Rincon Phase 2 Decommissioning Project – Evaluation of Effects and Effectiveness of three Different Treatments of State Coastal Conservancy Parcel at Punta Gorda, Ventura County Coast

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Introduction and Scope of Report

The State Coastal Conservancy (SCC) has jurisdiction over a small (approximately 0.88 of an acre) parcel on the east or downcoast side of the abutment leading to the Rincon Island causeway at Punta Gorda on the Ventura County coast (Study Area, Figure 1). As part of the decommissioning planning, the California State Lands Commission has proposed three alternatives for future management of this parcel, labeled as Alternatives 9A, 9B and 9C. The alternatives being considered are based upon past objectives of the State Coastal Conservancy to improve retention of sand and minimize erosion along this section of coastline.

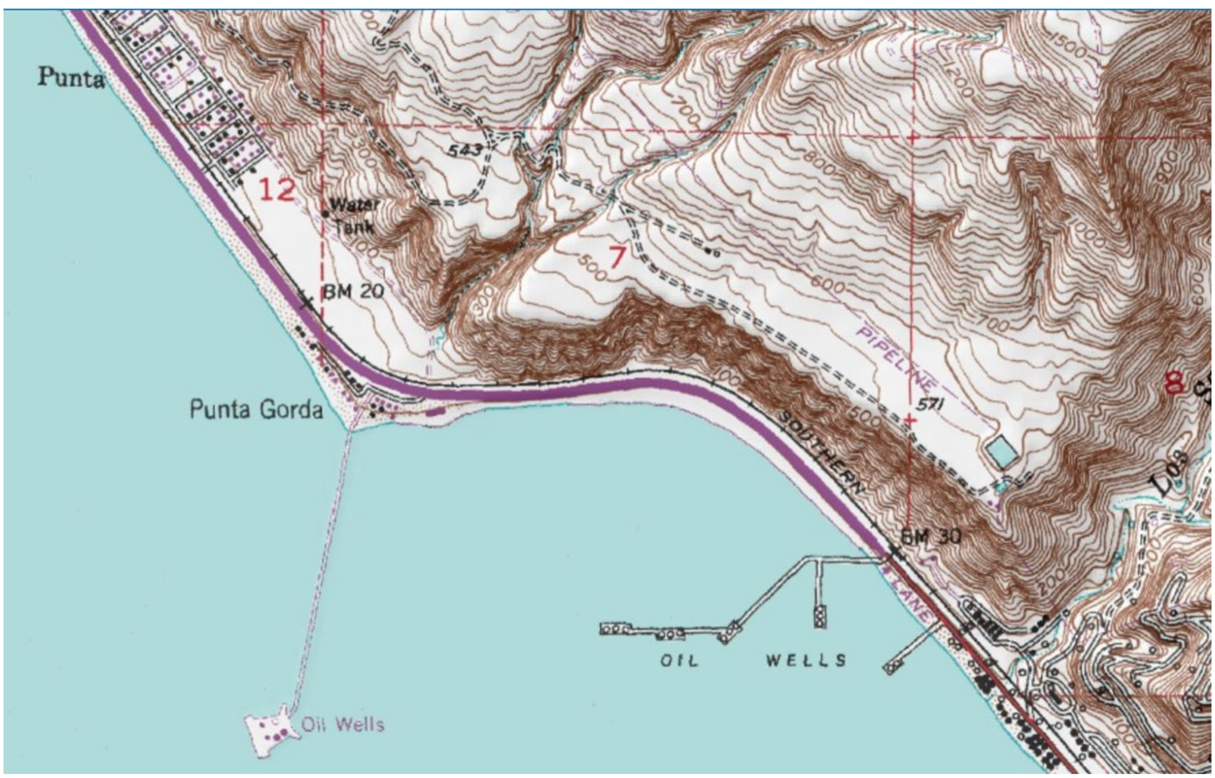

Figure 1. Site location map (USGS Punta Gorda Quadrangle, 2018)

The objectives of this report are to evaluate the effectiveness and possible impacts of the three different proposed alternative treatments of the shoreline on the parcel compared to existing baseline conditions using a combination of: 1) the historic aerial photographs of the area; 2) a site visit; and 3) a review of relevant existing reports. Briefly, the three approaches include:

• Alternative 9A – Plant the parcel with native revegetation and add miscellaneous State Coastal Conservancy parcel improvements (stairway to the beach, improved pathways, bench, etc.)

• Alternative 9B – All of 9A activities in addition to cobble placement both on the back beach and beneath the unprotected portion of the parcel in order to protect the shoreline and bluff from future erosion

• Alternative 9C – All of 9A activities in addition to placement of riprap at the shoreline on the back beach to prevent further bluff erosion.

INTRODUCTION – EVOLUTION AND PROTECTION OF THE STATE COASTAL CONSERVANCY PARCEL

The State Coastal Conservancy parcel at Punta Gorda (Little Rincon) is roughly triangular in shape and extends from the roadway leading to the causeway on the west, to Breakers Way on the north, and then across a nearly flat terrace, down a low bluff and across the beach on the southeast (Figure 2). Elevations range from about 20 feet (NAVD 88) along Breakers Way, to approximately one foot along the lowest part of the shoreline (Figure 3).

Before determining alternative approaches or treatments to best stabilize the parcel with the least impacts, it is important to first document the past changes at the site and then determine how natural processes are likely to be affected and change the parcel in the future. The aerial photographic history is quite complete and there is a mixture of both oblique and vertical aerial images that extend back nearly a century to 1927. The oldest aerial photographs don’t have the resolution of the recent digital photos but are still useful in documenting changes to the site over this 95-year period.

The oldest aerial photograph (1927) shows a slightly convex seaward shoreline extending about 400 feet downcoast from the end of Punta Gorda (Figure 4). The upper flat portion of the parcel appears to be mantled with some scattered vegetation and the sandy shoreline looks to be covered in part with rocks; it is much darker than the shoreline upcoast or west of Punta Gorda, which is a sandy beach backed by low dunes. Subsequent aerial photos from 1936, 1939, 1944 and 1945 indicate that the shoreline had eroded landward since the 1927 image and no longer extended as far out as the rock outcrop making up the end of Punta Gorda (Figures 5 & 6). In 1939, retreat along the east side of the point had reached 50 feet and by 1945, this had increased to about 100 feet. The shoreline was still mantled with scattered rocks in these pre-causeway installation (1959) photos.

Figure 2. Aerial photograph of the abutment, causeway and the State Coastal Conservancy parcel. Approximate boundaries outlined in white (2013 photo from California Coastal Records Project – Kenneth and Gabrielle Adelman).

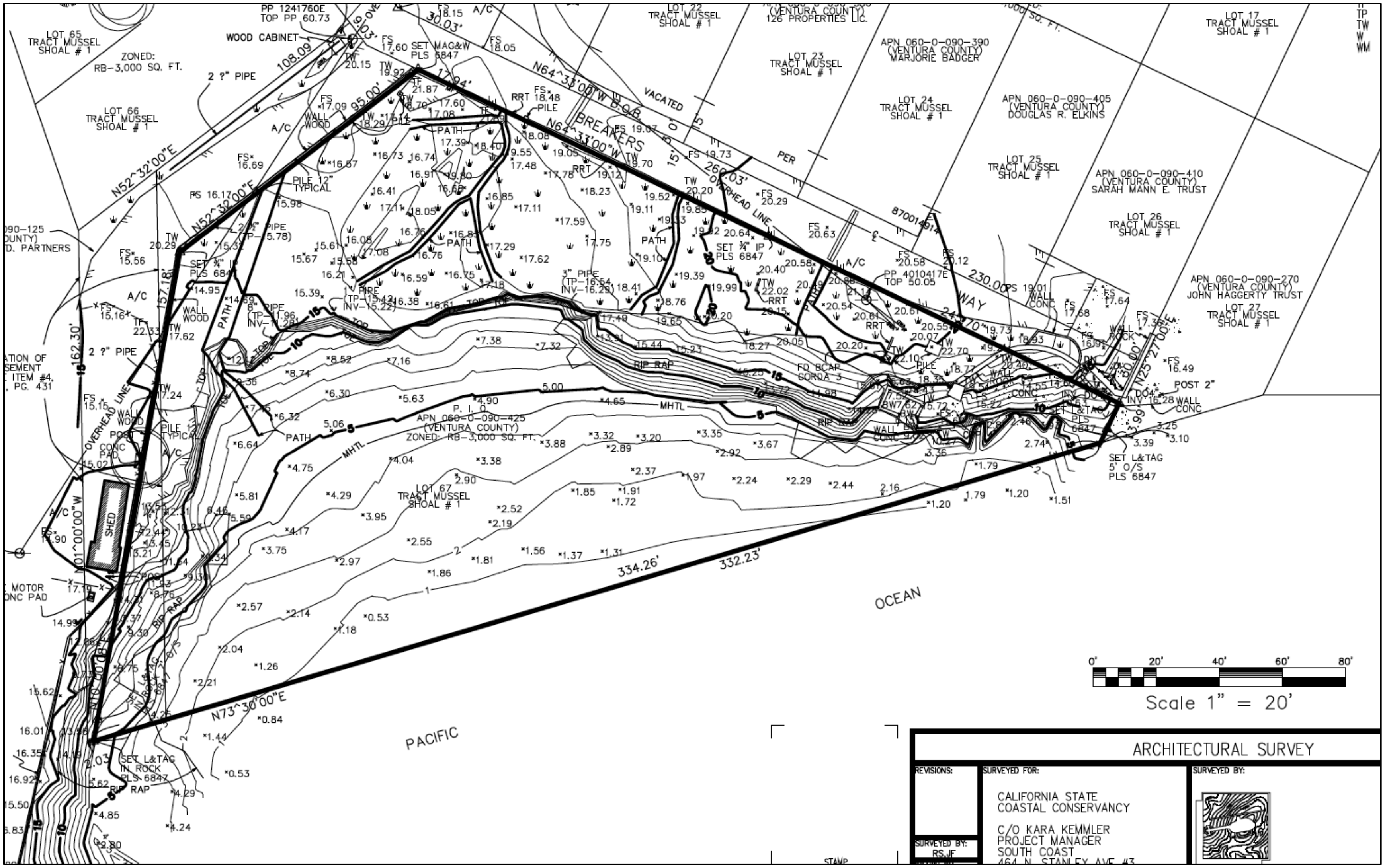

Figure 3. Topographic map of the State Coastal Conservancy parcel.

Figure 4. Coastal Conservancy parcel in 1927. There appears to be some vegetation on the inner and higher portion of the site (approximate site boundaries in white).

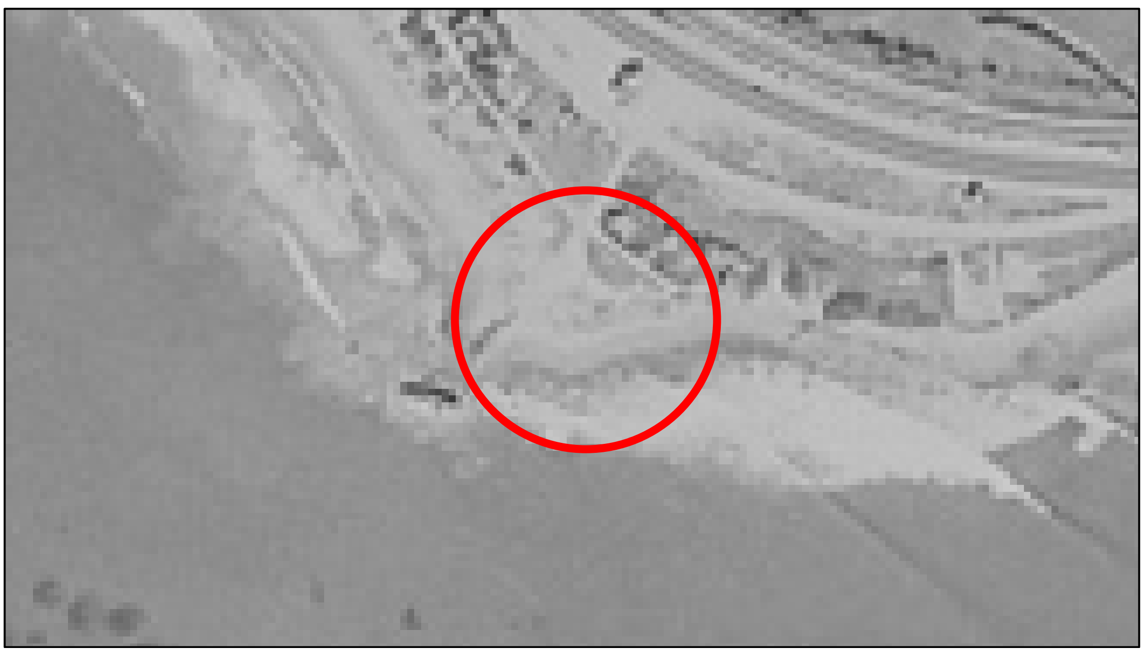

Figure 5. State Coastal Conservancy parcel(contained within red circle) in 1939 showing shoreline retreat the point.

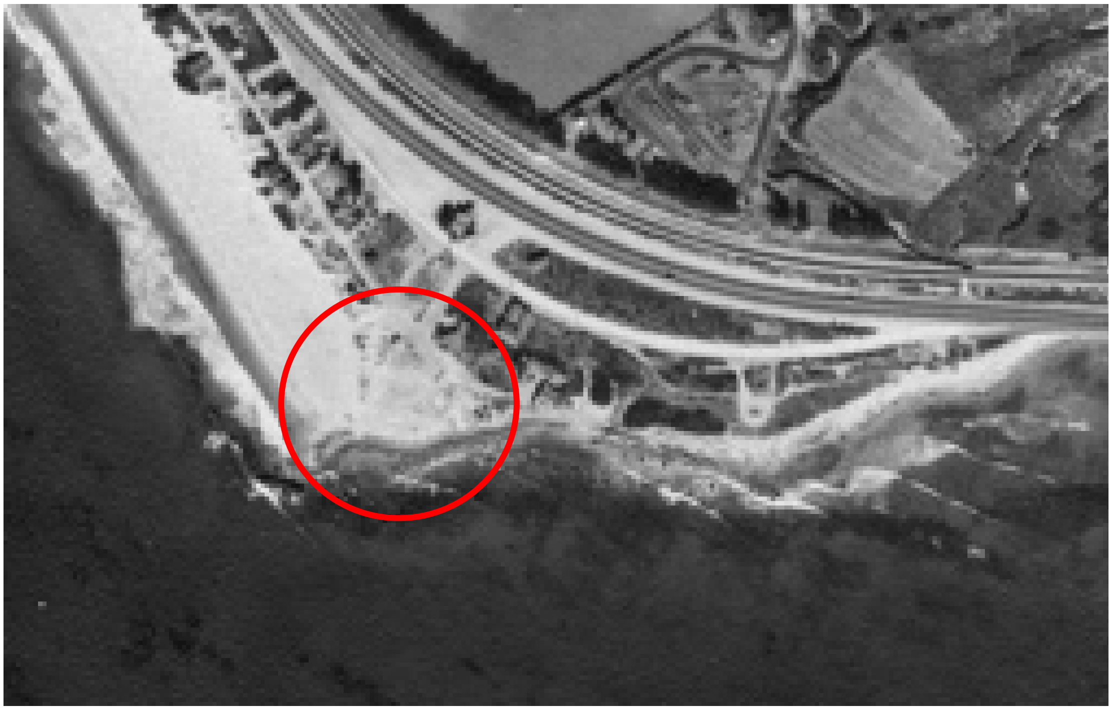

Figure 6. State Coastal Conservancy parcel (contained within red circle) in 1945 showing continued shoreline retreat east of the point.

Figure 7. State Coastal Conservancy parcel in 1963 following 1959 construction of abutment and causeway. Dark area along the shoreline (arrow) appears to be rip rap that was placed in an arc extending from the abutment downcoast along the back beach.

Figure 8. State Coastal Conservancy parcel in 1971 with riprap armoring the right side of the abutment and continuing downcoast in an arc along a portion of the shoreline (arrows).

The concrete abutment and protective revetment along with the causeway and island were constructed in 1959, although the aerial photograph from that year is of poor quality. By 1963, the shoreline next to the causeway abutment had retreated a total of about 160 feet (Figure 7). The seaward edge of the flatter upper surface of the parcel appears to be an eroded scarp. Eight years later, in 1971, the riprap is more evident and extends in an arc eastward for about 135 feet from the abutment across the downcoast shoreline (Figure 8).

This armor protected the shoreline adjacent to the causeway abutment, which by this time was approximately 150 feet inland from the end of Punta Gorda. Additional rock along the shoreline contiguous with the riprap appears to continue about 300 feet further downcoast. It is impossible to tell, however, if this was imported rock (e.g. more riprap), or if it is bedrock weathered from shoreline or nearshore outcrops of the resistant Pico Formation.

The 1972 oblique aerial photo illustrates a difference or contrast between the rock (riprap) adjacent to the abutment and what appear to be smaller cobbles scattered across the shoreline to the east (Figure 9). The cobbles have been overtopped and erosion has produced a scarp in the shoreline on the eastern side of the SCC parcel (Figure 9). It appears that the upper flat portion of the site is being used as a staging or storage area at this time. The 1987 aerial photo shows little additional shoreline change in this area (Figure 10).

Figure 9. SCC site in 1972. The downcoast or eastern side of the parcel shows a rocky beach but no riprap and a scarp that has been eroded into the low unarmored bluff (arrow) (California Coastal Records Project - Kenneth and Gabrielle Adelman).

Figure 10. 1987 image of SCC parcel, with the shoreline immediately east of the abutment now having developed a relatively smooth concave or arcuate shape.

While riprap was placed completely around the concrete abutment and in an arc downcoast, by the time of the 1993 vertical photograph, some of the riprap appears to have spread or collapsed onto the beach and bluff edge has been eroded back, narrowing the flatter upper portion of the parcel (Figure 11).

Figure 11. 1993 photograph. Recent wave action appears to have overtopped and moved the riprap seaward and eroded the coastal bluff landward at arrows.

Eight years later in the 2001 aerial image, the riprap and rock along the shoreline has developed an arcuate profile and no additional erosion had taken place. A curved face concrete seawall has also now been built on the far eastern end of the SCC parcel to protect the house directly inland (Figure 12).

In 2002, Kenneth and Gabrielle Adelman begin photographing the entire California coast with high resolution digital aerial photography (the California Coastal Records project) on a regular basis. All of their photos are available on an easily accessible website (Californiacoastline.org) and provide clear images of the entire shoreline of the state. For the Punta Gorda area (encompassing the SCC parcel) specifically, these high-resolution images are available for 2002, 2004, 2006, 2008, 2010 and 2013. The 2002 photograph shows two concrete seawalls at the eastern end of the SCC parcel and riprap now placed upcoast of the seawalls for about 115 feet as well (Figure 13). This has left a gap of about 115 feet, however, between the causeway revetment and the downcoast riprap that is not protected and where erosion of the bluff has continued.

Figure 12. 2001 photograph showing eroded shoreline and curved-face concrete seawall at eastern edge of parcel (arrow).

The most recent aerial photograph from the California Coastal Records Project (2013) shows some settling of the riprap along the abutment and seaward migration of the downcoast riprap. There doesn't appear to have been any additional retreat of the unprotected bluff immediately downcoast (Figure 14). It is likely due a combination of the 1) scattered rock along this unprotected rocky shoreline that disperses some of wave energy, and also 2) the wave shadow or protection offered by the causeway abutment to waves, such that any high energy waves from the dominant southwest sector undergo refraction and therefore lose energy before reaching the shoreline.

A field investigation on October 2, 2022, indicated that the Study Area contains a sandy beach with discontinuous boulders along the shoreline that have moved downcoast and seaward from the original 1959 causeway revetment (Figure 15). These boulders are of the same rock type as those flanking the abutment, so are what are referred to as "fugitives", or rocks which have moved from their original placement locations. These provide evidence for the forces that waves can exert, even on large riprap, at this location.

Figure 13. 2002 photograph showing two concrete seawalls at downcoast end of SCC parcel (red arrows) and riprap now added upcoast of the seawalls (orange arrow). The low bluff is now fronted with a scarp along its entire western section (blue arrow) (California Coastal Records Project – Kenneth and Gabrielle Adelman).

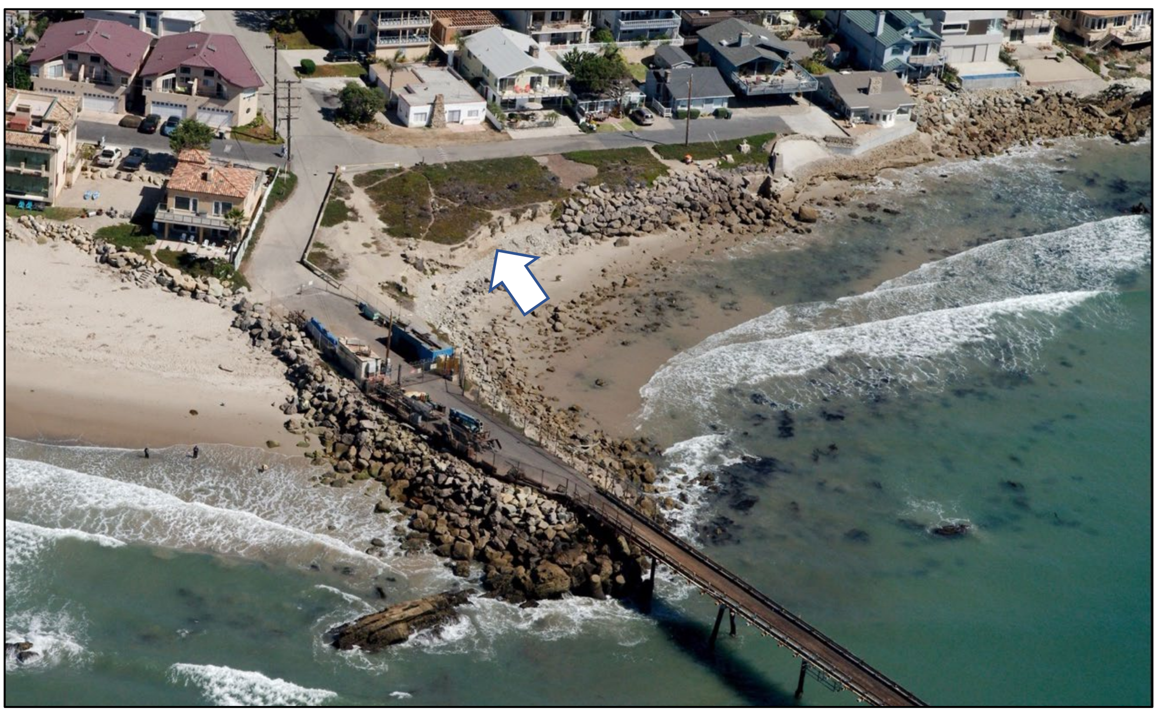

Figure 14. 2013 image of SCC parcel. The main section of eroded bluff backs the shoreline that is not armored (arrow). Original riprap adjacent to abutment has partially collapsed onto the beach (California Coastal Records Project – Kenneth and Gabrielle Adelman*).*

Figure 15. October 2, 2022, view towards the abutment and causeway showing riprap that has migrated east or downcoast since original emplacement in 1959.

The near vertical eroding bluff backing the shoreline is about eight feet high and consists of a mixture of poorly sorted material which is believed to be the alluvial fan material brought to the shoreline from the inland drainage over thousands of years. This material is only loosely consolidated so has eroded easily when impacted by large storm waves at very high tides. The bluff is fronted by a low cobble berm that provides some protection from wave attack (Figure 16).

Figure 16. Eroding bluff immediately downcoast from abutment that is fronted by a cobble berm but no riprap.

EVALUATION OF ALTERNATIVE PLAN 9A. NATIVE REVEGETATION AND MINOR IMPROVEMENTS OF SCC PARCEL

Alternative 9A would include removing non-native plants and replacing them with a combination of native plants and also seeding, which would both require water and maintenance for about a year to ensure survival. Existing pathways across the parcel would be improved and a short stairway to the beach from the low bluff would also be constructed. This option does not include any shoreline armoring.

This alternative would clearly result in the least changes to the existing site and also the lowest costs. The flat upper surface of the parcel would more clearly resemble a natural area, although from the oldest 1927 aerial photo, it appears that 95 years ago this surface had very little vegetation. In terms of effectiveness, access across this area would be better controlled by the improved paths and access to the beach would be developed. The vegetation planting should be effective if the coastal plants that are chosen can tolerate conditions at this location such as salt air and dry periods and they are irrigated long enough to root.

The proposed stairway to the beach could have a relatively short lifespan (months) or could serve effectively for years. This would depend upon 1) the construction materials and design (e.g. timber or concrete, for example); 2) how it is anchored at the top and base of the bluff or on the beach; and 3) what combination of elevated sea levels, high tides and large waves occur in the near future. The condition of the bluff edge at present is an indication that the unprotected area is still undergoing wave attack and erosion.

Under the Alternative 9A scenario, there would be no change in the existing conditions of the bluff (other than revegetation) and beach so that future wave action and bluff erosion would continue as it has historically along the approximately 115-foot-long unarmored gap between the existing riprap on both sides of the parcel (Figures 14 & 16). How quickly future bluff erosion proceeds would depend upon the combination of storm waves and high tides, the modest protection provided by the existing boulders and cobbles on the beach, and the erodibility of the bluff materials. Over the longer term (several decades into the future), the rate of local or relative sea-level rise will also be a factor affecting the rate of bluff retreat.

EVALUATION OF ALTERNATIVE PLAN 9B. INCLUDES ALL COMPONENTS OF 9A AND THE PLACEMENT OF A COBBLE BERM ON THE BACK BEACH AND BENEATH THE INLAND COASTAL BLUFF

Alternative 9B would include all of the components of Alternative 9A described above in addition to adding shoreline and bluff protection. The proposed plan would involve initially excavating the material on the upper unarmored portion of the parcel to a depth of about ten feet (Figure 16). The total soil volume removed has been calculated at approximately 3,800 yds^3. Cobbles would then be imported to replace much of the material excavated and then covered with the excavated “native” soil. Any excess soil (potentially up to 2,500 yds^3) would be trucked off-site to suitable area. The overall topographic profile would be altered from the nearly flat terrace existing at present which is fronted by a six-to-eight-foot-high, near-vertical bluff on the seaward side (Figure 17) to a narrower terrace and then a gradual slope to the beach at a 1:3.6 (V:H) slope, or about 16 degrees (Figure 17). The components of Alternative 9A would then be implemented, including native planting and seeding, pathway improvements and a stairway to the beach.

The cobble back berm would transition into a new cobble fill placed further down on the beach that would provide additional stability to the inland cobble fill. The profile of the cobbles was planned to mimic a “natural grade” from the inland vegetated portion of the parcel down to the beach and intertidal area (Figures 17 & 18). It is estimated that about 2,500 cubic yards of cobbles would be required to complete the cobble back berm and the back beach coverage of cobbles over an alongshore distance of “about 50 feet”. This is planned to fill in the existing gap between the revetments on either side (while 50 feet is the distance stated in the State Lands Commission report, the actual gap is closer to 100 feet). The cobbles would be imported to the site using dump trucks and placed with two excavators on the beach. Using dump trucks with a 10 yd^3 capacity, would require about 250 truckloads of cobbles.

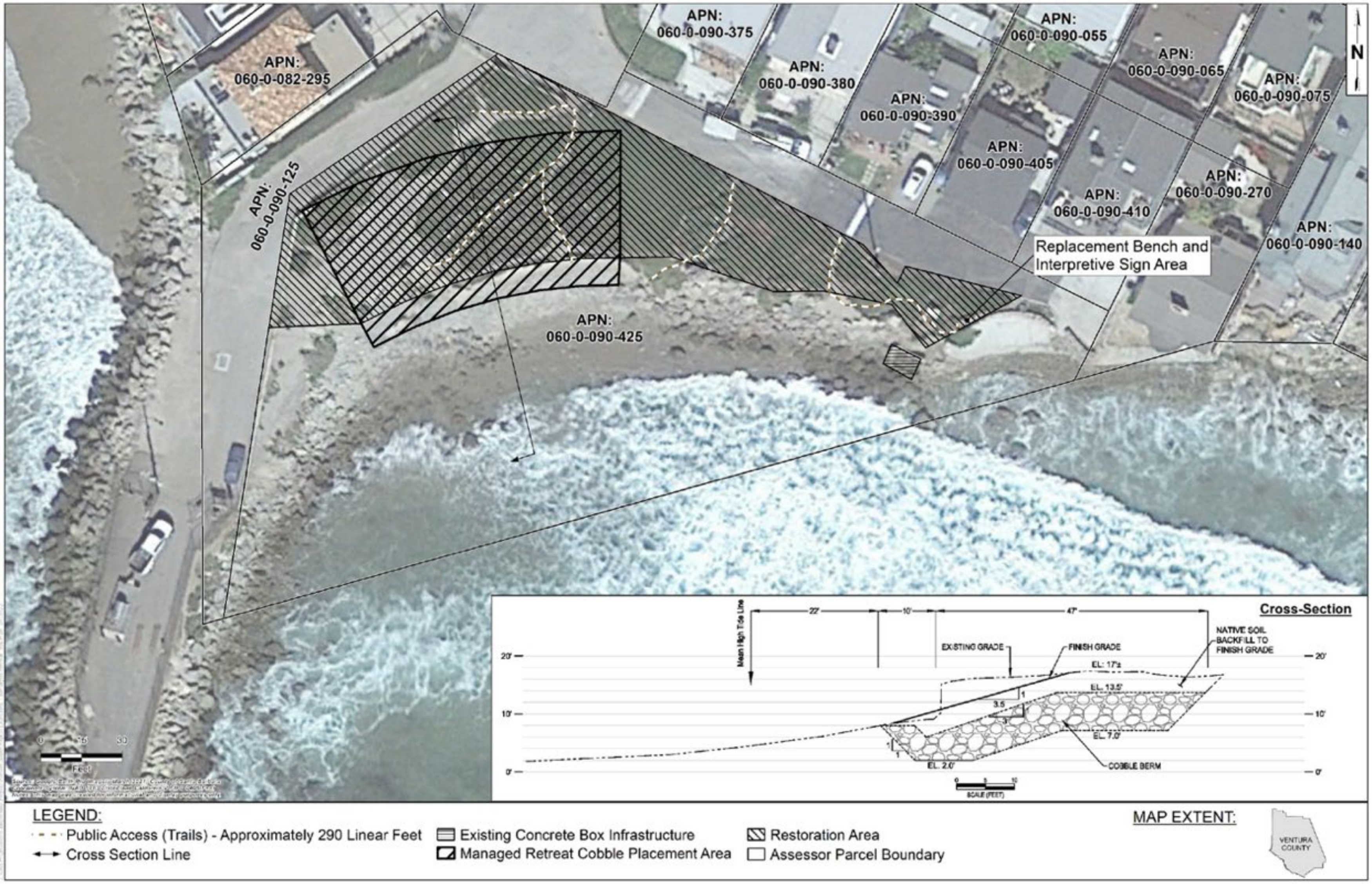

Figure 17. Plan and cross-section view of Alternative 9B (State Lands Commission).

Figure 18. View of the flat upper portion of the SCC parcel and the bluff fronted by a cobble berm (October 2, 2022).

Natural cobble beaches and/or cobble berms often form on high energy coasts where sand is mobilized and moved offshore in the winter months (Figure 19). Cobbles may be seasonal or permanent features of the shoreline depending upon their availability and changes in seasonal wave energy. Severe winter scour on some sandy beaches may reveal a basal accumulation of cobbles as a type of natural armor. The presence of these protective cobbles, that are much more resistant to beach scour than sand, has given rise to a number of cases where these natural conditions have been mimicked as a type of more natural shore protection.

Cobbles have been utilized at several west coast locations in recent years as a more natural solution to shoreline erosion than rigid concrete seawalls or riprap revetments in an effort to reduce or eliminate the well-studied impacts of seawalls (Griggs, 2005). Cobble berms, also known as “dynamic revetments”, use cobble-sized rocks (defined as generally rounded rocks ranging from 64-256 mm or 2.5-10 inches in diameter) to mimic a natural cobble storm beach in order to reduce wave energy and halt or slow coastal or shoreline erosion. Unlike seawalls or riprap, a dynamic revetment or cobble blanket is designed to allow wave action to rearrange the stones into an equilibrium profile, disrupting wave action and dissipating wave energy as the cobbles move. The objective of such a structure is to provide some level of shoreline protection that is natural in appearance and function while also providing acceptable protection to coastal properties or infrastructure.

Figure 19. Natural cobble berm on the Algarve, Portugal.

Perhaps the earliest idea for constructing a cobble berm for shore protection dates back about 50 years, when an artificial gravel beach was built along the banks of the Rotterdam Harbor entrance in The Netherlands in order to dissipate the energy of ship wakes. The structure was initially referred to as a "dynamic revetment", in that the gravel could be moved around by the waves rather than being static as would be a conventional riprap revetment. In recent years these structures, which typically are composed of cobbles, have been referred to as "cobble berms". This has also been seen as a more acceptable term, particularly in locations where the construction of revetments or seawalls are discouraged or forbidden by laws or policies (Komar and Allan, 2009).

Komar and Allen (2009) describe the planning, construction and monitoring of a cobble berm at Cape Lookout State Park on the high energy northern Oregon coast. Cobble beaches and berms are common along the Oregon coast, in part because the coastal cliffs in places consist of hard volcanic rock that break down into cobble and boulder size material. They first studied the existing cobble beaches to see what size, slope and stability conditions occurred near the site. An eroding dune existed landward of the beach that was overtopped during extreme winter wave conditions. Instead of a cobble blanket beneath the dunes, they actually constructed a core of large, sand-filled geotextile bags, which were then covered with sand and revegetated (Figures 20 and 21).

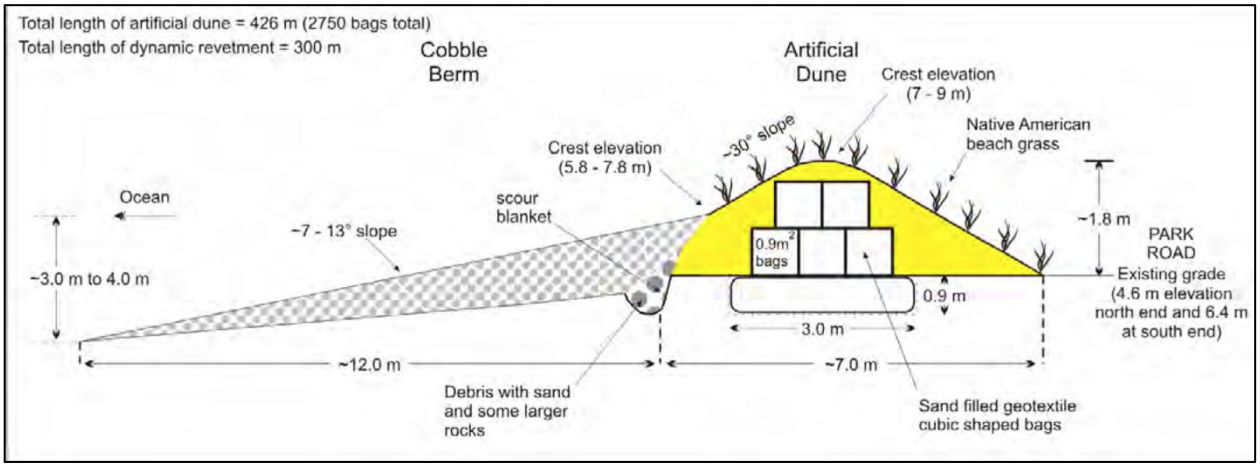

Figure 20. Cross-section of proposed Cape Lookout State Park cobble berm and dune (from Komar and Allan, 2009).

Figure 21. Cape Lookout State Park cobble berm under construction (from Komar and Allan, 2009)

Another major difference in the proposed Alternative 9B at Punta Gorda and the Oregon coast project was that there was a well-used sandy beach so that the constructed cobble berm was covered with sand. The Cape Lookout project was completed in 2000 and by 2008, it had lost about 6,500 yds^3 of cobbles. In response, 3,500 yds^3 of new rock was imported, but the cobble "mattress" was still deficient. The cobble berm was not built high enough initially nor completely according to the design. As a result, winter waves overtopped the berm and eroded the dunes, exposing the geotextile bags. The key lesson here is building what was designed, and that the wave conditions on the northern Oregon coast are far more severe than the Rincon coast of Ventura County.

One of the earliest examples of the effectiveness of such an approach in California took place in the early 1990s and resulted from a large landslide (the Lone Tree slide) about 10 miles north of San Francisco. In an effort to stabilize the landslide, the California Department of Transportation dumped excavated material, including material ranging in size from clay to large boulders, down a steep cliff face, creating a massive artificial landslide. This trial experiment provided an opportunity to document the early stages of landslide erosion, including the processes of waves eroding the toe of the slide. A beach began to form almost immediately along the toe of the eroding slide, which consisted of the coarsest materials, gravel, cobbles and boulders. As the finer-grained material (sand, silt and clay) was removed by wave action, the coarse material was left behind and the rate of toe erosion progressively slowed, the material having sorted itself into a protective gravel and cobble beach, backed by a line of large boulders.

Perhaps the best example of a comparable cobble berm in California is just ten miles downcoast to the southeast at a location known as Surfer’s Point immediately downcoast from the Ventura River mouth. Like Punta Gorda/Little Rincon, and Rincon, itself, this surfing spot is also a river delta that extends the shoreline outward, which leads to wave refraction and good surfing conditions (Figure 22). While the City of Ventura had historically taken the traditional approach of hardening the shoreline where there were erosion problems, it eventually realized that this typically had negative impacts (Griggs and Patsch, 2019; Griggs, Patsch and Savoy, 2005; Griggs, 2005).

Instead of building a seawall or other coastal armor along the retreating shoreline at Surfer’s Point, which would have destroyed the beach and potentially affected the surf break, stakeholders came together and agreed upon a plan to move the parking lot, pedestrian path, and bike path away from the shoreline.

Phase 1 of the Surfer’s Point construction was completed in 2011 at a cost of about $3.8 million using grant funds from the Coastal Conservancy and the Federal Highway Administration. A bike path and parking lot were relocated inland and the shoreline was stabilized with a cobble mattress or berm on the back beach, which was eight feet thick and about 80 feet wide (Figures 23 and 24), similar to the proposal for the cobble berm plan for Punta Gorda (see Figure 17). Sand was placed in the retreat zone to complement and cover the cobbles and help rebuild the dunes. The dunes were later augmented using imported sand. As the wave climate has changed seasonally, the cobbles are often exposed in the winter months under higher wave energy conditions and covered with sand in the summer and fall with less energetic waves when the beach is rebuilt.

Figure 22. Ventura River delta and Surfer's Point (arrow) showing wave refraction around point.

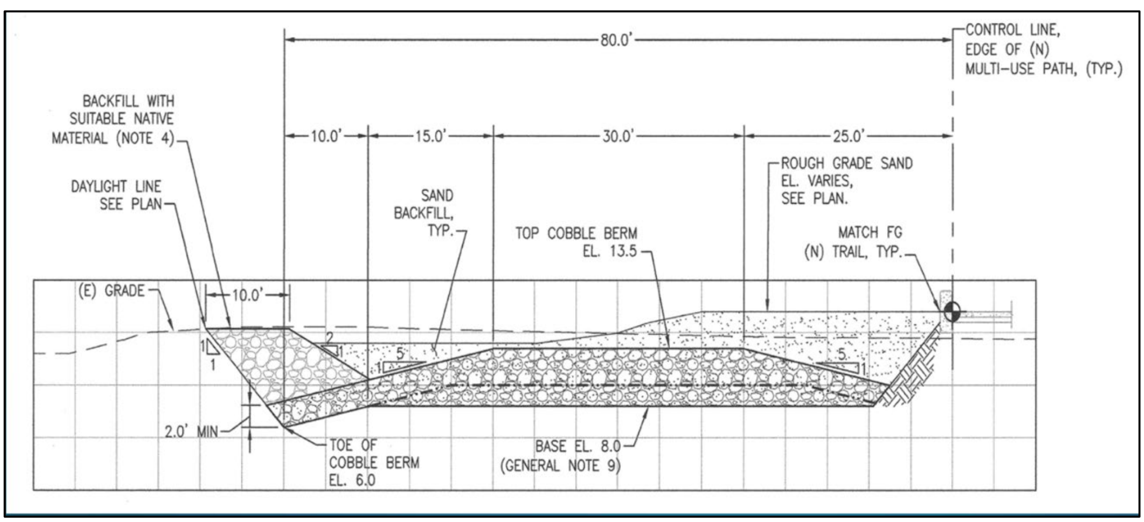

Figure 23. Cross-section of planned cobble berm at Surfer's Point.

Figure 24 .Cobble berm under construction at Surfer's Point.

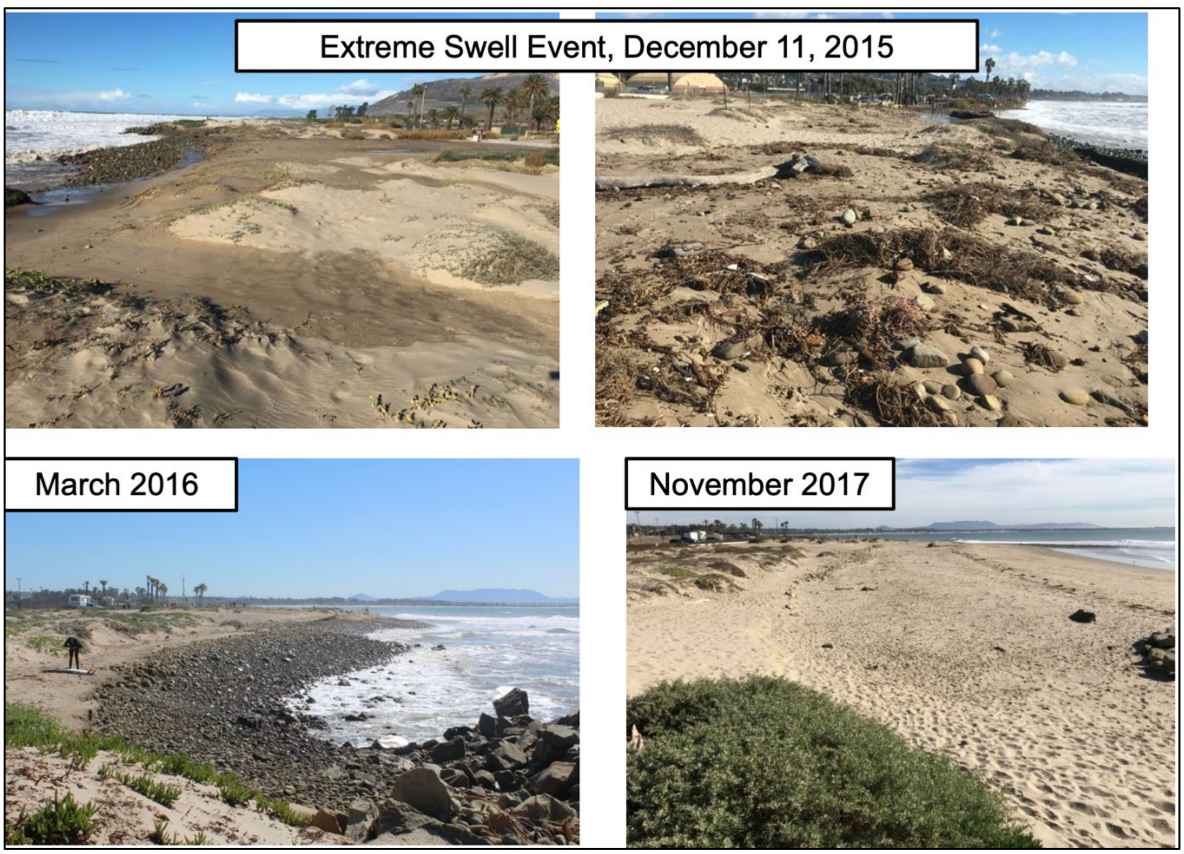

Figure 25. Cobble berm at Surfer's Point following 2015-16 storm wave attack and then recovery.

While significant wave attack occurred in the winter of 2015-2016, removing the sand cover and exposing the cobbles, a year later the beach had rebuilt and the cobble berm was nearly completely covered again (Figure 25).

Another approach to assessing the effectiveness of cobble berms was a prototype-scale experiment that tested the behavior and performance of a dynamic cobble berm under conditions of erosive waves and increased water levels (Bayle, et al., 2020). Results from the experiment showed that the cobble berm was “dynamically stable” under wave action and while individual cobbles were mobilized, the berm maintained a consistent overall shape. Tracking of individual cobbles using Radio Frequency Identification (RFID) technology showed that stability of the cobble revetment was likely maintained by rollover transport of cobbles onto the berm crest, as the revetment moved upward and landward under water level rise. The presence of the revetment reduced the vertical and horizontal runup as well as the retreat of the upper beach. It was concluded from this experiment that a dynamic cobble berm could be an inexpensive, efficient and low environmental impact solution for protecting sandy coastlines in a changing climate.

Based on the existence and behavior of natural cobble beaches and berms, observations and surveys of locations where cobble berms have been artificially built in California and Oregon, and also prototype experiments, it is clear that cobbles can provide and effectively enhance shoreline stability. Many sandy beaches are underlain by a lag deposit of cobbles or gravel indicative of their relative stability and permanence when winter or storm waves have scoured out the finer-grained sand. Wave energy along the Rincon coast is generally relatively low or moderate, which would indicate that cobbles would be stable.

The Surfer’s Point cobble berm/blanket provides good evidence for the potential effectiveness of such an approach at Little Rincon where wave climate is very similar. Cross-shore surveys over a decade (2011-2021; Figure 26) indicate that while the beach sand on the foreshore comes and goes seasonally in response to changing wave condition, the back beach and dune areas underlain by cobbles have remailed stable (Figures 27 & 28).

The only significant impact on the shoreline at the SCC parcel of constructing the cobble berm beneath the back beach, bluff and terrace would be the disruption of this already disturbed area during construction. This would include removal of the existing surface materials to a depth of about ten feet, replacement with cobbles, and then covering the cobbles with about 3.5 feet of surficial materials to produce a new more-gentle profile from the flatter upper portion of the parcel to beach level (Figure 18). This would then be followed by planting and seeding with native vegetation, development of pathways, and construction of a stairway to the beach.

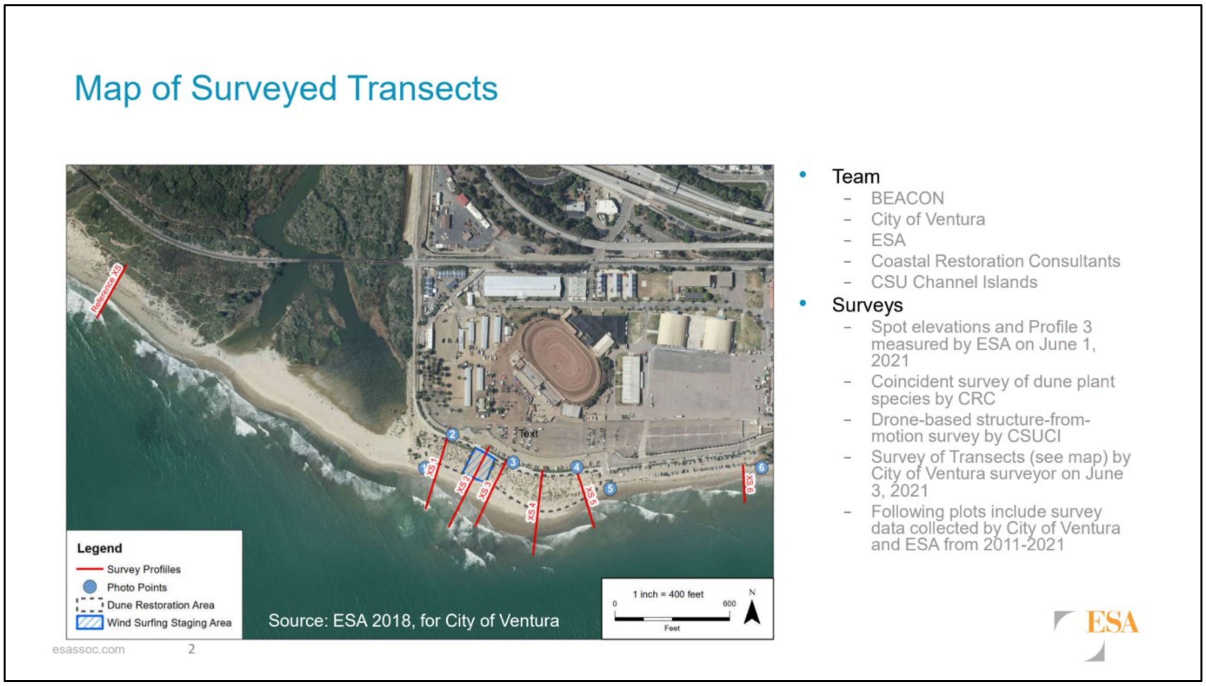

Figure 26. Survey profile locations across shoreline at Surfer’s Point.

The cobble back berm proposed as Alternative Plan 9B beneath the upper portion of the site would transition into the new cobble fill placed further down on the beach within the unarmored section of shoreline and would provide additional stability to that cobble fill (see Figure 17). The cobble berm should be relatively stable at this location as evidenced by the cobbles and boulders that have existed on the shoreline for many years. Even if the sand and soil covering was partially removed by an extreme wave event, as evidenced at Surfer’s Point, the cobbles should rotate and move around, but overall should remain intact and provide a more stable shoreline.

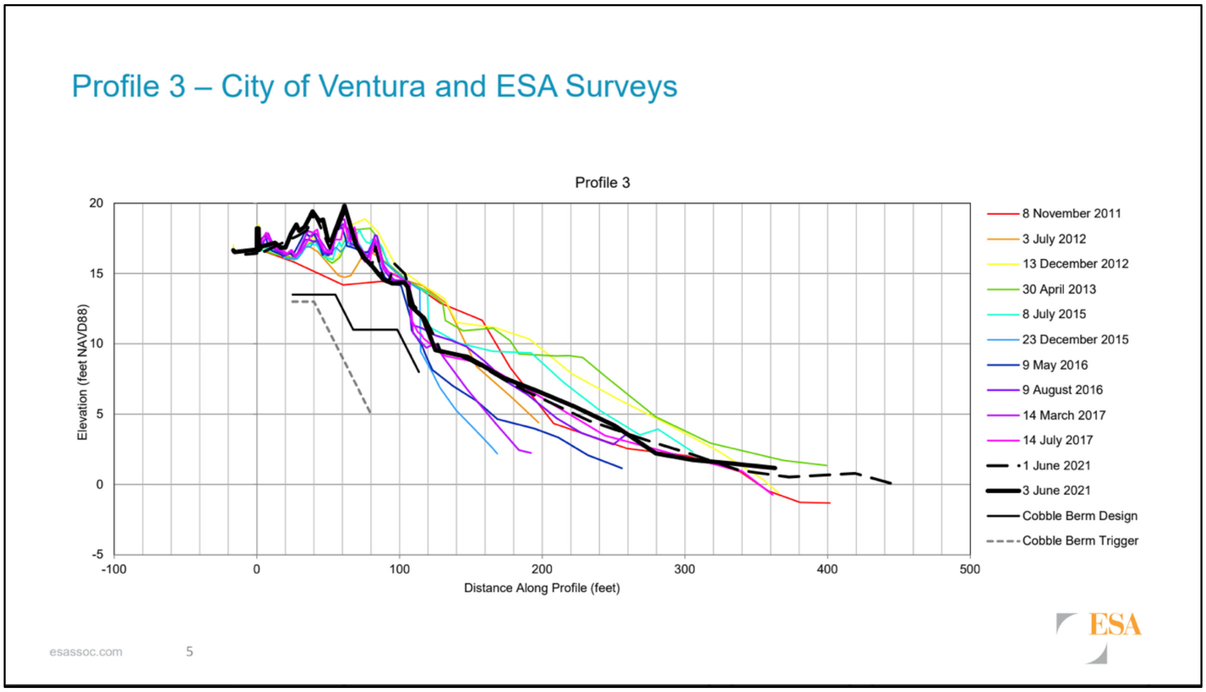

Figure 27. Profile 3 across dunes and shoreline at Surfer's Point built over the 10-year period from 2011 to 2021 showing stability and little change on the upper portion of the profile where cobbles were placed and dunes were constructed.

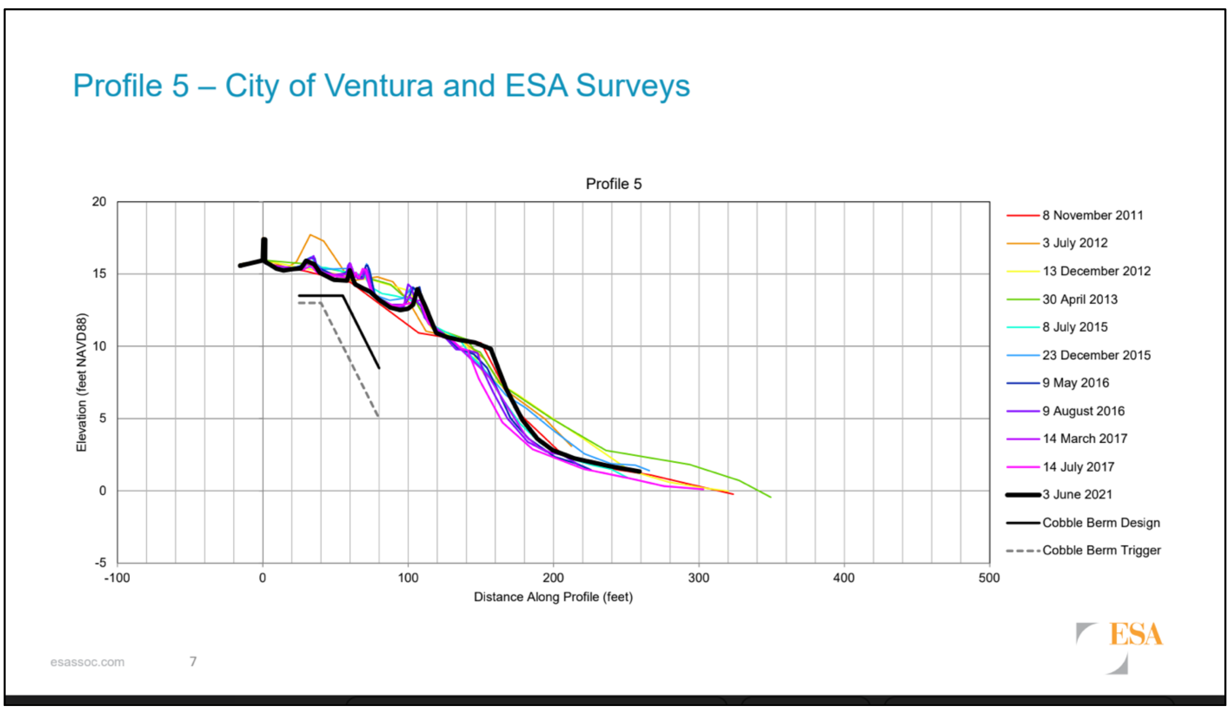

Figure 28. Profile 5 across the eastern end of the project, showing virtually no change on the upper portion of the profile over ten years of surveys. The sand on the beach does come and go seasonally.

EVALUATION OF ALTERNATIVE PLAN 9C. INCLUDES ALL COMPONENTS OF 9A AND THE PLACEMENT OF RIP RAP AT THE BASE OF THE BLUFF ON THE BACK BEACH

Alternative 9C would include all of the components included in Plan 9A and would add riprap to armor the roughly 130 feet of shoreline that is presently unprotected. The additional riprap would extend from the existing intact riprap adjacent to the abutment to the riprap protecting the downcoast homes and Breakers Way (Figure 29). About 135 feet of the western or upcoast portion of the shoreline was originally protected by riprap when the abutment was constructed in 1959 (see Figure 9). Over the subsequent 62 years, however, the rock has been broken down and displaced by wave action so that it no longer provides significant protection to the upper portion of the parcel (see Figure 15). Wave erosion has left an approximately eight foot high near vertical bluff (see Figure 16).

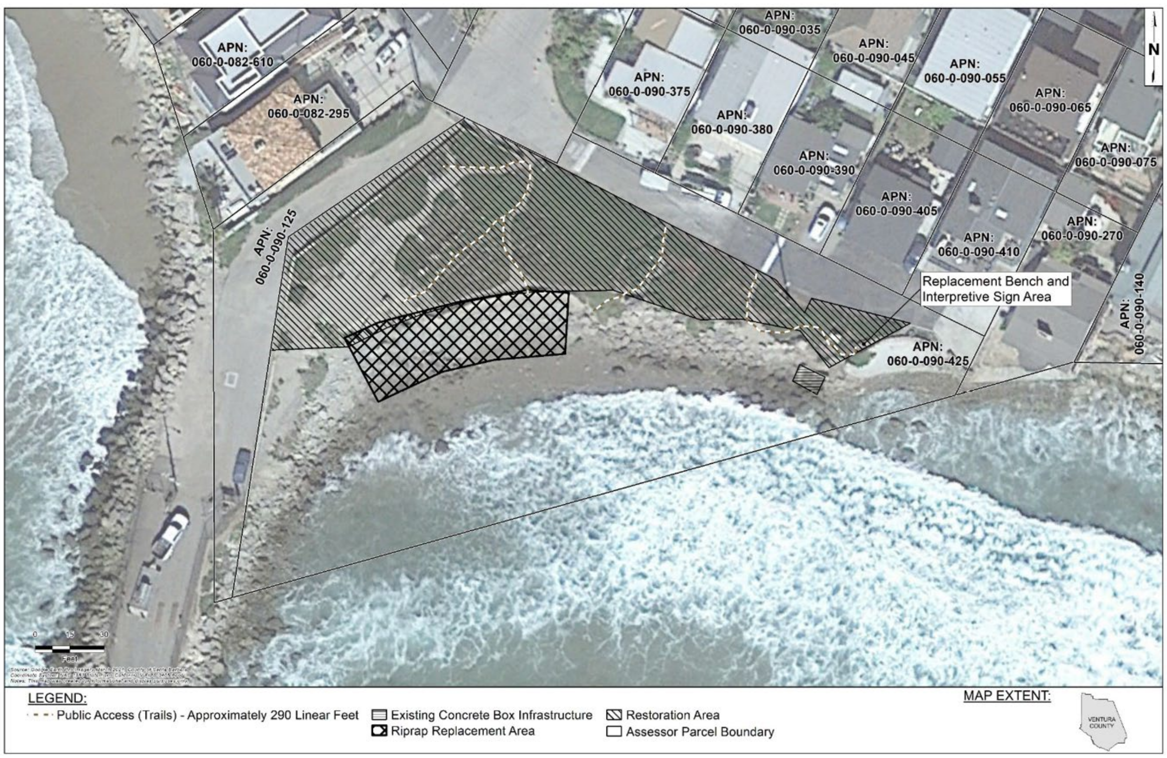

Figure 29. Details of placement of riprap for Alternative Plan 9c.

An estimated 360 yds^3 of riprap (chosen to match the size of the riprap that currently exists onsite) would be needed to complete the shoreline armoring in this area. The riprap would be initially hauled from a quarry in Ventura County to the SCC area in covered dump trucks and staged within the upper portion of the site between the beach and Breakers Way. Approximately 90 truckloads would be required. A small crane with a rock grapple and spider excavator would then be utilized to place the riprap onto this section of beach. The riprap configuration would be placed to match the configuration of the existing riprap on either side.

The existing riprap around the causeway abutment has performed well over the 62 years since its original placement, as has the rock protecting Breakers Way and the downcoast homes (Figure 30), which has been in place for at least 20 years. Additionally, the rip rap armoring the downcoast hotel has been in place since at least as far back as 1972 or 50 years. The rock revetment protecting Highway 101, both upcoast and downcoast of Punta Gorda have also performed well for over 50 years.

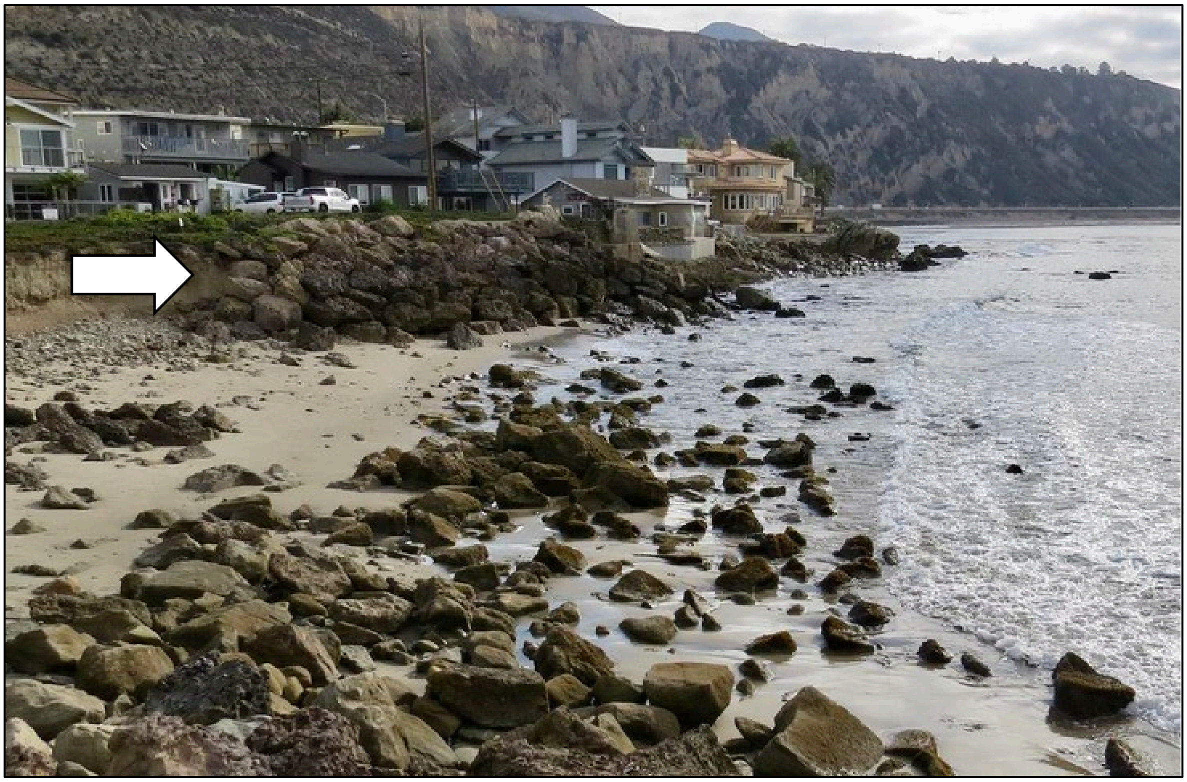

Figure 30. Riprap (arrow) protecting Breakers Way and downcoast homes and remnants of original 1959 riprap scattered along the shoreline.

Riprap can and has provided adequate protection along the Rincon coast for at least 50 years so is a viable approach for the SCC site and would connect the existing riprap on either side forming a continuous barrier to wave attack. The breakdown and scattering of the original 1959 riprap that protected the western side of the SCC parcel does provide evidence that revetments don't always provide long-term protection, however (see Figures 14 & 15). Riprap or rock revetments can fail or collapse from a number of design or construction shortcomings (Fulton-Bennett and Griggs, 1986). These include:

a. Rock that is too small for wave energy conditions at the site
b. Rock that is stacked too steeply such that it is prone to collapse
c. Not placing rock either on a bedrock platform or deep enough to withstand winter beach scour
d. Not stacking rock high enough such that it is overtopped by waves

e. Not extending rock far enough alongshore such that it is outflanked

The failed and scattered riprap along the shoreline immediately east of the abutment was likely due to either 1) outflanking on the unprotected downcoast end where erosion then led to collapse of the rock originally stacked against the low back beach bluff, or 2) wave overtopping of the riprap under conditions of high tides and large waves, which led to shoreline erosion and loss of support for the rock. Any additional riprap added along this unprotected section of shoreline would need to be designed and built to avoid these potential problems.

Placing a rock revetment along any shoreline or back beach will have some well documented effects (Griggs, 2005). These include:

Placement losses - placing a rock revetment on a beach will cover an amount of sandy beach depending upon how far the revetment extends seaward. This is a concern where there is any public use of the existing beach. The beach fronting the SCC parcel is narrow, covered with scattered riprap, and essentially covered at most high tides. The placement of riprap will, nonetheless, cover a small portion of the existing beach (see Figure 30). Restacking the older riprap that is now scattered across the beach into the new project, would actually reclaim a portion of the beach.

Reduction of sand supply - armoring an eroding shoreline that was previously providing sand to the shoreline will eliminate that source of sand to the littoral drift system. The volume and significance of this potential loss is a function of the amount of beach size sand in the bluff, the width of shoreline armored, the height of the dune or bluff being armored, the long-term erosion rate of the feature being armored, and also the littoral drift at that location. The bluff is relatively low (~8 feet), the lateral extent of the proposed armor is small (~130 feet), the bluff materials consist of a mixture of grain sizes (see Figure 16), and erosion of the bluff in recent years has been very small. A coastal hazards investigation by Everest (2014) concluded that "based on a qualitative review of the aerial photographs, it appears that the project site beach has been relatively stable between 1994 and 2013". Additionally, based on long-term upcoast dredging volumes, the average annual littoral drift along the Rincon coast is about 300,000 yds^3. As such, sand supply reduction from riprap emplacement would be insignificant.

Reduction or loss of access – the placement of a riprap revetment can reduce or eliminate either horizontal access along the shoreline or vertical access to the beach. Vertical access would be augmented in this plan by the proposed construction of a stairway to the beach. Horizontal access would be moderately impacted by the loss of back beach area, although there is very little or no dry sand at high tides or in the winter months and this beach is not connected to other shoreline areas, so access reduction is not deemed to be significant.

Visual impacts – depending upon the nature and size or extent of any coastal armor, there may be significant visual impacts in the immediate area. In this particular location, virtually the entire shoreline up and downcoast have been armored with riprap so filling the existing gap as proposed under this scenario would not have a significant impact. There is already older riprap scattered across the beach which could be incorporated into the new project, which would actually reclaim a portion of the beach.

Passive erosion – where a natural shoreline with a beach is able to retreat as sea-level rises, a beach will remain but simply gradually move inland. Where a back beach barrier is built, however, whether a seawall, revetment, road, railway or some other structure, the shoreline will not be able to retreat and over time, with a continuing rise in sea level, the beach will gradually be flooded or covered with seawater. This process has been recognized as passive erosion. The existing narrow low tide beach fronting the SCC parcel will gradually be flooded or lost because of the existing riprap with a continuing rise of sea level. The proposed 130 feet of additional riprap will simply fill a gap in the armor and will not have a significant impact on the process of passive erosion now occurring because of the nearly complete armoring of the Rincon coast.

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