to shorelines and beaches can also occur due to long-term (decadal) differences in wave climate, sand availability, changes in offshore seafloor conditions such as sand scour and deposition, and long-term sea-level rise.

All historic evidence from the numerous both vertical and oblique aerial photographs of this area, spanning nearly a century, indicate that the shoreline and beaches both upcoast and downcoast of Punta Gorda/Mussel Shoals were not impacted by the original construction of the causeway. In large part this is due to the small diameter and wide spacing of the pilings. Aerial photographs also show that waves pass through the causeway with no observable change so waves would reach the shoreline as they would without the causeway being present. Complete removal of the causeway would, therefore, have no impact on the shoreline and beaches.

Figure 31. Waves from WSW (from approximately 260°) passing unchanged through the causeway in April 2013.

Figure 32. December 21, 2006, aerial photograph of swell approaching Mussel Shoals and passing unchanged through the causeway during what has been called the largest swell in a decade (© Anthony Ghiglia).

Figure 33. Aerial view of a large swell breaking at Punta Gorda showing no change in waves as they pass through the causeway (© Josh Wolcott).

OPTION B. PARTIAL REMOVAL OF THE CAUSEWAY AND RETENTION OF THE ABUTMENT & REVETMENT

In this option, all but the approximately 840 feet of causeway closest to the shoreline would be removed (actual length to be determined following completion of engineering analysis). The existing causeway abutment and surrounding riprap revetment connected to the remaining causeway section would also be left in place. The causeway pilings and wooden pile stubs (used in the original construction of the causeway), from Rincon Island back to the 840-foot cutoff point would be removed to five feet below the seafloor as in Option A.

Would leaving the shoreward or inner section of the causeway have any different effect than complete causeway removal (Option A) ?

As discussed in response to Option A above, all historic evidence from the many aerial photographs of this area, spanning nearly a century, indicate that the shoreline and beaches both upcoast and downcoast of Punta Gorda/Mussel Shoals have not been impacted by the construction of the causeway and would, therefore, not be impacted by either partial or complete removal of the causeway. Additionally, the causeway is downcoast from where the waves break on the sandy beach so that the causeway has no impact on shoreline wave action at this location. Removing all but the shoreward 840 feet of causeway would therefore have no effect on the shoreline and the sandy upcoast beach. Therefore, there is no significant effect by either partial or complete removal of the causeway.

OPTION C. REMOVAL OF THE ENTIRE CAUSEWAY AND CONCRETE ABUTMENT

Option C would include removal of the entire causeway and also the abutment at the shoreline. Under this scenario, the riprap armor around the causeway abutment would first be removed and stored temporarily while the concrete abutment is demolished. The riprap would then be returned to armor Punta Gorda itself. The best approach for evaluating this option is to investigate how the initial construction of the abutment affected the adjacent upcoast and downcoast shoreline and beaches. Consideration of any potential effects of only the causeway removal have been treated above and all evidence indicates that this would have no significant shoreline or beach impacts.

Punta Gorda has been a significant coastal promontory along the Rincon coast for hundreds of years, and likely as long as sea level has been at or near its present elevation (several thousand years). When the Southern Pacific Railroad was built along this coastline in the 1880s, the railroad workers lived in a small beach settlement that was named *Punta* (now La Conchita, about a half mile to the west on the inland side of Highway 101). Prior to the establishment of the village of Punta, the coastal area was named *Punta Gorda*, Spanish for large or massive point, referring to the outstanding feature of this coastal area, a large rock promontory. Up through the 1930s, Mussel Shoals was known as Mussel Rock (Campos, et al., 2009).

The resistant rock of the Pico Formation that forms the point today was likely far larger in the late 1800s when it was given the name for its prominence. This discussion is important in putting Punta Gorda in its historical and geological perspective as a substantial coastal feature that had a major effect on the shoreline here well before the concrete abutment and riprap was constructed in 1959 (see Figure 7).

The pre-1959 aerial photographs (1927, 1936, 1939, 1944 and 1945) all show a prominent rock outcrop that forms the promontory or point at Punta Gorda. The size and shape of the rock has changed from the earliest 1927 image to the more recent 1945 photograph, however (Figure 34). The rock appears to have been reduced in size over this 18-year period by wave attack and erosion.

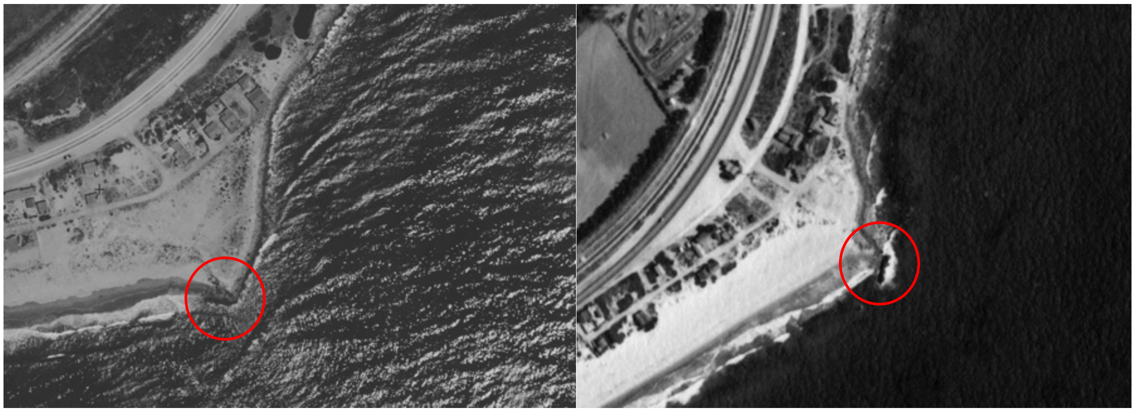

Figure 34. Changing configuration of the rock outcrop at Punta Gorda in 1927 (left) and 1945 (right).

The Pico Formation bedrock making up the point has continued to erode over time but still maintains its role as a natural groin, which is clear in all pre-1959 photographs. The point has been responsible for the formation of the 1.6-mile-long, linear upcoast beach. A portion of the ~300,000 yds^3 annual littoral drift at this location is impounded by the bedrock groin, and when it is fully charged or filled, the sand continues around the bedrock point and on downcoast towards Ventura. There is no shortage of littoral sand at this location and the presence and extent of a beach, here and elsewhere, is primarily a function of the rate of littoral drift, the shoreline orientation and/or the presence of a structure that can retain the sand.

The historical aerial photographs of Punta Gorda all indicate that the concrete abutment and revetment that was constructed in 1959 was built out only as far as the bedrock outcrop (Figure 35), so the additional rock did not extend the point any further seaward. Figure 25 shows additional bedrock outcrops on the beach about 400 feet downcoast and another outcrop extending normal to the shoreline in front of the hotel. These resistant rock outcrops along the shoreline have helped to stabilize the coast at this location and reduce shoreline erosion.

Where natural or built groins either exist or have been built, there is often a “groin effect”, where the shoreline adjacent to the downdrift side of the groin erodes and no beach forms or is retained (Figures 36a & b). While this groin effect doesn’t show up in the oldest aerial photographs of Punta Gorda, the recession of the shoreline immediately downcoast shows up in subsequent photographs (see Figure 42 – 1945 and Figure 35 - 1972). It seems likely that the rock outcrops along the shoreline here – and the name Mussel Shoals - may have originally protected this section of coast, but in recent years erosion has eroded portions of the bedrock and allowed erosion to take place.

Figure 35. Concrete abutment and riprap was built seaward only as far as the bedrock outcrop in 1959 (arrow). There are additional rock outcrops downcoast (arrows) (Photo 1972 California Coastal Records Project – Kenneth and Gabrielle Adelman).

Figure 36a. The Groin Effect. Groin constructed in city of Capitola in northern Monterey Bay which has retained beach to the left but erosion is occurring downcoast to the right.

Figure 36b. Natural bedrock groin that has trapped sand upcoast (to the left) but produced erosion downcoast requiring the installation of riprap to protect State Highway 1 in northern Santa Cruz County (both photos: California Coastal Records Project- Kenneth and Gabrielle Adelman).

Decommissioning Option C would remove the concrete abutment at the shoreline, which would involve removing and then replacing the existing riprap (Figures 37 & 38). The Feasibility Study describes this as follows:

“At the abutment, the riprap currently piled against the concrete walls of the abutment would be temporarily relocated and the concrete abutment demolished and transported to offsite recycling (Figure 37). Once the abutment demolition is completed, the riprap would be placed back over the existing point of land that supported the abutment within the abutment footprint but would be at a lower elevation (Figure 38). The existing riprap surrounding the groin and the groin itself would be left intact.”

Because the original construction of the abutment and riprap in 1959 did not extend the natural rock groin any substantial distance seaward, its removal would not significantly affect the trapping ability of the original natural bedrock point. The upcoast beach and shoreline would remain essentially unchanged. The upcoast beach and shoreline historically built out to the point where littoral drift of sand would move around bedrock point and on downcoast. Approximately 300,000 yds^3/yr. of littoral sand would continue to move downcoast, keeping the upcoast shoreline in an equilibrium condition, with sand eroded each winter replaced by littoral drift added each spring and summer. The riprap replaced around the point following abutment removal would make this a more substantial and erosion-resistant point than the native Pico Formation bedrock itself. As a result, the point’s lifespan and trapping efficiency would actually be enhanced over the original pre-1959 condition and remain essentially unchanged from the present condition other than being at a slightly lower elevation, which would not affect the upcoast beach.

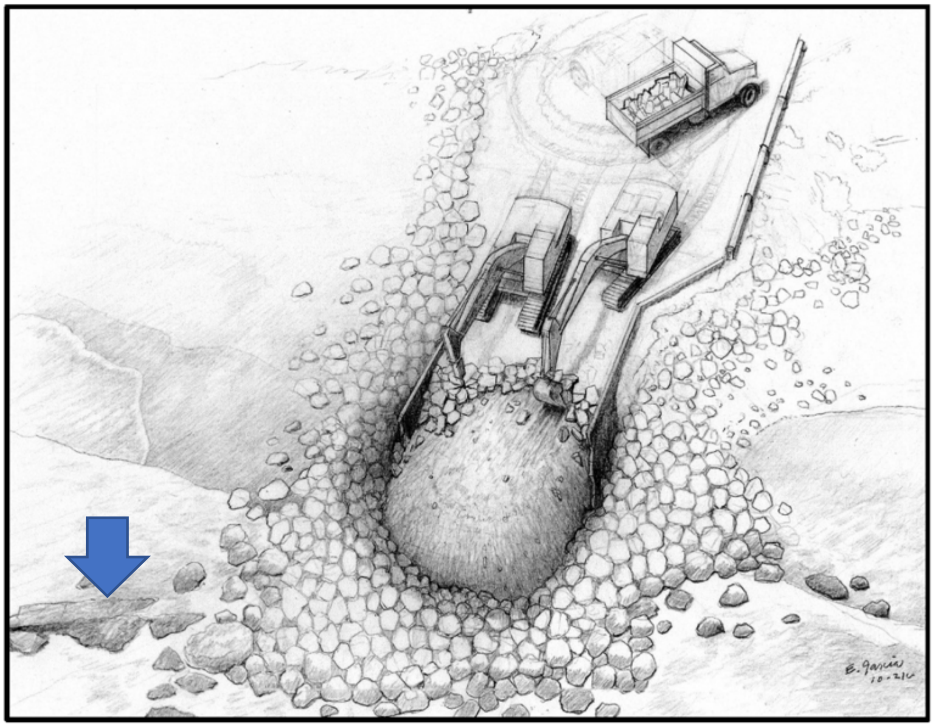

Figure 37. Diagram of riprap removal showing concrete abutment that would be then demolished (from State Lands Commission). Note Pico Formation bedrock to left (arrow).

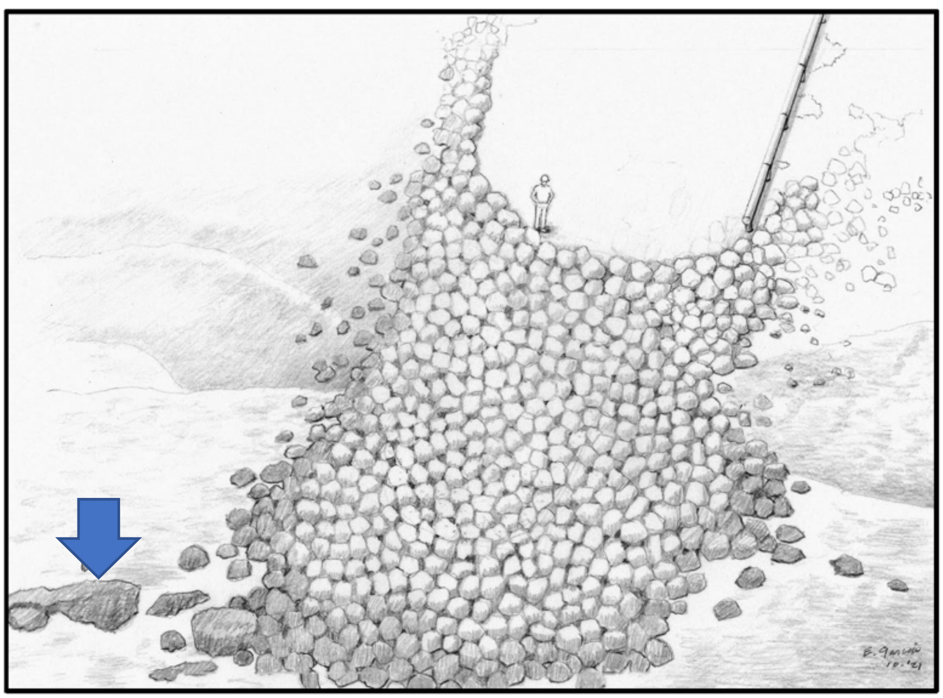

Figure 38. Diagram of proposed final condition of Punta Gorda after abutment removal and riprap replacement (from State Lands Commission).

With the concrete abutment removal and riprap replacement, the top elevation of the final riprap will be slightly lower than the present roadway surface. The precise difference in elevation can't presently be determined, however, and this won't be known until the riprap has been replaced (Figure 38). This slight elevation difference will not affect the trapping efficiency of the point, however, because the elevation and width of the upcoast beach is determined by both the seaward extent of the point, which will not change significantly, and the surrounding base of the riprap, not the elevation of the roadway and top of abutment. The roadway elevation is at elevation 15-16 ft. (NAVD 1988), whereas the elevation of the back beach immediately downcoast is 8-10 ft. (Figure 39). Lowering the top of the riprap by several feet will not affect the upcoast beach or shoreline.

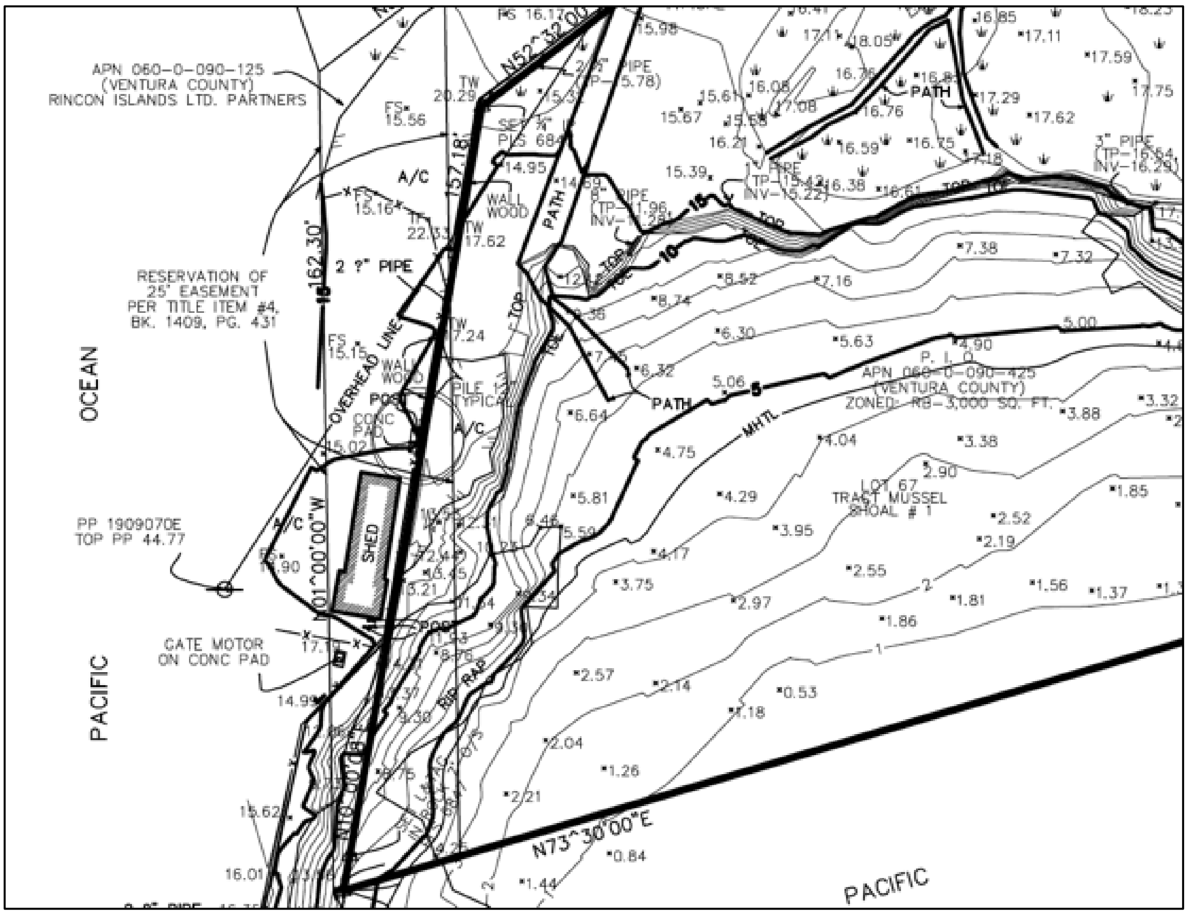

Figure 39. Portion of topographic map from California Coastal Conservancy (2013). All elevations based on NAVD 1988 datum.

The rocky shoreline and the low backing bluff immediately downcoast of the existing abutment and riprap have not changed significantly since 2002 when the first high resolution oblique aerial photographs were taken (Figure 40 & 41). Most of the low bluff has now been armored (with a combination of riprap and concrete seawalls) for a thousand feet downcoast where the riprap protecting the hotel merges with the revetment protecting State Highway 101.

There is an approximately 115-foot gap of coastal bluff which has not been armored, however, extending from the abutment to the first area downcoast riprap, although the shoreline here is mantled with cobbles and boulders that does provide some degree of protection (Figure 41). Large waves at times of high tide, however, have continued to erode the eight-foot high nearly vertical coastal bluff (Figure 42). The removal of the abutment and replacement of the existing riprap on the same footprint, even at a slightly lower elevation, will have no significant effect on the downcoast shoreline as the general footprint and seaward extent of Punta Gorda will not be significantly changed. Neither the upcoast beach nor the downcoast beach will be affected by the removal of the underlying concrete abutment and the replacement of the protecting riprap.

Figure 40. Downcoast shoreline in 2002 (California Coastal Records Project, Kenneth and Gabrielle Adelman).


Figure 41. Downcoast shoreline in 2013 (California Coastal Records Project, Kenneth and Gabrielle Adelman).


Figure 42. Eroding coastal bluff immediately east of the abutment.

References

Campos, J., Kelm, B., Moore, D., Moore, T. and the Carpinteria Valley Museum of History. 2009. Greater Carpinteria, Summerland and La Conchita. Arcadia Publishing, Charleston, SC.

Endris, A.E., Greene, H.G., and Golden, N.E. 2013. Marine Benthic Habitats, Offshore of Ventura Map Area, California. USGS Scientific Investigation Map. 325 Sheet 7 of 11.

Johnson, S.Y., Ritchie, A.C., Seitz, G.S., and Gutierrez, C.I., 2013. Offshore and Onshore Geology and Geomorphology, Offshore of Ventura Map Area, California. USGS Scientific Investigations Map 3254, Sheet 10 of 11.

NV5, 2021. Engineering Study for Rincon Island Decommissioning Project. 73pp.

Patsch, K.B. and Griggs, G.B. 2008. A sand budget for the Santa Barbara Littoral Cell, California. Marine Geology 252:50-61.

Patsch, K. and Griggs, G., 2006A. Littoral Cells, Sand Budgets and Beaches: Understanding California's Shoreline. Institute of Marine Sciences, University of California Santa Cruz and California Department of Boating and Waterways. 39p.

Patsch, K. and Griggs, G., 2006B. Development of sand budgets for California's major littoral cells: Eureka, Santa Cruz, Southern Monterey Bay, Santa Barbara, Santa Monica (including Zuma), San Pedro, Laguna, Oceanside, Mission Bay, and Silver Strand Littoral Cells. Report for California Coastal Sediment Management Workgroup, 111p.

Patsch, K. and Griggs, G. 2021. California harbor dredging: history and trends. Shore and Beach 89(3) 13-25.

State Lands Commission. Rincon Phase 2 Decommissioning Feasibility Study, Ventura County California.