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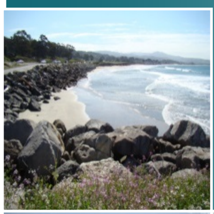

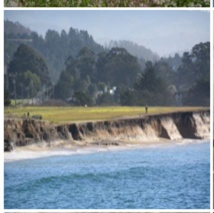

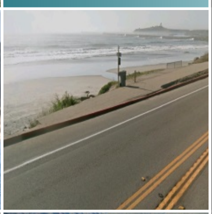

NORTHERN HALF MOON BAY SECTION 111 CAP STUDY

ECONOMIC ANALYSIS

U.S. Army Corps of Engineers
San Francisco District

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EXECUTIVE SUMMARY

The Federal Breakwater has Accelerated Erosion in the Study Area

Previous studies and historical anecdotal observations indicate that the Half Moon Bay shoreline has been eroding since at least the 1860s. Prior to 1959, this erosion, which was caused by natural processes, was low because of the presence of a permanent sandy beach and an equilibrium shoreline shape relative to the incident waves. Construction of the East Breakwater at Pillar Point Harbor in the 1960s disrupted this equilibrium wave pattern and focused wave energy at the low cliffs south of the breakwater, causing rapid cliff erosion along the shoreline for at least one mile south of the breakwater. This accelerated erosion has had adverse impacts to the infrastructure and recreation in the area, including threatening the integrity of Highway 1, which runs parallel to the coast in this area and is a vital traffic artery. In response to this threat, the State of California (Caltrans) and others constructed a rock revetment fronting approximately 750 feet of the bluff, and there are approved and funded plans to extend the revetment by approximately 300 feet to respond to the threat of continued erosion at a cost of approximately $2 million. Meanwhile, the beach in front of this revetment has eroded to the point that it is covered by water except at lower tides. And erosion is expected to continue. For the approximately one-third of a mile of unprotected bluff just south of the revetment, recent coastal engineering studies by the US Army Corps of Engineers (USACE) predict that it will erode at an average annual rate of 1.6 ft., which is estimated to be 1.4 ft. greater than the "background" erosion rate – i.e., the erosion rate that is expected to occur in areas of Half Moon Bay not influenced by the presence of the breakwater.

The Economic Analysis Estimates the Net Economic Impact of an Erosion Risk Reduction Project

It is clear that the breakwater has had physical impacts on the adjacent shoreline, and it is expected to continue to do so in the future. This economic analysis is aimed at understanding and reasonably quantifying the economic value of those additional future physical impacts and then estimating the benefit-cost ratio of one or more potential projects that would mitigate or eliminate those future economic impacts. This economic analysis fulfills the requirement that all USACE projects have a benefit-cost analysis to determine whether or not they are economically justified when considering whether the project should be constructed from a federal perspective. The benefits and costs from a federal perspective are termed "National Economic Development (NED)" impacts by USACE.

The economic analysis is part of a larger feasibility study that is being conducted as part of the Continuing Authorities Program (CAP) that is authorized under Section 111 of the River and Harbor Act of 1968 for prevention or mitigation of future damages by a federal navigation structure to both non-federal public and privately-owned shores. Critically, the project benefits must be associated with the prevention or mitigation of *future* damages, and these future damages must be *directly attributable* to the construction and existence of the federal navigation project – in this case the breakwater.

Future Without-Project Damages in the Study Area are Relatively Low

The without-project economic damages are associated with an adverse impact on recreation value and land value, and on the increased cost of maintenance dredging to ensure safe and reliable use of the boat launch located between the inner and outer breakwaters. The analysis does not include road damage or damage to the California Coastal Trail because of the aforementioned extension of the rock revetment planned by Caltrans and the County. The extension of the rock revetment should effectively eliminate erosion damage to these two assets for at least the next twenty years, and possibly longer.

The expected future decrease in recreation value is a result of Surfer's Beach becoming narrower and steeper, which generally shortens the window of time for safe ingress and egress. Local surfers contend that the quality and safety of surfing at Surfer's Beach has dramatically decreased over the past several years as a result of the narrowing of the beach. Surfing activity has decreased as a consequence. As the beach narrows further (disappears really) it is reasonable to expect that surfing activity and quality will also further decrease. Using the Unit Day Value (UDV) method of recreation valuation, the current total annual NED value of surfing at Surfer's Beach is estimated to be $308,000. Over the twenty-year period of analysis this value decreases by two-thirds, and the ultimate average annual loss to surfing is estimated to be $114,000.

The unprotected coastal terrace along Vallejo Beach, which is owned by San Mateo County, is zoned for public open space and recreation. The California Coastal Trail bisects the terrace between the bluff and Highway 1. It is estimated that this land will continue to erode at an average annual rate of 1.64 ft., of which 1.4 ft. is directly attributable to the presence of the federal breakwater. At this rate, the annual loss of land across the 1,900 ft. stretch of bluff equates to approximately 2,660 square feet (sf). Inflating the appraised value (2002 sale price) of this land ($2.31/sf) to current dollars ($3.1/sf) results in an estimated average annual value of land loss of approximately $8,100.

While is it classified in this analysis as a without-project damage, because the boat launch was constructed after the East Breakwater, there is some question as to whether or not the increased cost of dredging the area in front of the boat launch should be classified as an impact that is directly attributable to the construction of the breakwater. It is possible that the cost to periodically remove the sediment from in front of the boat launch ($530,000 every 7 or so years) could more appropriately be categorized as a maintenance cost associated with the construction of the boat launch in that particular location rather than an adverse impact of the adjacent breakwater whose construction predates that of the boat launch itself. In any event, if a project reduced the future cost of maintenance dredging, this could likely be considered an incidental NED benefit of the project. Of course, the presence of this accumulated sediment clearly serves as a convenient and available source of material with which to nourish the adjacent open-coast beach, and because of its proximity to the project area would certainly be the least cost source of beach fill.

When the recreation loss and land value loss are combined with the cost to periodically dredge sediment from in front of the boat launch, the total expected future without-project average annual damage is estimated to be $199,000.

Beach Fill is the Only Type of Project Measure Likely to be Effective

The Coastal Engineering Appendix describes in detail the analysis of several measures that could potentially reduce the future adverse physical and economic of the breakwater. It was determined by the Continuing Authorities Progam (CAP) §111 Project Delivery Team that beach fill was the only project measure that had a high likelihood of actually doing so. For this reason, the economic analysis was limited to an evaluation of beach fill as a damage mitigation measure or alternative.

A “Medium Beach Fill” project would move 150,000 cubic yards of sand from inside the harbor to Surfer’s Beach and Vallejo Beach. The sand would be spread across an approximately 3,100-foot stretch of beach, creating a 125-foot wide beach berm. The engineering analysis predicts that the visible portion of the sand placement would last at least 6 years, and that sand that migrated from the beach to the nearshore may continue to provide some level of erosion mitigation benefits for up to 40 years before the last of it was transported out of the study area. This means that the benefits to recreation (widened beach) of the project are expected to last 6 years or more, and the benefits associated with erosion risk reduction would decrease over time but may exist to some small degree for as many as 40 years after project construction. As with any beach fill project, there is a significant amount of uncertainty regarding the performance of the beach fill under persistent stormy conditions (e.g., El Niño). The preliminary cost estimate for this alternative is approximately $5 million, which in average annual terms equates to approximately $348,000 over 20 years at the FY15 applicable discount rate of 3.375%, and $472,000 at a rate of 7%.

A "Maximum Beach Fill" project would move 210,000 to 240,000 cubic yards (cy^3) of sand from inside the harbor to Surfer's Beach and Vallejo Beach. Like the smaller beach fill alternative, the sand would be spread across an approximately 3,100-foot stretch of beach. The crest elevation of the beach fill near the toe of the bluff would be the same as for the smaller beach fill alternative, but the larger volume would mean a berm width of 180 feet as compared to 125 feet for the smaller beach fill. The visible portion of the sand placement is expected to last at least 7 years under typical conditions, and sand remaining in the nearshore could mean that some amount of erosion reduction benefits may accrue for as many as 50 years. One benefit that applies exclusively to this larger beach fill project is a reduction in future dredging costs incurred by the Harbor District to ensure safe and reliable use of the boat launch. According to the Harbor District, historically they have had to dredge the boat launch area every 7 or so years at a cost of up to $530,000. The Maximum Beach Fill alternative would remove a large volume of sediment from in front of the boat launch, which would ostensibly eliminate the need for one or more dredging cycles within the harbor. This alternative is estimated to cost $6.4 million. Amortized over 20 years at the current water resources discount rate this equates to an average annual cost of $445,000, and at a discount rate of 7% equates to $605,000.

Economic Justification is Highly Unlikely

To be economically justified, the NED benefits of the project must equal or exceed the NED costs. The NED benefits of the Medium Beach Fill alternative are limited to a delay in the additional loss of recreation value associated with surfing and a delay in the additional loss of total land value in the study area. At the estimated project cost of $5 million, the NED impact of this beach fill project would be negative. The average annual costs of the project are estimated to be four times the average annual benefits over the twenty year period of analysis. The benefit-cost ratio is estimated to be 0.25. Generally speaking, it is USACE policy that recreation benefits cannot account for more than fifty percent of the total benefits needed for project economic justification. If the recreation benefits of the Medium Beach Fill alternative were constrained in this way, the benefit-cost ratio would be lower still.

The NED benefits of the Maximum Beach Fill alternative include the two categories of benefits associated with the smaller beach fill project, but also include a reduction in the expected future cost of dredging near the boat launch. While this alternative has greater total benefits than the smaller beach fill project, at the estimated project cost of $6.4 million, the NED impact of the beach fill project would also be negative. The average annual costs of the project are estimated to be approximately three times the estimated average annual benefits over the twenty year period of analysis. The benefit-cost ratio is estimated to be 0.39. If the recreation benefits were constrained to half the total benefits needed for economic justification, the benefit-cost ratio would be lower still.

1. INTRODUCTION

1.1 PURPOSE

The study is being conducted as part of the Continuing Authorities Program (CAP), and is authorized under Section 111 of the River and Harbor Act of 1968 for prevention or mitigation of future damages to both non-federal public and privately owned shores – to the extent that such future damages can be identified and directly attributed to a federal navigation project. As described in more detail below and in the Main Report, coastal engineering analyses support the conclusion that the federal navigation project (the breakwater) has disrupted what would be the natural movement of sand along the coastline in the study area. This disruption has accelerated erosion along the adjacent coastline southeast of the breakwater. The eastern breakwater has also trapped sand inside the harbor near the boat launch, resulting in periodic closure of one or more of the ramps as well as increased dredging costs to remove the accumulated sand from the area.

The primary purpose of this Economic Analysis is a benefit-cost analysis, for one or more project alternatives, that considers total National Economic Development (NED) benefits and total NED costs. That purpose will be attained by a) describing and estimating the expected future economic damages along the shoreline that are attributable to the existence of the federal breakwater at Pillar Point Harbor, CA, and b) estimating the economic benefits of potential measures that could be implemented to reduce or eliminate the adverse impacts caused by the breakwater.

1.2 GUIDANCE AND REFERENCES

The approach taken by this Economic Analysis is in accordance with current principles and guidelines and standard economic practices, as outlined in the Planning Guidance Notebook (PGN) – ER 1105-2-100, as well as the Institute for Water Resources (IWR) Report 2011-R-09, *Coastal Storm Risk Management National Economic Development Manual*. The base year (the first year in which a project could be implemented) is assumed to be 2017. All discounting is done using the 2015 Federal water resources discount rate of 3.375%. For reasons that are described in the report, a 20-year period of analysis was chosen. Guidance and procedures for estimating recreation value came from USACE Economic Guidance Memorandum (EGM) 15-03 and the PGN.

1.3 Basis for Federal Involvement: Federal Interest and Objective

"*Federal Interest"* is the rationale for Federal participation in water resource projects. The extent of this interest is the basis for determining cost sharing and other project responsibilities. It determines how and where the government can spend taxpayer money. Verification of the Federal Interest in a project is a prerequisite to project implementation. Study reports must have a conclusive statement of why such interest does or does not exist. Criteria for determining the Federal Interest are presented in the PGN, Section 3-1, and include a determination as to whether or not the water resources issue and potential solution set falls within the authorized missions of USACE, and requires consistency with Federal policies and budgeting priorities. Federal projects must be open to public use and have reasonable public access.

The "*Federal Objective"* of water and related land resources project planning is to contribute to NED consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area as well as in the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.

Marketed goods and services are those that are bought and sold, while non-marketed goods are not. Marketed goods have a known price – for example, the cost to repair or replace a damaged roadway. An example of a non-marketed good is the value of a day at the beach to a beachgoer. Another example is the value of time an individual spends cleaning up a flooded house in the aftermath of a coastal storm. For non-marketed goods the valuation is typically estimated at a person's theoretical "willingness-to-pay." This is also referred to as "consumer surplus."

Below is a description of the categories of NED impact that are typically considered for this type of study.

1.4 NED Impacts Categories

NED analysis considers all NED benefits and costs wherever they occur. Therefore, to the extent there are economic effects other than those specifically intended, they must be identified and taken into account. As an example, if shore protection has a negative impact on recreation use or adverse impacts to the shoreline outside the study area, this impact must be considered and displayed.

Importantly, NED focuses on the efficiency gain that is produced for the Nation as a whole and not on transfers from one U.S. region to another. A project may be economically attractive from a regional perspective but unwise from a national perspective. In contrast, if a study area is not large enough, problems or projects may affect other areas many miles away. This project could be highly attractive from the NED perspective, but may not look as attractive regionally to the non-Federal sponsor, community, other stakeholders and other government agencies.

NED costs are the opportunity costs of diverting resources from another source to implement the project. The NED costs of a project include the design, construction, and maintenance of a project, as well as any associated costs (mitigation, property relocations, etc.). NED benefits of USACE projects are typically damages and costs avoided. A project is considered feasible if the NED benefits are greater than the NED costs. The benefit-cost ratio for such a project would then be greater than one, and the project would be deemed economically justified according to USACE policy.

Below is a listing and description of the NED categories that are typically considered for this type of study according to IWR Report 2011-R-09. Note that not all of these damage categories will be relevant for all studies.

Property Damage – The prevention of costs associated with repair, relocation, or abandonment (if damage is severe enough) of property would all be considered benefits of a project. Also, the cost of measures taken by property owners to prevent damage is relevant to the evaluation of potential project benefits. That is, if a project would save property owners from incurring costs associated with preventing damage to the property, the value of those expenses would be considered a benefit of a project.

Recreation Impacts – The value of recreation land or beach lost to erosion is typically calculated as the lost recreation value to users in accordance with their willingness-to-pay for the recreation experience. Willingness-to-pay can be measured various ways, but for a small study like this with a low-use recreation area, USACE typically uses the Unit Day Value (UDV) method[1]. This method relies on expert or informed opinion and judgment to approximate the average willingness-to-pay of users of recreation resources.

[1] http://planning.usace.army.mil/toolbox/library/EGMs/EGM13-03.pdf

Land Loss – For USACE feasibility studies, the value of private land lost because of erosion is typically valued at the market value for the private land. The land at risk from erosion in the study area, however, is exclusively public. Public land loss can be captured as either the value of land OR the value of recreation lost, but not both.

Transportation Delay Costs – This impact is calculated as the sum of a) the time value of driver and passenger delay, and b) the additional vehicle operating costs as a result of a delay or detour. Only those delays and road closures that could actually be avoided by the proposed project may be counted, as the presence of the damaging storms with or without a project may be sufficient to precipitate road closure or delays.

Emergency Costs – Any emergency costs – such as the actions taken by police or other officials to reroute traffic around an eroded stretch of roadway – that would be avoided by the existence of a project would be considered a relevant NED benefit of a project.

Income Loss – This is the loss of wages or profits to business as a result of physical damages that cannot be deferred or transferred regionally. Prevention of income losses result in a contribution to NED only to the extent that the losses cannot be compensated for by postponement of an activity or transfer of the activity to other establishments.

Importantly according to the PGN, USACE policy is that recreation is general incidental when it comes to project economic justification. From page E-133 of the PGN:

> The Corps participates only in those projects formulated exclusively for hurricane and storm damage reduction, and justified based solely on damage reduction benefits, or a combination of damage reduction benefits plus (at most) a like amount of incidental recreation benefits. In other words, recreation benefits useable to establish Corps participation may not be more than fifty percent of the total benefits required for justification, which in turn means they may not exceed an amount equal to fifty percent of costs. If the criterion for participation is met, then all recreation benefits are included in the BCR. Costs incurred for other than the damage reduction purpose, i.e. to satisfy recreation demand, are a 100% non-federal responsibility.

Given that the authority for this project is CAP §111, which is aimed at the mitigation of adverse impacts from a federal navigation project, it is possible that all of the recreation benefits could count towards project economic justification. But at this time it is not clear whether or not that is the case. Given that this is an open question, the analysis will address economic justification when constraining the recreation benefits to half the total benefits for justification, and when not constraining the benefits as such.

1.5 The Economics of Beach Nourishment

As the report explains, the construction of the Federal breakwater has led to increased accretion of sediment inside the harbor, and an acceleration of coastal erosion outside the breakwater. One obvious project alternative to consider is the transfer of excess sand from inside the harbor to the erosion area of concern located just over the breakwater. In general, the actual economic benefits (national or otherwise) of a beach nourishment project such as this will, of course, depend on the specifics of the particular project and of the particular location. The size of the project; the duration that the project is effective; and the location, value, and vulnerability of the assets at risk are all important variables for the quantification of storm damage risk reduction and project economic benefits.

The degree to which any nourishment project or regime would mitigate or eliminate the damage caused by any single storm is uncertain and would require detailed modeling to understand. Importantly, any reduction in risk to property and infrastructure from a single beach nourishment project is temporary. The risk reduction and the benefits associated with the nourishment will decrease over time as the sand is naturally transported elsewhere in or out of the littoral cell. Table 1 illustrates how the economic benefit from a delay (and not a total prevention) in damage is calculated.

Year	Damage WITHOUT Nourishment				
	Asset A	Asset B	Asset C	Total	Present Value of Total
2016	$0	$0	$0	$0	$0
2017	$500	$0	$0	$500	$467
2018	$0	$500	$0	$500	$437
2019	$0	$0	$500	$500	$408
2020	$0	$0	$0	$0	$0
2021	$0	$0	$0	$0	$0
2022	0	$0	$0	$0	$0
2023	0	$0	$0	$0	$0
2024	0	$0	$0	$0	$0
2025	0	$0	$0	$0	$0
Total	00	$500	$500	$1,500	**$1,312**
				Average Annual Value	**$187**
Year	**Damage WITH Nourishment**				
	et A	Asset B	Asset C	Total	Present Value of Total
2016	$0	$0	$0	$0	$0
2017	$0	$0	$0	$0	$0
2018	$0	$0	$0	$0	$0
2019	$0	$0	$0	$0	$0
2020	$0	$0	$0	$0	$0
2021	$0	$0	$0	$0	$0
2022	$500	$0	$0	$500	$333
2023	$0	$500	$0	$500	$311
2024	$0	$0	$500	$500	$291
2025	$0	$0	$0	$0	$0
Total	$500	$500	$500	$1,500	**$936**
				Average Annual Value	**$133**

5-Year Delay in Damage

Table 1: Example - The Benefit of a Delay in Damages

In the example in Table 1, the damage expected to Assets A, B, and C as the result of coastal erosion is delayed by five years from a one-time beach nourishment project. The economic benefit from nourishment is the difference in the total present value with and without nourishment – in this case $1,312 minus $936. This example uses a discount rate of 7% over a ten-year period. All else equal, the present value of the decrease in damage is positively correlated with the value of the assets and the duration of the delay in damage and negatively correlated with the interest rate. A lower discount rate makes future benefits more valuable in today's dollars, which, when compared to a one-time project cost, would increase the likelihood of economic justification.

To estimate the economic benefits to property and assets of a beach nourishment project, an estimate or assumption would have to be made regarding how the new beach profile changes over time and how effective it is along the way at reducing the risk to coastal value and assets. A complete and accurate benefit estimate would also require considering what actions would be taken in the absence of a nourishment project. For example, it would not be accurate to assume that in all cases the benefit of beach nourishment is equal to the value of the vulnerable land or the replacement value of structures and infrastructure. This is because property owners or others may take action on their own when possible to mitigate or prevent damage from storms and erosion.

The placement of riprap along the bluff is one type of measure that has been implemented in the study area to protect properties and infrastructure from wave attack and erosion. If this type of action is allowable, would likely be taken, and would be effective at slowing or stopping erosion, then it would need to be considered a without-project condition. In this case, one benefit category of beach nourishment might be a delay in the cost of implementing the protective measure.

1.6 The Study Area

The study location spans approximately one mile of the coastline of the City of Half Moon Bay. The unincorporated communities of Princeton-by-the-Sea (Princeton) and El Granada are in the study area, but the erosion concern area is along coastline owned by the City of Half Moon Bay. Combined, the City of Half Moon Bay and the unincorporated areas of El Granada and Princeton have a population of approximately 12,600.[2] Figure 1 shows the study and project area and the locations where the adverse impacts from either bluff erosion or sand deposition occur. Part of the study area has been designated a Beach Erosion Concern Area (BECA) by the Coastal Sediment Management Workgroup (CSMW), which is a task force consisting of federal, state (CA), and local agencies and non-governmental organizations[3].

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[2] http://www.census.gov/

[3] http://www.dbw.ca.gov/csmw/pdf/CBEAS_Final_10252010a.pdf, http://www.dbw.ca.gov/csmw/

The San Mateo County coastline is famous for its rugged, natural beauty. Nature lovers, surfers, and hikers come from all around for the unique recreational opportunities offered by this stretch of California's coast. The beaches are a valuable source of recreation for locals and tourists alike, and a central part of the economies of the local coastal communities.

The tourism industry not only creates and supports jobs in the region, but is also an important source of tax revenue for the cities and county in the study area. For the City of Half Moon Bay, the Transient Occupancy Tax (TOT), which is a tax charged to hotel guests, is the largest contributor to the City's General Fund (almost $5M in 2013-2014). Visitor-generated tax receipts account for more than 25% of the total tax receipts for San Mateo County (Dean Runyan Associates, 2014).

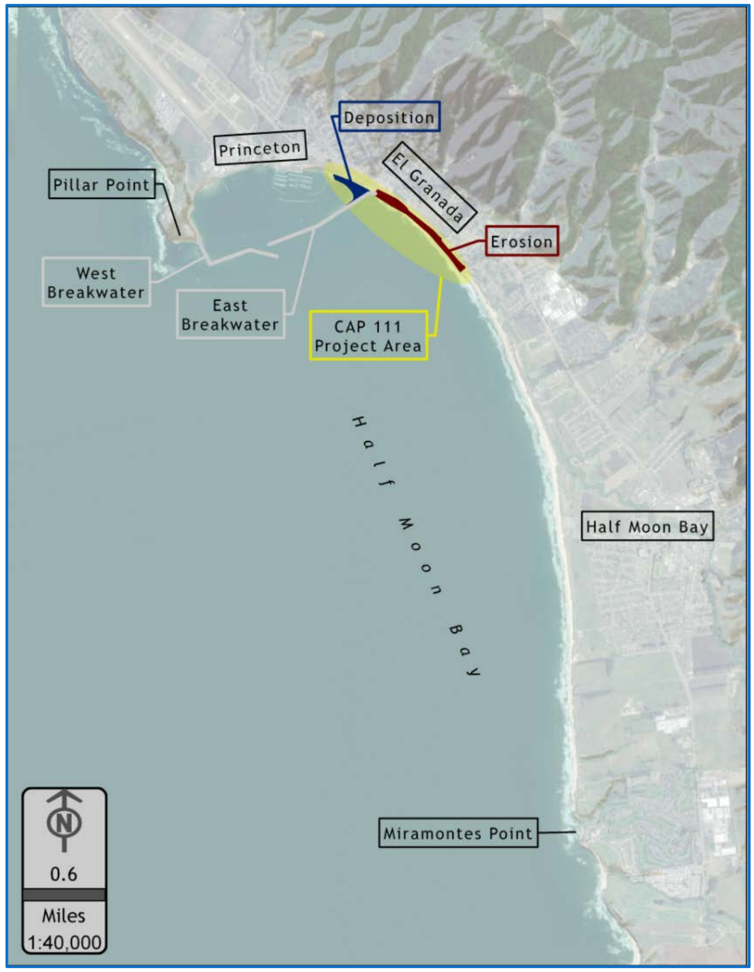


Figure 1: Study Area and Project Location

As the population in the region continues to grow, so will the demand for beach and coastal recreation. According to the California Department of Finance's Demographic Research Unit, the population of San Mateo County is expected to grow approximately 25% between 2015 and 2060 (California Department of Finance, 2013). The population of the surrounding counties is forecast to grow by approximately 15% over that same period. Given that a large percentage of the visitors to the coastal towns come from other Northern California counties, the forecasted population growth in these counties will mean continued growth in demand for the study area's beaches and other coastal recreational opportunities.

Pillar Point Harbor is a state-designated harbor of refuge for the commercial fishing fleet and other vessels. It is protected by two rubble mound breakwaters built and maintained by USACE, and a group of three inner breakwaters built and maintained by the Harbor District. The Harbor includes: three recreational docks and five commercial docks; a main commercial pier serving the commercial and sport fishing industry, with three wholesale commercial fish handling leaseholds, a fuel dock, and ice facility; a small recreational fishing pier; a public small boat hoist; a commercial building leased to five businesses including two restaurants, two sport fishing concessions, and a surf shop; the District's Harbor Office; a kayak rental business; public restrooms; vehicle parking lots; public access trails and public beach; and an RV park.

According to the San Mateo County Harbor District website, "the Harbor has 369 berths and an inner and outer breakwater, making it one of the safest harbors in the United States." According to Harbor District officials, the boats located at the Harbor are about evenly split between commercial and recreational vessels. The commercial fishing industry is significant at the Harbor, and the annual value of fish landings is generally more than $3 million and has recently been as high as $4.8 million[4]. There are four commercial facilities at the harbor that receive the fish landings.

The study area beach consists of a very narrow area along the Highway 1 revetment known as "Surfer's Beach", a slightly wider stretch of beach known as Vallejo Beach, and a very narrow area along Mirada Road known as Miramar Beach. Adjacent to the coastline are the Cabrillo Highway (Highway 1) and a segment of the California Coastal Trail that is maintained by the San Mateo County Parks and Recreation Department. At the southern end of the project area near the bluff edge is a small two-lane road (Mirada Road) and several residential and commercial properties including a restaurant. There are several small and large hotels in the area whose business is driven by the recreation opportunities in the region. The figure below shows the location of the important assets in the study area.

[4]Source: Peter Grenell, San Mateo County Harbor District General Manager

Figure 2: Study Area Features
Aerial Imagery Source: Google Earth

1.6.1 Recreation in the Study Area

The short stretch of coastline southeast of the harbor in the study area is used by visitors and locals for walking, running, biking along the coastal trail, and surfing (Figure 3). Given the narrow to nonexistent beach, frequently cool-and-cloudy weather, and lack of amenities such as restrooms, beach activities in the study area are generally short-lived in nature and must take place at or near low tide. The beach, bluff-top trail, and harbor are sources of recreation for locals, tourists, and patrons of the area's many hotels. Locals estimate that Surfer's Beach currently has, on average, around 35,000 annual users. No estimate was available for use of the California Coastal Trail through the study area. is scene at Surfer's Beach.

Figure 3: Surfers at Surfer's Beach during a typical weekend: looking North (top) and South (bottom).

1.7 The Project's Impact on Sediment Transport

USACE studies have confirmed that the construction of the East Breakwater altered the wave energy and sediment transport pattern in the study area. The presence of the breakwater has accelerated erosion of the bluff and beach south of the breakwater and has caused sand accumulation north of the breakwater, inside the harbor. According to coastal modeling performed recently and described in the Coastal Engineering Appendix, the bluff in the area that is not protected by riprap has been retreating over the past decade at an average rate of about 1.6 ft. per year (Figure 4). Of the 1.6 ft. of average annual erosion, USACE engineers estimate that 1.4 ft. of this is caused by the breakwater, while 0.2 ft of annual erosion is consistent with the regional "background rate" of erosion.

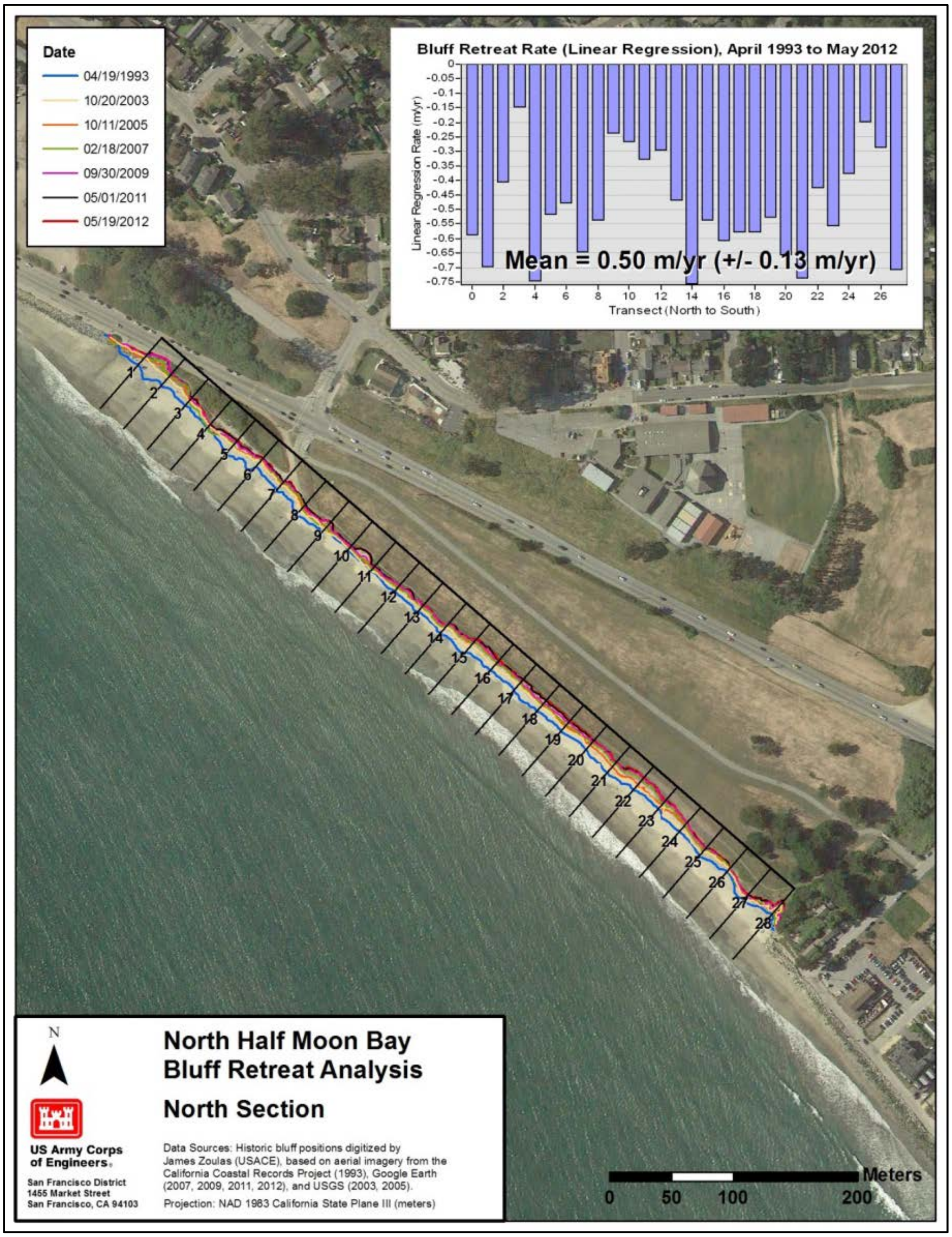


Figure 4: Historical Erosion in the Study Area

Source: Coastal Engineering Appendix

As described in the Coastal Engineering Appendix, in addition to the problem of bluff erosion, the construction of the East Breakwater has also been associated with the accumulation of a significant amount of sediment (primarily sand) within Pillar Point Harbor (Figure 5). Some of this sand has formed a beach near the root of the breakwater, which includes a fairly well-developed set of vegetated dunes. Additional sand has accumulated along the harbor side of the East Breakwater to form a shoal that is 200 to 250 ft. wide and close to 2,000 feet long. This shoal presents a potential navigation hazard for vessels utilizing the nearby small-boat launch ramp. Hydrographic surveys taken in 1994 and 2007 suggest that shoaling rates adjacent to the East Breakwater have exceeded 3,000 yd^3/yr (Gahagan & Bryant Associates, 2007). A comprehensive hydrographic and topographic survey taken in 2011 suggests that much of this shoal is at least 10 feet thick (Towill Inc., 2011), and a GIS-based analysis indicated it could yield up to 150,000 $yd^3$of sand.

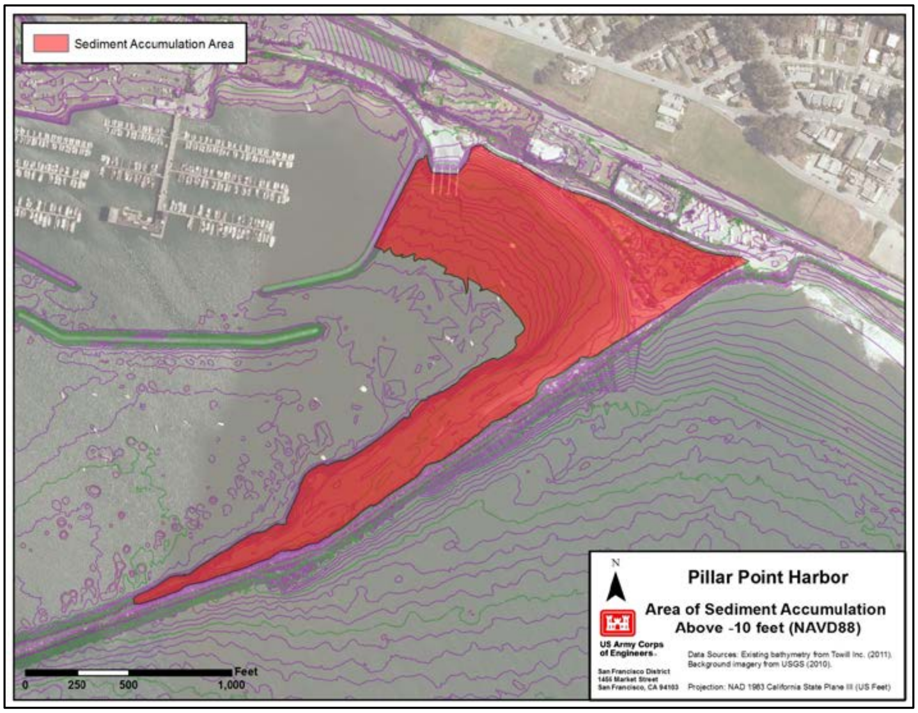


Figure 5: Area of Excessive Sediment Accumulation and Shoaling
Source: Coastal Engineering Appendix

According to the Coastal Engineering Appendix, both the bluff erosion and the sand accumulation result from changes in hydrodynamic conditions and sediment transport wrought by the construction of the East Breakwater. The current scientific understanding is that prior to the construction of the harbor, sand traveled in a generally southeast direction in the littoral zone owing to longshore currents induced by waves approaching from the northwest (Griggs et al., 2005). This southeastward transport of sand, however, was effectively disrupted on completion of the harbor, resulting in a sand deficit on the beaches and in nearshore directly southeast of the root of the East Breakwater. Numerical modeling with the Coastal Modeling System (CMS) suite confirms this hypothesis and suggests that prior to harbor construction there was a node (at Surfers Beach) where southeast and northwest longshore currents might have converged to deposit sand. This node then disappeared following construction of the harbor, and now much of the sand that would have been transported to Surfers Beach is trapped in the shoal on the harbor side of the East Breakwater. Additional information and details on the erosion and accumulation impacts can be found in the Coastal Engineering Appendix.

2. FUTURE WITHOUT-PROJECT CONDITION

The without-project condition, as its name suggests, is an assessment and forecast of the risks, assumptions, and conditions, assuming no action is taken by USACE. If erosion risk-reduction (or in-harbor sand removal) measures or any other actions are imminent or likely during the period of analysis without USACE's action, those measures and actions should be considered to be part of the without-project condition. Imminent measures and actions include those that are under construction, funded storm-protection measures, development under construction, development limitations as specified under the National Flood Insurance Program, Executive Order 11988, Coastal Zone Management Plans, and any state and local regulations in effect. Since future conditions sometimes include plans that have yet to be approved or may be speculative, USACE guidance states that all assumptions about including or excluding them in the future without-project condition should be carefully explained and justified.

One important future action that needs to be considered is a project that has been approved and funded to improve pedestrian safety and reduce the risk of erosion to Highway 1. According to a presentation to the San Mateo County Parks and Recreation Commission Meeting on April 9, 2015, the County of San Mateo, the California Department of Transportation (Caltrans), and the City of Half Moon Bay are partnering on the estimated $2 million project that is anticipated to be fully constructed in November of 2015.[5] The project will reduce the erosion risk to the highway by extending the riprap by around 200 feet, will improve access to the beach with a staircase, and will connect the Coastal Trail on either side of the project area.

The completion of this project is an important future without-project condition, since it effectively removes protection of Highway 1 as a benefit category for all alternatives. It also removes as a benefit category the protection of the most exposed portion of the California Coastal Trail that runs along Highway 1. This without-project assumption is included below in the list of major assumptions made for this analysis.

[5] https://parks.smcgov.org/sites/parks.smcgov.org/files/events/20150409_REVISED_0403_0406_Agenda_Rescheduled_PRC-linked_0.pdf

2.1 MAJOR ASSUMPTIONS

For coastal studies such as this, the consideration of future actions by others is especially important to the benefit-cost-analysis of the project. The critical future without-project assumptions of this analysis are described below.

1. *Bluff Erosion Rate*: Any areas of the shoreline unprotected by a rock revetment in the study area will experience an average rate of bluff erosion of 1.6 ft./yr. According to the Coastal Engineering Appendix, the "natural" background rate of erosion is approximately 0.2 ft./yr., so, where applicable, the federal breakwater is assumed to cause 1.4 ft./yr. of erosion to the unprotected stretch of the study area where no revetment exists.
2. *Cabrillo Highway (CA-1)*: The previously-described project planned by Caltrans and San Mateo County to protect and improve the exposed stretch of the Highway 1 and the coastal trail will be completed before any Federal project could be implemented.
3. *Boat Ramp*: The boat ramp area will continue to accumulate sand, and periodic dredging will be necessary to provide safe and reliable access. The most recent three dredging episodes were in 1998, 2006, and 2013. The most recent dredge episode cost just over $530,000[6]. It is assumed that in the future dredging will continue to be required every 7 years to maintain safe access to and use of the boat ramp.
4. *Mirada Road Homes and Businesses*: The protective riprap that is in place along the bluff adjacent to Mirada Road will be maintained such that Mirada Road, adjacent homes, and businesses in the area will not be significantly adversely affected by future erosion.
5. *20-year Period of Analysis:* According to the PGN, the period of analysis is defined as the duration of time over which the project will have significant beneficial or adverse impacts. The period of analysis must be the same for all alternatives considered. While the engineering analysis estimates that some beneficial effect of the final array of alternatives could extend as long as 40 or 50 years from project completion, it is likely that the benefits after 20 or 30 years would be small since the visible beach for the beach fill alternatives will likely have disappeared within 10 years of project implementation.

2.2 NED IMPACTS

The adverse impacts of the East Breakwater can be broadly classified as associated with either a) increased erosion outside of the breakwater, or b) increased sediment accretion inside the

[6] Source: San Mateo County Harbor District

breakwater. The following paragraphs describe the estimated without-project impacts for each of the relevant damage categories. These impacts are economic damages that are believed to be directly attributable to the presence of the breakwater and that qualify as NED as defined previously.

2.2.1 Understanding Recreation Value

Bluff erosion and a net transport of sediment out of the study area will have adverse impacts on the recreational resources in the area. While there is a significant amount of uncertainty regarding the timing and magnitude of the future impacts to recreation, there is obviously a need to reasonably quantify them. The following paragraphs describe the logic and method used to quantify these impacts.

Market vs. Non-Market Impacts

California's beaches play a prominent role in making California the number one travel destination in the United States (Kildow & Colgan, 2005). The San Mateo coastline is a popular destination for foreign and domestic tourists alike. There are several hotels along the waterfront in the study area, and numerous restaurants and shops along the waterfront. Visitors to this area and others in the region have both market and non-market economic impacts. The paragraphs below explain the difference in these two categories of impact, and explain why this benefit-cost analysis focuses on the non-market impacts of a project.

Visitors to beaches stimulate the local economy by purchasing goods and services (gas, food, sunscreen, surf lessons, hotel stays, etc.) at or near the beach. The impact to the local and regional economy of tourist spending is a function of the number of tourists, the average spending per visitor, and to what extent each tourist dollar gets spent again in the local economy (known as a multiplier). This impact is classified as a market impact because it can be measured in a market transaction (sales). This is the type of impact local governments are typically most interested in because of the impact on employment, income, and tax revenue in the region.

From a local or regional perspective, the actual impact of these expenditures exceeds their dollar value as the spending stimulates additional demand for goods and services. For example, store shelves or inventories are restocked, and income received by owners and employees is spent elsewhere in the economy. Economists classify the impact of spending on aggregate demand as either a direct, indirect, or induced effect.

To illustrate the difference between these three effects, take, for example, the case where a beach nourishment project is anticipated to increase the number of overnight tourists visiting a beach town. The additional demand for hotel rooms increases hotel revenues and employment, and the additional employee wages and local and state taxes would be classified as a direct effect of the increased demand. The increased demand for hotel rooms would then increase the demand by the hotel industry for goods and services supplied to the hotel by others – such as from a restaurant supply company. This would be an indirect effect of the increase in demand attributed to the project. Finally, when the newly-hired hotel employees spend their income in the local economy (going to dinner, getting a massage, etc.), this is an example of the induced effect of the increased demand for hotel rooms. In this way, each additional dollar spent in an economy results in more than one dollar's worth of increase in final demand.

This increase in demand is very important for employment, income, and tax revenue in communities like those along the San Mateo County coastline. From a national perspective though, the ability of a particular coastal community to attract tourists and their vacation dollars with high quality recreational resources is somewhat less of a concern. This is because, as the theory goes, there is little net gain in economic activity in the nation overall when one particular town, city, or county attracts additional tourists. If they hadn't vacationed at that particular beach they would have gone to a different beach or undertaken a different type of vacation altogether somewhere else in the country. One clear exception, of course, would be foreign tourists that come to the U.S. expressly for the beach experience that otherwise would not have visited – in which case there would be a net loss in national output. While the theory may not reflect reality for all beaches all of the time, it forms the basis for the policy perspective of USACE and other federal agencies. Generally speaking, USACE does not consider the impact of recreation on final demand to be a NED impact, and thus does not factor it into the benefit-cost ratio for potential projects.

While USACE doesn't consider the *market* impacts of recreation or tourism for purposes of project economic justification, that does not mean that recreation does not have value from a national (or federal agency) perspective. Beaches have additional *non-marketed* value that is not reflected in a market transaction such as the purchase of a night's stay in a hotel. The value to the individual that is above and beyond what was actually paid (which at the beach is often zero or close to zero) has non-market value that is often referred to as "consumer surplus." The most complete and accurate estimate of the value of a recreation experience would capture the total willingness-to-pay of each individual beachgoer, which would include each person's consumer surplus. Summing the consumer surplus values for all beach users gives an estimate of the total non-market recreation value of the beach, and the change in value caused by a project would be considered an NED impact to be counted in the benefit-cost ratio. Importantly though, according to USACE policy there is a limit on the percentage of the benefits for economic justification of a project that can be from recreation. This limitation is described in Chapter 4 of this report.

What is a Beach Day Worth?

Besides the occasional parking fee and the cost to get there, use of the beach is free. As a result, there is no direct market data that can be used to estimate the value of the beach to the public. However, numerous studies have tried to estimate what people would, in theory, be willing to pay for a day at the beach. The estimates are typically based on an analysis of survey responses of beach users. According to information on the National Ocean Economics Program website (www.oceaneconomics.org), the results of the various studies indicate that willingness-to-pay varies significantly by beach. When adjusted for inflation, studies of California beaches that used the Travel Cost Method (an accepted and widely-used valuation method), and reported their results on a per person basis, estimated that, depending on the beach, a beach day was worth between $13 and $126 dollars per person. A much-referenced study by Chapman and Hanneman (2001)[7] estimated that a day of recreation at Huntington State Beach in Orange County, CA had a non-market value of around $13 per person in 1990 dollars. Inflating this value to 2015 prices using the U.S. Consumer Price Index would make it approximately $23. Huntington Beach is a wide beach with nice sand and many high quality amenities such as good surfing, convenient pay parking, lifeguard towers, beach volleyball nets, and concessions. Regardless of the method, the value of a beach day in the study area would be significantly lower than this.

2.2.2 Baseline Recreation Value in the Study Area

According to conversations with a local resident and coach of the Half Moon Bay Surf Club, on the average day there are around 100 surfers at Surfer's Beach. According to the locals, wave quality has dropped significantly over the past several years, and safety has become a regular concern because of the challenge of entering and leaving the surf zone with such a narrow beach. Use of the beach along the adjacent area known as Vallejo Beach is very low, typically being limited to those walking and watching the surfing activity at low tide. An unknown number of people use the bluff-top California Coastal Trail for walking, dog walking, running, and biking.

[7] http://ageconsearch.umn.edu/bitstream/6868/2/wp000913.pdf

For practical reasons no user survey was conducted for this recreation analysis – the low use and expected total value simply do not justify the time and expense to prepare, conduct, and analyze the results of a beach use survey. Instead, the analysis uses what is known as the Unit Day Value[8] method. This method is often used by USACE to value qualifying low-use recreation experiences. It has been criticized for being too simplistic and for generally undervaluing recreational experiences of users – including beach users[9]. For low use recreational resources, however, its use often makes sense because no direct survey data are needed, which reduces the time and expense of the recreation value analysis. This method relies on expert or informed opinion and judgment to approximate the average willingness-to-pay of users of recreation resources. The categories used to evaluate recreational resources are: Recreation Experience (number of activities), Availability of Opportunity (proximity of similar opportunities), Carrying Capacity (how additional use degrades the experience for the users), Accessibility, and Environmental (aesthetic qualities). The latest USACE Economic Guidance Memorandum (EGM 15-03) estimates the value of a general (non-specialized) recreation experience at between $3.91 and $11.72.

Given that current use of the beach for non-surfing activity is so low, the recreation analysis focuses exclusively on the impact to surfing. Willingness-to-pay per surfer was estimated using the Unit Day Value method.

As Table 2 shows, surfing at Surfer's Beach was valued at 52 out of a possible 100 points. The surfing experience received a higher point rating than it otherwise would have because the beginner break is popular and somewhat unique in the region. The assignment of values for each category is admittedly highly subjective, but the overall results seem reasonable. Table 2 shows the valuation broken down by criteria in accordance with the UDV method.

[8] http://planning.usace.army.mil/toolbox/library/EGMs/EGM15-03.pdf

[9] http://www.dbw.ca.gov/csmw/PDF/Economics_of_RSM_0706.pdf

Table 2: UDV Points Assigned to Surfing

UDV Criteria	Key Variables	Range of Point Values	Surfing Points
Recreation Experience	Number & Type of Facilities	0-30	15
Availability of Opportunity	Number of Similar Opportunities Nearby	0-18	9
Carrying Capacity	Adequacy of Facilities for Activities	0-14	9
Accessibility	Ease of Access to and Within Site	0-18	9
Environmental	Aesthetic Quality of Site	0-20	10
Total		0-100	52

Figure 6 below shows how the recreation experience is valued across the possible point assignment according to the UDV method. The surfing experience is valued at $8.45.

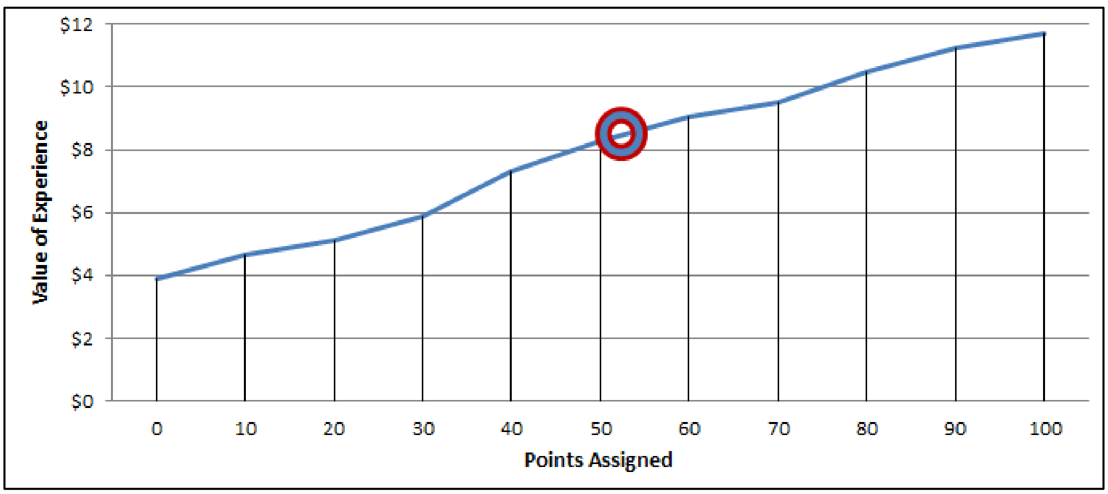


Figure 6: UDV Points vs. Value (USACE EGM 15-03), and Study Area Values Assigned

Multiplying the total estimated annual users (36,500) by $8.45 results in a total annual non-market recreation value estimate of approximately $308,000.

2.2.3 Future Recreation Value

The CAP §111 authority under which this study is being conducted specifies that potential projects should address future adverse impacts of the federal breakwater. Thus, the critical question is: how will the estimated recreation value change over time in the absence of a project with federal participation?

As described in detail in the Coastal Appendix, the East Breakwater has accelerated erosion in the open-coast part of the project area. The beach along Surfer's Beach is essentially gone and will steepen over time, In general, the quality and safety of surfing in the study area is expected to decrease over time under the without-project condition. In the absence of measures taken, it is reasonable to assume that the availability and safety of recreation at Surfer's Beach will continue to degrade over time.

While it is admittedly highly speculative and uncertain how surfing activity will change over the next twenty years, it is necessary for purposes of this analysis to quantify the impact to value by making some reasonable assumptions about use and value. A longtime surfer of the break, who is coach of the local surf club, believes that, given the trend observed over the many years, it is possible that continued reduced wave quality and increased danger could combine to render the area "unusable for recreation." While assuming that use by surfers falls to zero over the period of analysis is probably overly pessimistic, given the anecdotal evidence related to the decrease in use over the past few years, it is considered reasonable to assume that surfing activity decreases by at least half by the end of the period of analysis (2036), and that the quality of the surfing decreases by a similar percentage over that period. Table 3 shows the calculation of the loss in value to surfing over the twenty year period of analysis between 2017 and 2036. The annualized loss is estimated to be approximately $114,000.

Table 3: Average Annual Loss in Value to Surfing

	Year	Annual Users	UDV per User	Annual Recreation Value	Annual Loss in Value	Present Value of Impact
	2015	36,500	$8.45	$308,425	n/a	n/a
	2016	35,631	$8.25	$293,913	n/a	n/a
Beginning of Period of Analysis	2017	34,762	$8.05	$279,751	$14,162	$13,700
	2018	33,893	$7.85	$265,938	$27,975	$26,178
	2019	33,024	$7.65	$252,475	$41,438	$37,510
	2020	32,155	$7.44	$239,362	$54,551	$47,769
	2021	31,286	$7.24	$226,598	$67,315	$57,021
	2022	30,417	$7.04	$214,184	$79,729	$65,332
	2023	29,548	$6.84	$202,120	$91,793	$72,761
	2024	28,679	$6.64	$190,405	$103,508	$79,369
	2025	27,810	$6.44	$179,040	$114,873	$85,207

2026	26,940	$6.24	$168,025	$125,888	$90,329
2027	26,071	$6.04	$157,360	$136,553	$94,783
2028	25,202	$5.83	$147,044	$146,869	$98,615
2029	24,333	$5.63	$137,078	$156,835	$101,869
2030	23,464	$5.43	$127,461	$166,452	$104,585
2031	22,595	$5.23	$118,195	$175,718	$106,803
2032	21,726	$5.03	$109,278	$184,635	$108,559
2033	20,857	$4.83	$100,710	$193,203	$109,888
2034	19,988	$4.63	$92,493	$201,420	$110,822
2035	19,119	$4.43	$84,625	$209,288	$111,391
2036	18,250	$4.23	$77,106	$216,807	$111,625
Total Present Value					$1,634,117
Average Annual Loss					$113,682

2.2.4 Land Loss

The County of San Mateo owns the large public parcel that is located between Highway 1 and the beach in the study area (Figure 7). The area between the beach and Highway 1 exposed to future erosion risk is approximately 14 acres in size, and the total acreage of the parcel is 18 acres. According to the San Mateo County Assessor's Office, the County acquired the land in 2002 in a purchase of two parcels totaling 59.7 acres in size for $6 million. This means that the land was purchased for approximately $100,400/acre, or $2.30/sf. According to documents provided by the County[10], the purchase price was based on "an independent appraisal." The low price per unit of the land reflects the fact that it was zoned as "Open Space and Public Recreation" in the County's General Plan, which restricts the "highest and best use" of the land, which in turn limits the fair market value of the property that is the basis of the appraisal.

[10] Inter-Departmental Correspondence, Office of County Counsel to County Board of Supervisors, January 8, 2002

Figure 7: Aerial View of Public Parkland

According to the PGN, USACE uses the nearshore market value to estimate the loss of private land from coastal storms. This represents the net loss assuming that the oceanfront is the most valuable factor with a rent gradient declining as you move inshore. As the shoreline recedes, the extra oceanfront differential value is transferred landward so the net economic loss is measured at nearshore value. For publicly-owned land, Engineer Regulation (ER) for *Flood Damage Reduction Measures in Urban Areas* (ER 1165-2-130) states that the value of recreation can be used to estimate the value of public lands lost to erosion. In this case, it is important to display *either* the value of land lost (based on nearshore land values) or recreational losses to avoid double counting.

Currently the recreational value of the park is almost exclusively associated with the use of the trail that bisects the park. The trail was relocated further inland several years ago because of the recession of the bluff. At the north end of the park, the trail is approximately 75 feet from the edge of the bluff, and at the south end of the park it is more than 250 feet from the bluff top. No official estimates of the use of the trail are available, and unofficial estimates have a high degree of uncertainty. Even if official estimates were available, it is not clear how the recreational value of the park would be quantified. The trail south of the planned Caltrans project to protect the Highway would not be affected for more than 20 years at the assumed rate of bluff erosion. Given the challenges and uncertainties associated with trying to estimate the recreation value of the land, it was determined that it was best to value the land based on nearshore land values in accordance with USACE guidance.

Since the land in question (the 14 acres southwest of Highway 1) was purchased along with a larger area of nearshore land (north of Highway 1), it is not known what the nearshore land alone would have been bought for in isolation. This is of relatively minor consequence since the nearshore land accounted for two-thirds of total land purchased, so it is reasonable to use the total purchase price to estimate the price per unit of the park land west of Highway 1. Using the 2002 purchase price, the price per acre was approximately $100,000, and the price per square foot was $2.30. The 2002 value should, of course, be inflated to current dollars, but it is not obvious which index or method is most appropriate to use. First, it is not known if and to what extent the change in the value of public space over time is correlated with the change in the value of private, developed (or developable) land in same area or region. Assuming that the value of the public space is a function of its use, then a reasonable alternative might be to use the rate of population growth in the region. Ultimately, for simplicity's sake a purchasing power approach was taken and the 2002 purchase price was simply inflated by the overall consumer price index for urban consumers in the San Francisco-San Jose metropolitan area.[11] The result is a 33% increase in the land value compared to 2002 – an average annual increase of approximately 2.5%.

Consequently, the 2015 value is estimated to be $3.07/sf. At the estimated future average rate of erosion of approximately 1.4 feet per year, the breakwater will be responsible for an average of approximately 2,660 square feet of public land lost annually. At a value of $3.07/sf, the average annual loss in total land value would be approximately $8,166 (Table 4).

Table 4: Average Annual Loss in Land Value

Total Acreage of Land Purchase x Square Feet per Acre =	Total Square Footage
59.73 x 43,560 =	2,601,839
Total Purchase Price in 2002 / Total Square Footage =	**Value per Square Foot (2002)**
$6,000,000 / 2,601,839 =	$2.31
Value per Square Foot in 2002 x (Inflation Index 2015/Index 2002) =	**Value per Square Foot (2015)**
$2.31 x (254.91/191.3) =	$3.07
Average Annual Erosion in Lineal Feet x Length of Bluff =	**Average Annual Erosion in Square Feet**
1.4' x 1,900 =	2,660

[11] U.S. Bureau of Labor Statistics, Series ID CRRRA422SA0

Value per Square Foot x Average Annual Erosion in Square Feet =	Average Annual Loss in Land Value
$3.07 x 2,660 =	**$8,166**

2.3 Sediment Accretion Impacts

According to the San Mateo County Harbor District and the Pillar Point Harbor Master, the accretion of sediment inside the breakwater has forced the closure of one or more of the boat launch ramps and can cause delays to recreational and commercial fishermen. Shoaling has also reportedly reduced the space available for anchorage between the inner and outer breakwaters.

As noted previously, over the past fifteen years, there have been three dredging episodes to remove sediment from the area near the boat launch –1998, 2006, and 2013. A total of $530k was spent on dredging in 2013. The Harbor District anticipates that the area will need to be dredged approximately every 7 years at an average cost of $530,000. A project that takes sediment from inside the harbor to nourish the beach outside the harbor may have benefits in the form of reduced dredging maintenance costs to keep the boat launch open. The benefits would be a function of the volume and location of the removed sediment.

In addition to the cost of dredging the area to keep the boat launch open, the additional time spent waiting to launch a boat during those times when dredging is needed can be considered an NED impact according to USACE policy. The value of the delay would be based on the methodology described in IWR Report 91-R-12, "*Value of Time Saved for Use in Corps Planning Studies*." Because of the difficulty and uncertainty involved in estimating the value of future delays at the boat ramp (depends to a large extent on fisheries status, tide, and other variables), this impact is not quantified in this report. It is believed that the vast majority of the economic impact can reasonably be captured by accounting for the cost to periodically dredge the area to keep it open and maintain safe transit.

2.4 Summary of Without-Project NED Impacts

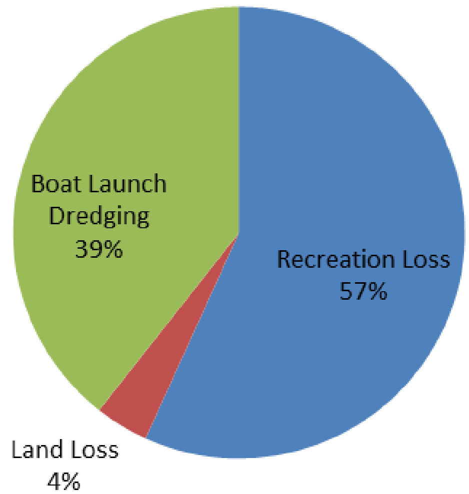
Summing the estimates for the values of recreation impact, land loss, and boat launch dredging cost, the total annual NED impact under the without-project condition is estimated to be $199,000 (Table 5). It is important to note that not all of these impacts will be reduced or avoided by the project alternatives.

Table 5: Summary of Future Without-Project NED Impacts

Year	Recreation Value Lost	Land Value Lost	Boat Launch Dredging Cost	Annual Total Nominal Value Lost	Annual Present Value Lost (2017)
2017	$14,162	$8,166		$22,328	$21,599
2018	$27,975	$8,166		$36,141	$33,820
2019	$41,438	$8,166		$49,604	$44,903
2020	$54,551	$8,166	$530,000	$592,717	$519,022
2021	$67,315	$8,166		$75,481	$63,938
2022	$79,729	$8,166		$87,895	$72,023
2023	$91,793	$8,166		$99,959	$79,234
2024	$103,508	$8,166		$111,674	$85,630
2025	$114,873	$8,166		$123,039	$91,264
2026	$125,888	$8,166		$134,054	$96,189
2027	$136,553	$8,166	$530,000	$674,719	$468,330
2028	$146,869	$8,166		$155,035	$104,098
2029	$156,835	$8,166		$165,001	$107,173
2030	$166,452	$8,166		$174,618	$109,716
2031	$175,718	$8,166		$183,884	$111,767
2032	$184,635	$8,166		$192,801	$113,361
2033	$193,203	$8,166		$201,369	$114,532
2034	$201,420	$8,166	$530,000	$739,586	$406,920
2035	$209,288	$8,166		$217,454	$115,737
2036	$216,807	$8,166		$224,973	$115,830
Total Present Value of Damage					$2,853,487
Average Annual Damage (3.375%)					$198,510

As the pie chart below shows, recreation loss accounts for more than half of the total present value of the estimated without-project damages.

Figure 8: Proportion of Without-Project Damages by Category



1.1. Regional Economic Development (RED) Impacts

Continued erosion over the period of analysis would be expected to have some adverse impact to the local and regional economy, but the impact would likely be small. That is not to say that there will be no impact, but rather just that the impact will not be significant in the context of overall local and regional sales, jobs, and tax revenues. This is because the changes in the study area over time would not significantly adversely affect the main draw for the hotels and restaurants in and around Pillar Point Harbor, which are the view, the harbor ambiance, and the many regional recreational opportunities.

3. PROJECT MEASURES & ALTERNATIVES

The study team considered seven measures that would potentially reduce or eliminate the future adverse impacts described in the Future Without-Project Conditions section of this report:

- Sand Placement on Surfer's Beach from Inside the Harbor (2): Maximum and medium designs considered
- Modifications to the East Breakwater (2): Notch and impermeability
- Construction of a Spur Breakwater
- Continuous Movement of Sand to Harbor Mouth
- Relocation of Highway 1

The Coastal Engineering Appendix describes in detail the analysis of several measures that could potentially reduce the future adverse impact of the breakwater. It was determined that beach fill was the only project measure that had a high likelihood of being effective at reducing the adverse economic impacts of the breakwater. For this reason, the economic analysis was limited to an evaluation of beach fill as a damage mitigation measure or alternative.

3.1 BEACH FILL ALTERNATIVES

There is estimated to be around 260,000 yd^3 of sand along and near the East Breakwater that could be available for use as beach fill (Figure 9).

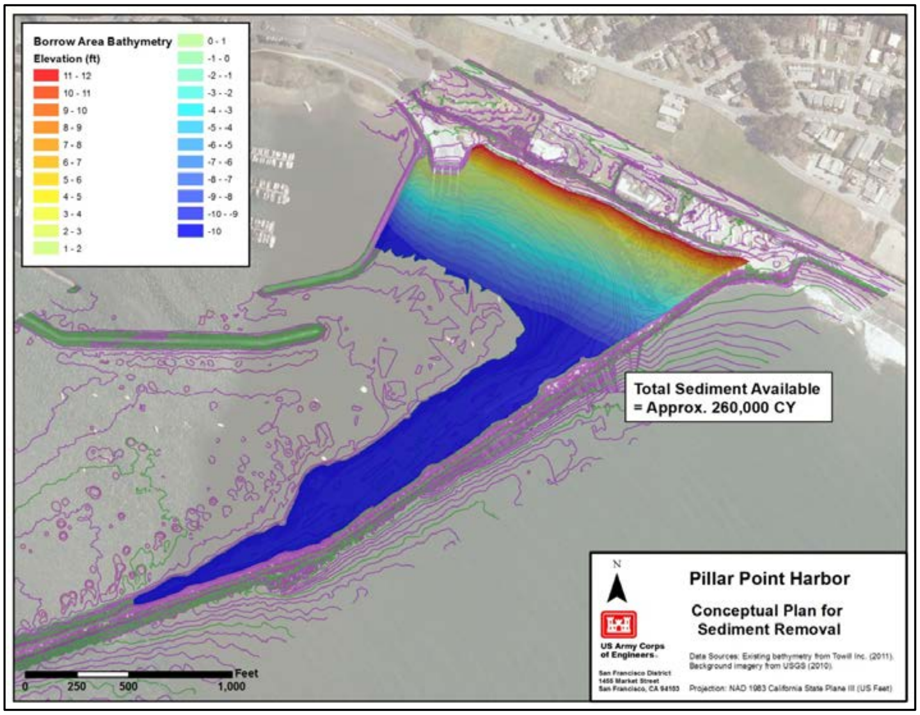


Figure 9: Conceptual plan for removing the maximum amount of available sediment

The coastal engineering analysis evaluated the effectiveness of two beach fill projects – termed "Medium Beach Fill" and "Maximum Beach Fill." The modeling found that the two projects would be similar in their effectiveness at widening the beach and reducing future erosion risk. In percentage terms, the difference in estimated project costs ($5 million versus $6.4 million – 28%) was slightly larger than the difference between the estimate for how long sand would persist in the study area for the two projects (40 years versus 50 years – 25%). The larger project would remove sediment from the boat launch area, which would have the incidental benefit of decreasing the cost of maintenance dredging that is periodically needed to ensure safe and reliable use of the boat launch. The two alternatives are described in more detail below.

3.1.1 Medium Beach Fill Alternative

The Medium Beach Fill alternative would involve a one-time placement of sand on an approximately 3,100-foot-long section of the coastline. This alternative was developed to represent a modest sand removal effort from inside the harbor, because there are potential environmental and recreational concerns associated with removing large sections of the vegetated sub-aerial beach (northeast corner of borrow area in Figure 9). Thus, this alternative was designed under the assumption that only the sand that had accumulated along the East Breakwater can be used for placement on Surfer's Beach (Figure 10).

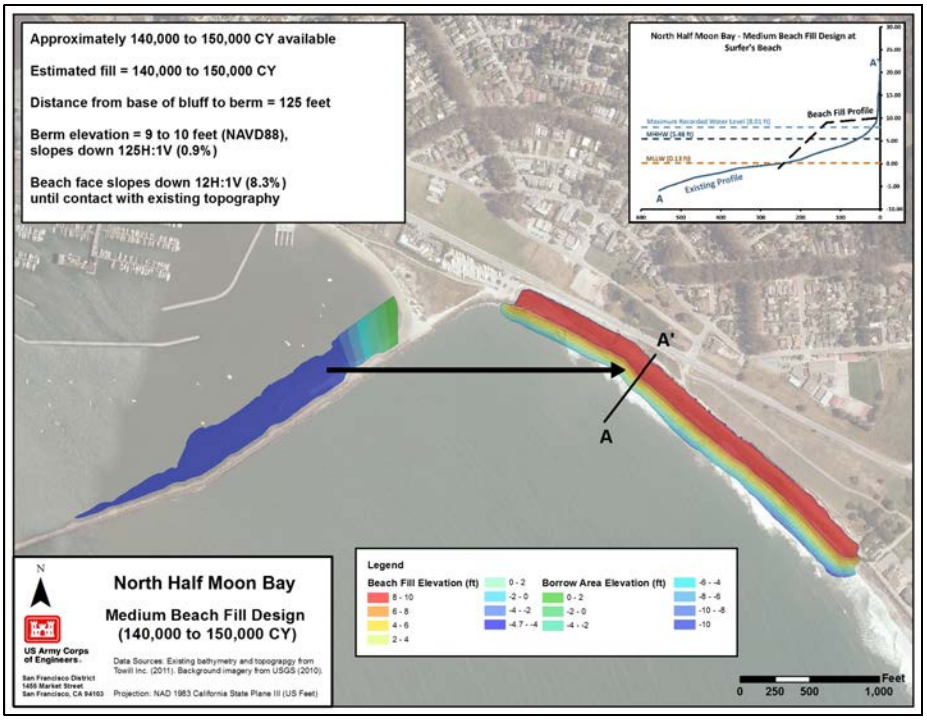


Figure 10: Medium Beach Fill Conceptual Design

Volumetric computations indicate that the shoal along the East Breakwater could yield approximately 140,000 to 150,000 yd^3 of sand if the shoal area is dredged down to a depth that approximately matches the surrounding bathymetry (-10 feet, NAVD88). A target berm crest elevation of 9 feet was used, and iterative volume computations were carried out to determine the maximum berm width that could be constructed with 140,000 to 150,000 yd^3 of sand. As a result, the Medium Beach Fill design will include a 125-foot-wide beach berm, with a beach face that will slope down at 12H:1V until it contacts the existing nearshore bathymetry.

The performance of the Medium Beach Fill alternative was simulated over the course of one year with the CMS modeling suite (more details can be found in the Coastal Engineering Appendix). The modeling results show approximately 10% to 15% of the sand eroding within one year, with the vast majority of this sand moving seaward into the adjacent nearshore zone. A simple linear extrapolation of this erosion rate (24,000 yd^3/yr) would yield a lifespan of approximately 6 years for this (mostly) visible fill placement. It is anticipated, however, that this erosion rate will decrease after an initial period of adjustment to ambient hydrodynamic conditions, so the expected lifespan of the visible placement is likely longer than 6 years. The total residence time of the placed sand in the project area could be on the order of 30 to 40 years given the net erosion rate of 4,000 yd^3/yr in the vicinity of the beach fill placement.

The preliminary cost estimate for this alternative is approximately $5 million, which in average annual terms equates to approximately $348,000 over 20 years at the FY15 applicable discount rate of 3.375%, and $472,000 at a rate of 7%.

3.2 Maximum Beach Fill Alternative

A "Maximum Beach Fill" project would move 210,000 to 240,000 yd^3 of sand from inside the harbor to Surfer's Beach and Vallejo Beach. Like the smaller beach fill alternative, the sand would be spread across approximately 3,100 feet of beach. The crest elevation of the beach fill near the toe of the bluff would be the same as for the smaller beach fill alternative, but the larger volume would mean a berm width of 180 feet as compared to 125 feet for the smaller beach fill. The visible portion of the sand placement is expected to last 7 or so years under typical conditions, and sand remaining in the nearshore could mean that some amount of erosion reduction benefits persist for as long as 50 years.

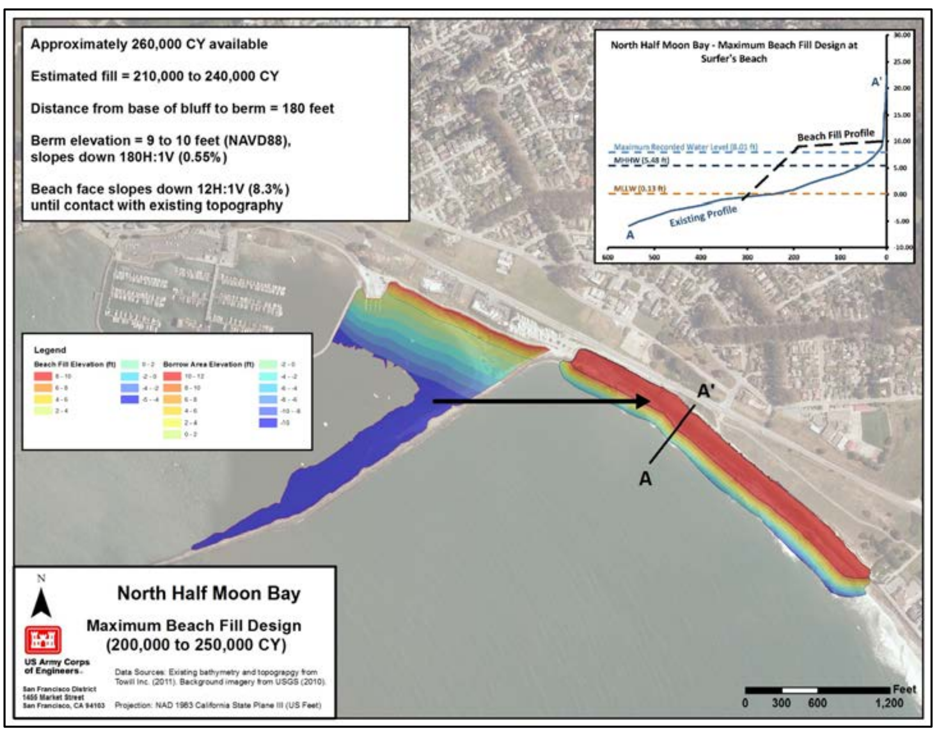


Figure 11: Alternative 1 – Maximum Beach Fill Conceptual Design

One benefit that applies exclusively to this larger beach fill project is a reduction in future dredging costs incurred by the Harbor District to ensure safe and reliable use of the boat launch. According to the Harbor District, historically they have had to dredge the boat launch area every 7 or so years at a cost of up to $530,000. The Maximum Beach Fill alternative would remove sediment from in front of the boat launch, which would ostensibly eliminate the need for at least one dredging cycle within the harbor. This alternative is estimated to cost $6.4 million. Amortized over 20 years at the current water resources discount rate this equates to an average annual cost of $445,000, and at a discount rate of 7% equates to $605,000.

4. ECONOMIC JUSTIFICATION – BEACH FILL ALTERNATIVES

This section describes the estimated NED benefits of the Medium and Maximum Beach Fill alternatives as described in Chapter 3 of this economic analysis and in the Coastal Engineering Appendix. For reasons stated previously, it was decided to limit the detailed with-project analysis to these two beach-fill alternatives. A project is economically justified if its NED benefits equal or exceed the total NED cost of the project.

4.1 MEDIUM BEACH FILL

The implementation of this beach fill project would be expected to widen the beach for at least 6 years under typical (non-El Niño) conditions. While there is a significant degree of uncertainty, it was assumed for this analysis that the visible beach created by this beach fill project would last for 9 years. This assumption was made because the estimate of 6 years assumed a linear rate of annual sand loss, which, according to the Coastal Engineering Appendix, "likely overestimates the rate of loss after the initial period of adjustment to ambient hydrodynamic conditions." A 50% increase over the modeled lifespan of the visible beach was determined to be reasonable based on the professional judgment of the study team members. Table 6 shows the economic damages for each category for each year of the twenty-year period of analysis. Compared to the without-project NED impacts (Table 5), the with-project damages to recreation are simply delayed by 9 years, which is reflected in the table by the downward shift in damages. Additional loss in land value from bluff erosion is assumed to be delayed for at least the twenty-year period of analysis since the sand is expected to persist in the nearshore for up to forty years.

Table 6: With-Project NED Impacts - Medium Beach Fill Alternative

Year	Recreation Value Lost) ($)	Land Value Lost ($)	Boat Launch Dredging Cost ($)	Annual Total Nominal Value Lost ($)	Annual Present Value Lost (2017) ($)
2017	0	0	0	0	0
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	530,000	530,000	464,102
2021	0	0	0	0	0
2022	0	0	0	0	0
2023	0	0	0	0	0
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	14,162	0	0	14,162	10,162
2027	27,975	0	530,000	557,975	387,297
2028	41,438	0	0	41,438	27,824
2029	54,551	0	0	54,551	35,433
2030	67,315	0	0	67,315	42,296
2031	79,729	0	0	79,729	48,460
2032	91,793	0	0	91,793	53,971
2033	103,508	0	0	103,508	58,872
2034	114,873	0	530,000	644,873	354,809
2035	125,888	0	0	125,888	67,002
2036	136,553	0	0	136,553	70,306
Total Present Value of Damage					1,620,533
Average Annual With-Project Damage (3.375%)					112,737

The widened beach would be expected to not just temporarily prevent additional recreation value loss, but would also increase to some unknown degree the recreation value at the beach for as long as the additional visible beach persists. This additional value was not estimated for this study, however, in large part because the project authority is concerned with the mitigation of future adverse impacts and not with the creation or enhancement of recreation value.

Table 7 shows the results of the benefit-cost analysis for the Medium Beach Fill alternative. The annual damages reduced is the difference between the without- and with-project average annual damages, the net benefits are difference between the average annual damages reduced and the average annual project costs, and the benefit-cost ratio is the ratio of average annual damages reduced and average annual costs. The results illustrate that the alternative is not economically justified. If analyzed assuming a higher opportunity cost of capital (greater discount rate), the benefit-cost ratio would be even lower. If the recreation benefits of the project were constrained to no more than 50% of the total benefits needed for justification, the benefit-cost ratio would be significantly lower than what is shown here.

Table 7: Benefit Cost Analysis Results - Medium Beach Fill Alternative

Without-Project Average Annual Damage	$198,510
With-Project Average Annual Damage	$112,737
Average Annual Damages Reduced	$85,773
Average Annual Costs	$348,000
Annual Net Economic Benefits	**($262,227)**
Benefit-Cost Ratio (3.375%)	**0.25**

4.2 MAXIMUM BEACH FILL

The implementation of this beach fill project would be expected to widen the beach for at least 7 years under typical (non-El Niño) conditions. While there is a significant degree of uncertainty with respect to how long the visible beach would persist, it was assumed for this analysis that the visible beach created by this beach fill project would last for 11 years. Following the same logic as was used for the Medium Beach Fill alternative, the lifespan of the visible beach was assumed to be approximately 50% longer than the modeling indicated. Additional loss in land value from bluff erosion is assumed to be delayed for at least the twenty-year period of analysis since some portion of the sand is expected to persist in the nearshore for up to fifty years.

As with the Medium Beach Fill, the widened beach under the Maximum Beach Fill alternative would prevent additional recreation and land loss in the study area. In contrast to the smaller beach fill alternative, however, the sand would be taken from along the East Breakwater and from the area in front of the boat launch. This would very likely have the incidental benefit over the period of analysis of significantly reducing the cost of emergency and maintenance dredging that is periodically undertaken by the Harbor District to ensure full, safe, and reliable use of the boat launch for commercial and recreational boaters and fishermen. While it is not known how many dredging events the removal of sand as part of the project would prevent, because the volume of sand removed under this alternative would be so large, it was assumed for the benefit-cost analysis that no emergency or maintenance dredging would be required for the entire twenty-year period of analysis. Table 8 shows the economic damages for each category for each year of the twenty-year period of analysis. Compared to the without-project NED impacts shown in Table 5, the with-project damages are simply delayed by 11 years, which is reflected in the table by the downward shift in damages.

Table 8: With-Project Average Annual Damages - Maximum Beach Fill

Year	Recreation Value Lost) ($)	Land Value Lost ($)	Boat Launch Dredging Cost ($)	Annual Total Nominal Value Lost ($)	Annual Present Value Lost (2017) ($)
2017	0	0	0	0	0
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	0	0	0
2021	0	0	0	0	0
2022	0	0	0	0	0
2023	0	0	0	0	0
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	0	0	0	0	0
2027	0	0	0	0	0
2028	14,162	0	0	14,162	9,509
2029	27,975	0	0	27,975	18,171
2030	41,438	0	0	41,438	26,036
2031	54,551	0	0	54,551	33,157
2032	67,315	0	0	67,315	39,579
2033	79,729	0	0	79,729	45,347
2034	91,793	0	0	91,793	50,505
2035	103,508	0	0	103,508	55,091
2036	114,873	0	0	114,873	59,143
Total Present Value of Damage					336,538
Average Annual With-Project Damage (3.375%)					23,412

Delay in Damage *Delay in Damage*

Table 9 shows the results of the benefit-cost analysis for the Maximum Beach Fill alternative. The annual damages reduced is the difference between the without- and with-project average annual damages, the net benefits are difference between the average annual damages reduced and the average annual project costs, and the benefit-cost ratio is the ratio of average annual damages reduced and average annual costs. The results illustrate that, like the Medium Beach Fill alternative, this alternative is not economically justified. If analyzed assuming a higher opportunity cost of capital (greater discount rate), the benefit-cost ratio would be even lower. If the recreation benefits of the project were constrained to no more than 50% of the total benefits needed for justification, the benefit-cost ratio would be lower than what is shown here.

Table 9: Benefit-Cost Analysis Results – Maximum Beach Fill Alternative

Without-Project Average Annual Damage	$198,510
With-Project Average Annual Damage	$23,412
Average Annual Damages Reduced	$175,098
Average Annual Costs	$445,000
Annual Net Economic Benefits	**($269,902)**
Benefit-Cost Ratio (3.375%)	**0.39**

4.3 Sensitivity Analysis

Uncertainties abound in this analysis. The future rate of erosion, the human response to changed conditions in the area, and the effectiveness and duration of the beach fill projects are all unknowable and involve a great amount of uncertainty. The analysis relies on complex and detailed coastal modeling but also to a large extent on professional judgment, local knowledge, and anecdotal evidence. Using what are considered the most-likely, middle-of-the-road future scenarios and assumptions, neither of the beach fill projects is economically justified.

The total without-project average annual damages are less than the average annual cost of each of the project alternatives, which means that neither would be economically justified by changing assumptions or data related to the with-project effectiveness. For the benefits to exceed the costs, the without-project damages would have to be approximately twice as large as estimated, and the beach fill projects would essentially have to eliminate all damages over the period of analysis.

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