Encinitas-Solana Beach Coastal Storm Damage Reduction Feasibility Study

San Diego County, California

Appendix E

Economics

U.S. Army Corps of Engineers
Los Angeles District

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EXECUTIVE SUMMARY

The study area is located along the Pacific Ocean coastline in San Diego County, California. The City of Encinitas is the northern boundary of the study area, approximately 10 miles south of Oceanside Harbor, and 17 miles north of Point La Jolla. The southern boundary of the study area is the southern end of the City of Solana Beach. The study area coastline consists primarily of denuded beaches and coastal bluffs from 30 to 100 feet high with the exception of San Elijo Lagoon, a low-lying area about one mile in length near the center of the study area.

Beach erosion and bluff failures have been ongoing problems in both Encinitas and Solana Beach. As the beaches narrow, sensitive sandstone bluffs are exposed to crashing waves, which carve notches into the bluffs. Bluffs affected by these notches are then prone to episodic collapse. Consequently, residential properties on the upper bluff experience land loss and property owners are required to spend significant resources to try to protect their property otherwise the structures will eventually be lost. In addition to this problem, the study area also has high demand for recreation while the narrow beach area combined with bluff failures represent a significant safety issue for those recreating. Opportunities exist to reduce bluff failures and/or mitigate the danger from those failures. Both cities employ lifeguards year-round that encourage recreating away from the base of the bluffs. Unfortunately, deaths and injuries have continued to occur from bluff instability and failures. Other opportunities exist to reduce coastal processes that cause bluff failures, and therefore reduce National Economic Development (NED) costs and damages, as well as threats to life and safety. Certain alternatives which increase the size of the beach area can provide significant recreational benefits as well.

The without project conditions are forecasted to include two distinct responses to ongoing land loss: either armor the parcel with a seawall to prevent structure collapse or fail to armor the parcel and allow structure collapse. The damages under these two scenarios were weighted and combined to determine the expected without project damages. Residual sloughing at the bluff top edge was accounted in those expected damages. Based on the findings from the without project conditions analysis, approximately 2.9 miles of the study area was determined to have sufficient economic damages and suitable coastal characteristics to justify construction of project alternatives. That includes 1.5 miles of coastline within Encinitas—labeled Segment 1—and 1.4 miles of coastline within Solana Beach—labeled Segment 2—and both sites were evaluated independently for project alternatives. Among the array of alternatives proposed, economic analysis was performed on four hard and soft-structural alternatives. These include constructing a series of seawalls at the base of the coastal bluffs, placing notch fill in all seacaves, placing notch fill in combination with sand on the beaches to enhance coastal storm damage protection, and placing sand only. When evaluating sand placement only or when paired with notch fill, we analyzed sand placement that would initially extend the beach in 50-foot increments on average from 50 feet to 200 feet mean sea-level (MSL) within Encinitas and 50 feet to 400 feet mean sea-level within Solana Beach. In tandem with incremental increases to the beach footprint from sand placement, we also evaluated delaying nourishment cycles from 2 to 16 years leading to a large number of possible combinations to aid in selecting the tentatively recommended plans among hard and soft-structural alternatives.

Among this array of alternatives the NED Plan for Segment 1 (Encinitas) is sand placement extending the mean sea-level beach 100 feet on average immediately after fill placement and nourishing every five years. The NED Plan for Segment 2 (Solana Beach) is sand placement extending the beach 200 feet MSL and nourishing every 13 years. These are the results under the low/historic sea-level rise scenario. We also evaluated the high sea-level rise scenario and found the NED Plan was unchanged at Segment 1 but altered to nourish every 14 years at Segment 2 while extending the beach 300 feet MSL. The net annual NED benefits for Segment 1 would be $1.20 million and $860,000 for Segment 2 ($1.70 million and $1.20 million under the high SLR scenario, respectively). The tentatively recommended plans for Segment 1 and Segment 2 are the NED Plans.

The project alternatives were analyzed under three distinct scenarios in addition to sea-level rise to determine whether identification of the NED Plan at each segment was sensitive to the weighting used to establish without project damages, dredging cost increases at the secondary borrow site, and cost savings from joint nourishments at each segment.[1] Our analysis revealed that identification of the NED Plans was insensitive to the weighting used to establish without project damages, was insensitive to dredging cost increases at the secondary borrow site, but Segment 2 only was sensitive to cost savings from joint nourishments. Specifically, if nourishments can predictably occur concurrently at each segment, the resulting cost savings would alter the NED Plan at Segment 2 to nourish every 10 years rather than every 13 years (the “footprint” or average width to extend the beach would remain unchanged at 200 feet MSL). The NED Plan at Segment 1 would be unaltered by synchronized nourishments.

The tentatively recommended plans were evaluated in the Regional Economic Development (RED) and Other Social Effects (OSE) accounts. The No Action Plan was also evaluated in the OSE account. Results from the RED analysis show that the tentatively recommended plans would produce moderate income growth and job development to the greater San Diego area. The benefits from increased economic activity related to recreation would be more substantial but still relatively moderate compared to the gross regional product within the greater San Diego, the smallest economic unit of measure for the RED analysis. The regional economic impact to the communities of Encinitas and Solana Beach would likely be more profound and substantial due to increased hotel occupancy and related spending on local goods & services; however, we are not able to quantify those positive impacts at the community-level.

Evaluation under the OSE account revealed four dimensions that would be positively impacted by implementing the tentatively recommended plans—life-safety, social vulnerability & resiliency, displacement to population, and community cohesion & social connectedness. We found strong evidence that life-safety risks would be significantly reduced by implementing the tentatively recommended plans compared to the No Action Plan. Existing beach widths are typically narrow with limited “dry sand” areas closer to the bluffs or only “wet sand” in some areas. The tentatively recommended plans reduce life-safety risks primarily because the affected areas would be subject to less frequent episodic bluff collapse while at the same time beach visitors would be able to utilize wider beaches to keep a safe distance from the bluffs (currently 2.8 to 3 million visits occur in the study area annually). At the same time social vulnerability & resiliency, displacement to population, and community cohesion & social connectedness would all benefit moderately compared to the No Action Plan.

[1] At this feasibility stage we are unable to determine if synchronizing nourishments at Segment 1 &2 would occur in practice due to differences in erosion rates at each segment and unknown financial and political constraints during the 50-year study period; therefore, the NED Plan was identified assuming only the initial fill could occur jointly. However, if joint nourishments could occur the savings would be substantial.

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1 INTRODUCTION

This report documents the National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE) analyses of storm related damages to shoreline property in the cities of Encinitas and Solana Beach, San Diego County, California, and the benefits derived from various protection alternatives, and the findings from these analyses.

1.1 Study Authority

This study was authorized by a May 13, 1993 Resolution of the House Public Works and Transportation Committee that reads as follows:

"*Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that, in accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army, acting through the Chief of Engineers, is directed to make a survey to investigate the feasibility of providing shore protection improvements in and adjacent to the City of Encinitas, California, in the interest of storm damage reduction, beach erosion control, and related purposes*."

Additional authorization was given in an April 22, 1999 Resolution of the House Committee on Transportation and Infrastructure that reads as follows:

> *"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army, in accordance with Section 110 of the River and Harbor Act of 1962, is hereby requested to conduct a study of the shoreline along the City of Solana Beach, San Diego County, California, with a view to determining whether shore protection improvements for storm damages reduction, environmental restoration and protection, and other related purposes are advisable at the present time."*

1.2 Study Purpose and Scope

The purpose of this economic appendix is to present a feasibility-level investigation to determine the average annual coastal storm-related damage to shoreline properties from the City of Encinitas southward through the City of Solana Beach under without and with-project conditions, determine with-project costs and benefits, analyze this information to determine the NED plan, and perform RED and OSE analyses. Storm-related damage is estimated in this analysis following the guidelines and procedures established for the assessment of National Economic Development (NED benefits in the *Economic and Environmental Principles for Water and Related Land Resources Implementation Studies*, February 3, 1983; the *Planning Guidance Notebook (Appendix E: Section IV, Hurricane and Storm Damage Protection*, ER 1105-2-100, 22 April 2000); and the *National Economic Development Procedures Manual – Coastal Strom Damage and Erosion*, IWR–91–R-6, dated November 1991. RED and OSE analyses follow the procedures and guidelines set forth in *Regional Economic Development Procedures Handbook*, 2011-RPT-01 and *The Planning Guidance Notebook*, ER 1105-2-100.

1.3 Study Area

The study area is located along the Pacific Ocean coastline in San Diego County, California as shown in see **Figure 1.3-1**. The City of Encinitas is the northern boundary of the study area, approximately 10 miles south of Oceanside Harbor, and 17 miles north of Point La Jolla. The southern boundary of the study area is the southern end of the City of Solana Beach. The Encinitas shoreline, about 6 miles long, is bounded by Batiquitos Lagoon to the north and to the south by San Elijo Lagoon. Major portions of the shoreline consist of narrow sand and cobble beaches fronting near-shore bluffs. The southern segment at Cardiff (4,920 feet) is a low-lying barrier spit fronting the San Elijo tidal lagoon. The study area continues through 1.7 miles of coastline in the City of Solana Beach for a total study area length of approximately 7.7 miles. The distinguishing characteristic of the study area is cliffs that rise to typical heights 100 feet above the Pacific Ocean. Storm-induced waves erode the bluff base leading to episodic bluff failures and bluff-top land loss that poses a threat to residential and commercial structures.

Figure 1.3-1 Encinitas- Solana Beach Study Area Map

1.4 Problems & Opportunities

Beach erosion and bluff failures have been ongoing problems in both Encinitas and Solana Beach. As the beaches narrow, sensitive sandstone bluffs are exposed to crashing waves, which carve notches into the bluffs (**Figure 1.4-1**). The bluffs affected by these notches are then prone to episodic collapse. Consequently, residential properties on the upper bluff experience land loss and property owners are required to spend significant resources to try to protect their property otherwise the structures will eventually be lost (**Figure 1.4-2**). In addition to this problem, the study area also has high demand for recreation while the narrow beach area combined with bluff failures represent a significant safety issue for those recreating. This risk, which is represented by repeated bluff failures in the study area, has been documented by the cities of Encinitas and Solana Beach. This documentation was used to create **Table 1.4-1** which lists major bluff failures since 2000 and consequences for those involved.

Opportunities exist to reduce bluff failures and/or mitigate the danger from those failures. Both cities employ lifeguards year-round that encourage recreating away from the base of the bluffs. Unfortunately, deaths and injuries have continued to occur from bluff instability and failures as shown in **Table 1.4-1**. Other opportunities exist to reduce coastal processes that cause bluff failures, and therefore reduce NED costs and damages, as well as threats to life and safety. Certain alternatives which increase the size of the beach area can provide significant recreational benefits as well. There are two major engineering methods, soft-structural and hard-structural, to reduce storm damage. The soft-structural method includes beach fills, sand scraping, or sand bypassing/recycling. Hard structures consist of the sand retention features that impede alongshore sand movement (e.g., groins, jetties, artificial reefs, or detached breakwaters), and the storm-protective features, which directly prevent shoreline or upland erosion (e.g., coastal armoring, seawalls or revetments).

Figure 1.4-1 Wave attacks to study area bluffs

Figure 1.4-2 Example of damage to structure and land loss at bluff top edge

Table 1.4-1 Major Bluff Failures since 2000

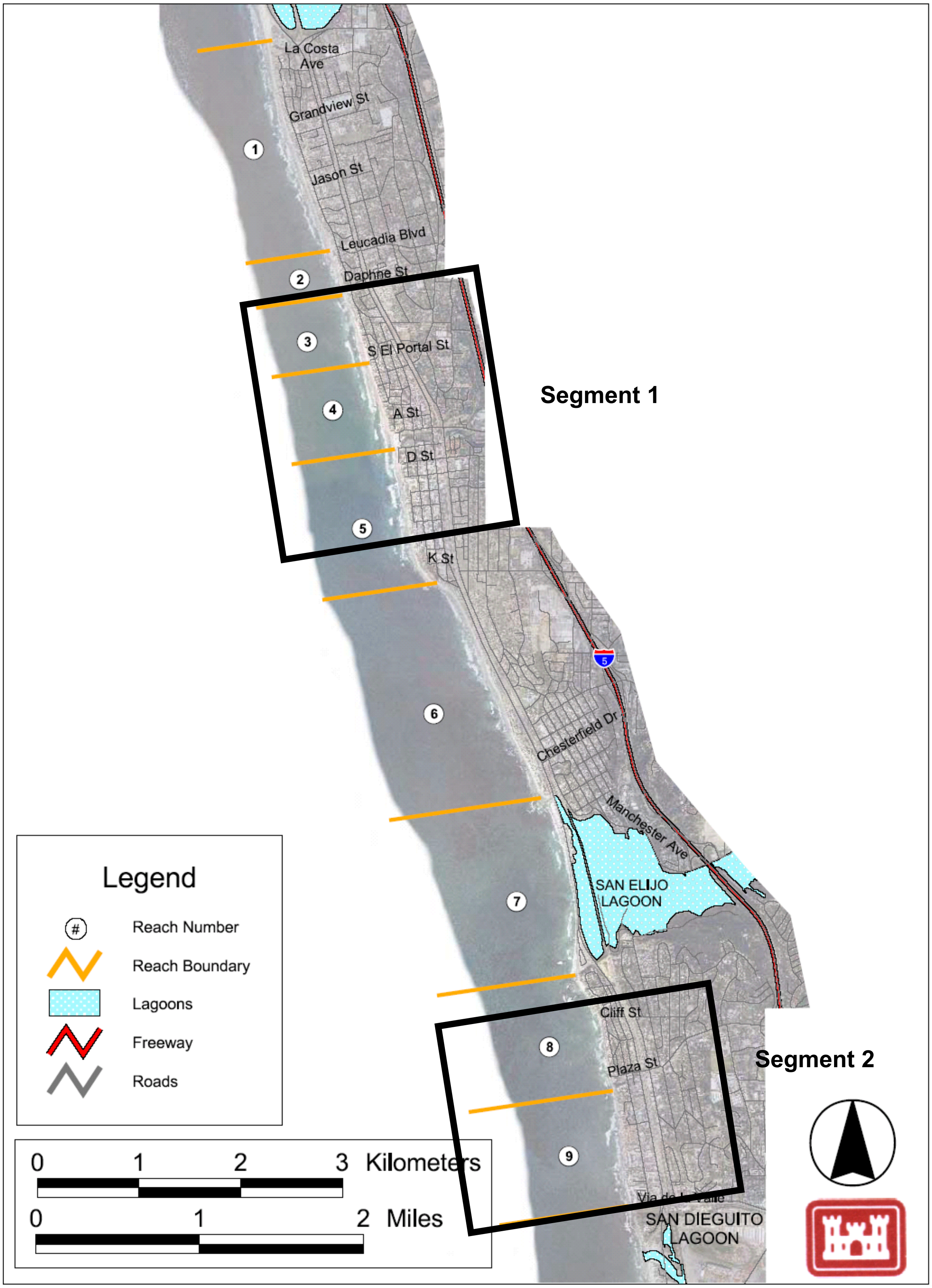
January 2000	A woman was killed in a bluff collapse while sitting on the beach in Leucadia.
January 2001	Four bluff-top homes in Leucadia (south of Beacon's Beach) were deemed unsafe by the City of Encinitas due to unstable and cracked bluffs. Large rocks were piled at the base of the bluffs to protect the cliffs from large surf and tides.
February 2001	A bluff collapse destroyed a portion of the trail at Beacon's beach off Neptune Avenue in Leucadia.
May 2001	In Solana Beach an adjoining bluff gave way as a neighbor was trying to reinforce it by driving steel pilings in to the bluff. A concrete slab from patio slid down toward the shore, taking with it a workman who had been standing on it. The bluff collapse also claimed part of an additional adjacent yard and rendered a portion of the house unsafe for occupancy. Owners of the three parcels obtained an emergency permit to build a 100-foot long, 35-foot high seawall.
July 2002	A man camping overnight in a small cave at South Carlsbad State Beach was killed when a portion of a bluff collapsed.
July 2002	About 80 tons of sandstone, rocks, and boulders fell onto the beach as a 75-foot wide by 12-foot high section of bluff collapsed just south of Fletcher Cove Park, a major recreation area.
September 2002	Major bluff failure; Potential threat; Approx. 4 cu. yd. boulders, aluvium, and iceplant debris cascaded onto the beach
December 2002	Major bluff failure; Potential threat; 10 cu. yds of earthen debris and concrete; Posts, concrete footings, and other wooden retaining devices precarious; Continuation of already badly eroded area

February 2003	Major bluff failure; Potential threat; Approx. 3 cubic yards, in and around existing sea cave plugs, large portion of bluff un-supported and in danger of collapse.
February 2003	Major bluff failure; 3rd Major failure 100 yards south of previously reported area; 3 cu. yd. of solid sandstone composition, debris and boulders.
November 2003	Major bluff failure; N. of cove, water flowing mid-bluff, report from Geosoils on file
March 2004	Major bluff failure; Upper and lower bluff failure over 2 cu. yds, dangling posts/rope
June 2004	Major, potential threat from overhang patio. Signs posted. Geosoils evaluating all.
July 2004	Major bluff failure; Directly S. of other failures, approx. 15' X 6' X 4'. Potential threat from overhang patio. Signs posted. Geosoils report on file. On or about 6/30, contractor removed wall and concrete deck that had become undermined. 7/6, u-channel posts and "Bluff Warning" signs installed
November 2004	Major bluff failure; Approx. 6' X 5' X 3', Initial failure was contained by protective shoring and fence system; subsequent bluff failure resulted in damage to shoring system.
November 2004	Major bluff failure; Potential threat; 2' X 8-10' portion of block wall separated from patio, large upper bluff failure, undermined a portion of concrete patio adjacent to rear of home. Overhanging portion to be removed and report to be updated.
November – December 2004	Major bluff failure; Approx. 22' X 5' X 3', bluff debris along with length of black pip, portion of fence dangling. Letter sent to owners 11/3.
November 2004	Major bluff failure; Upper bluff failure N. of Cove, area at top closed due to undermined fence along edge. Fence to be relocated and bench will be removed from outlook point, SW of Community center building.
April 2005	Major bluff failure; Although a large amount of material was deposited on the beach, it occurred from a localized area. Surrounding bluff does not appear in imminent danger of further failure.
June 2005	Major Upper bluff failure 2 cubic yards or more witnessed by lifeguard personnel.
August 2006	Major bluff failure; Potential threat; North of Seascape Sur access at reoccurring failure site; Geotechnical attached
July 2007	Significant failure, geotechnical evaluation on-going
August 2007	Major bluff failure; pre-existing failure site.
February 2008	A landscaper was trapped and injured when a retaining wall atop beach bluffs in Encinitas collapsed.
May 2009	Major bluff failure; pre-existing failure site.
January 2010	Debris from private access staircase scattered across 1/2 mile of Beach - referred to Code Enforcement
March 2010	Major bluff failure, photos taken, caution tape placed. On 3/12/2010 confirmed that the issue was resolved to satisfaction of Engineering Department
March 2010	Major bluff failure, photos taken, caution tape placed. On 3/17/2010 confirmed that the issue was resolved to satisfaction of Engineering Department
April 2010	300-350 cubic yards detached from lower bluff, fell to beach.

July 2010	Minor bluff failure, photos taken. Existing signage to be maintained by Marine Safety.
August 2010	Lifeguards and firefighters rescued an injured man who was found on the beach at the bottom of a 30-foot cliff at the end of E Street. He suffered fractures to his legs. The victim probably rolled the first sloped 60 or 70 feet before the 30-foot vertical drop-off. Signs warn visitors of the unstable cliffs.
December 2010	A bluff collapsed across two parcels damaging the existing seawall at the bluff base. An Encinitas lifeguard official subsequently warned, "Anybody that's walking anywhere on the North [San Diego] County beaches should be extremely aware of the danger and stay away from the cliffs."
January 2011	The southbound portion of San Elijo Avenue at Dublin Drive and Cornish Drive closed because of bluff collapses in mid-December leading to approximately 30 days of partial road closure.
January 2011	Major bluff failure (2 cubic yards or more). Lifeguards taped off area, photos taken. On 2/9/11 City staff member, Dan Goldberg confirmed the reported issue had been resolved to the satisfaction of the Engineering Department. The area at that time was reported as "currently appears stable. Marine Safety should continue to monitor the area and report any changes to the Engineering Department".

1.5 Study Area Delineation

To better characterize the coastal bluff and shoreline morphology as well as oceanographic conditions the study area was separated into nine reaches. Each reach was surveyed for the same characteristics including, but not limited to, parcel area, structure value, structure setback distance from bluff edge, presence of staircases, presence of seawalls, and toe notch depths at the base of the bluff. Without project analysis and plan formulation was performed on all reaches; however, through that process only reaches 3-5 and 8-9 were identified for viable alternatives primarily because of susceptibility to future bluff failures, the existence of viable alternatives to address this problem, and sufficient economic value to justify those alternatives. Alternatives were formulated for Segment 1, which is approximately 7,800 feet in length and resides within reaches 3-5, and Segment 2, which is approximately 7,200 feet in length and consists of reaches 8 and 9. **Figure 1.5-1** shows the delineation of the study area reaches as well as Segments 1 and 2. As noted above, these segments were determined to be those with the greatest problems, opportunities, and potential for federal interest. The detailed description of each reach can be found in the Integrated Report (**Section 1.8.1**) and the reasons why the specific reaches were selected for detailed evaluation and plan formulation can be found below.



1
2 **Figure 1.5-1 Reach Delineation**
3

1.5.1 Reach 1

This reach is protected by many small seawalls, crib walls, masonry block structures, and concrete structures placed at the bottom and on the face of the bluff. Project alternatives were not proposed for this reach since the seacliffs along Reach 1 are comparatively stable because the bluff base is resistant to erosion, it has a relatively flatter upper bluff slope, vegetation cover, and presence of a continuous protective cobble berm.

1.5.2 Reach 2

This reach is protected by a substantial crushed rock slope and private seawalls constructed in the middle of the reach. Project alternatives were not proposed for this reach because of instability at the upper bluff as evidenced by severe landslides throughout the reach as opposed to instability at the base of the bluff due to toe notch erosion typical of the remaining reaches.

1.5.3 Reach 3

Reach 3 was evaluated for project alternatives because of the substantial number of unprotected parcels and the propensity for continued episodic bluff collapse.

1.5.4 Reach 4

Along the entire reach, except for the southern portion of the reach immediately adjacent to Moonlight Beach, an approximate 2 to 4- foot notch exists at the base of the bluff where notch protection measures have not been instituted. The prevalent notch development coupled with the already over-steepened upper bluff zone is prone to future bluff failures, some of which could be catastrophic. Consequently, Reach 4 was evaluated for project alternatives.

1.5.5 Reach 5

Large notches form sea caves that are often large enough to crawl and sometimes walk into. Due to the deteriorated nature of the bluff face along this reach, numerous bluff top failures have occurred in the last few years. As a result Reach 5 was evaluated for project alternatives.

1.5.6 Reach 6

Although a small number of private homes occupy the northern end, most of the reach segment contains the Highway 101 right-of-way and the San Elijo State Beach. A robust rock revetment was installed to protect the highway from future storm and tidal impacts in 1961. The southern portion of the reach is backed by the San Elijo State Beach Campground and contains non-engineered riprap that protects five beach access points. Given the protective features already in place and the small number of structures, Reach 6 was not evaluated for project alternatives.

1.5.7 Reach 7

This reach possesses a narrow sandy and cobble spit beach backed by Highway 101, which is protected by a non-engineered rock and concrete rubble revetment. The close proximity of the restaurants located in the northern section of the reach to the water’s edge has rendered and will continue to render them susceptible to periodic episodes of incidental inundation and structural damage. Moreover, severe storms also cause flooding along Highway 101. Reach 7 was evaluated for coastal storm surge (flooding) damages rather than bluff retreat/erosion.

1.5.8 Reach 8

The bluff top is fully developed throughout the reach with large multi-story private residences. The cliffs are approximately 80 feet high and presently the shoreline may be characterized as consisting of a narrow to non-existent sandy beach backed by high, wave cut cliffs. During the 1997-1998 winter months, sand was stripped away and the bluff face became directly exposed to wave abrasion. Severe toe erosion subsequently developed and bluff failures have been continuously reported since that event. Presently, notches, on the order of 4 to 8 feet, and large seacaves exist throughout the lower bluff region. Consequently, Reach 8 was evaluated for project alternatives.

1.5.9 Reach 9

Repeated wave exposure has resulted in the continued erosion of the bluff face and the associated recession of the upper bluff. It is expected that without corrective action, the magnitude of the upper bluff recession will most likely accelerate in this reach until the upper bluffs have fully equilibrated with the ongoing erosion occurring at the base of the bluff. Reach 9 was evaluated for project alternatives.

1.5.10 Del Mar Reach

This 1,510 ft stretch of shoreline lies immediately south of Solana Beach within the city of Del Mar and could benefit from soft-placement project alternatives, such as beach nourishment, evaluated for Reach 9. The beach width varies throughout the reach from 65 to 130 feet. There are functional and decorative fences and paved walkways at the edge of the bluff, three residential structures at varying distances from the bluff edge, and public access at the southern end. There are no coastal protection structures in this reach. This reach is included in the benefits calculations for soft-placement alternatives only.

2 DEMOGRAPHICS

2.1 Introduction

The cities of Encinitas and Solana Beach, California are located 25 and 23 miles north of San Diego, respectively. Both municipalities are located in San Diego County and were incorporated in 1986. Both cities are located along South Coast Highway 101 and are bordered on their western sides by the beaches of the Pacific Ocean. The communities are convenient to the metropolitan areas of both San Diego and Los Angeles, and are just 35 miles north of the United States border with Mexico.

2.2 Population

Approximately 60% of Californians live in Southern California, a distribution that has not changed significantly in the past four decades. Almost 75% of Californians live in the coastal regions, with the inland-dwelling proportion increasing steadily over the past three decades. The 2000 Census reported that the San Diego region (San Diego and Imperial Counties) of southern California maintains a population roughly equivalent to the State of Iowa within a land area (8,375 square miles) that is approximately the size of Massachusetts.

The population of San Diego County in 2010 comprised 8% of the population of California; the county population was 3,095,313 and the State population was 37,253,956. As shown in **Table 2.2-1**, the county experienced a net population increase of 10% between 2000 and 2010. This rate of growth is the same rate as California (10.0%) and the United States (9.7%) during the past decade. Through 2050 the State of California is projected to increase population by 59%, which is a faster rate of population growth than the United States (29%) or Encinitas and Solana Beach (29% and 24%) during that same period.[2]

Table 2.2-1 Historical and Projected Population

	1980	1990	2000	2010	2050	% Change (2000-2010)
Encinitas	n/a[3]	55,386	58,014	59,518	76,659	2.6%
Solana Beach	n/a[4]	12,962	12,979	12,867	15,942	-0.9%
San Diego County	1,861,846	2,498,016	2,813,833	3,095,313	4,384,867	10.0%
California	23,667,764	29,760,021	33,871,648	37,253,956	59,507,876	10.0%
United States	226,549,000	248,709,873	281,421,906	308,745,538	398,528,000	9.7%

The City of Encinitas has increased in population by 1,504 between 2000 and 2010. Total migration over that period is unknown but likely modest. The City of Solana Beach has maintained a fairly stable population since at least 1990 when there were just under 13,000 residents. The median age of the population of Solana Beach is 45.1 years and the median age

[2] Refer to Table 2-9 below.
[3] Encinitas and Solana Beach were not incorporated municipalities in 1980. They became incorporated in 1986.
[4] Ibid.

in Encinitas is 41.7 years. This compares to San Diego County's median age of 35.0 years, and the median age for California of 34.7 years. Solana Beach has a higher percentage of the population above age 65 (19%), compared to Encinitas (12%), and the State of California and San Diego County (both 11%). Solana Beach also has a lower percentage below age 18 (16%), compared to Encinitas (19%), and San Diego County (24%).

The population of the City of Encinitas is 75% White/Caucasian. Minority populations include: Asian (4%); American Indian & Alaskan Native (<1%); African American (<1%); Native Hawaiian (<1%); and other (<1%). Approximately 18% of the population is of Hispanic or Latino heritage.

The population of the City of Solana Beach is 74% White/Caucasian. Minority populations include: Asian (4%); American Indian & Alaskan Native (<1%); African American (<1%); Native Hawaiian (<1%); and other (<1%). Approximately 19% of the population is of Hispanic or Latino heritage.[5]

2.3 Housing

Encinitas has 23,664 households and the average household size is 2.69 persons. Solana Beach has 5,773 households and the average household size is 2.34 persons. According to the 2010 US Census data on housing tenure, 46% of San Diego County households are renters compared to 37% in Encinitas and 40% in Solana Beach (see **Table 2.3-1**). Among occupied units, 11% are owned free and clear of any mortgage or loan in San Diego County, while that figure is 11% in Encinitas and 13% in Solana Beach. Among the two largest populations in Encinitas and Solana Beach, White and Latino/Hispanic, housing tenure within the white population is predominantly owner-occupied (65-69%), while tenure within the Latino/Hispanic population is predominantly renter-occupied (56-75%). Neither population has a significant share of owner-occupied units held free-and-clear of any mortgage (7-13%)[6], as shown in **Table 2.3-2**. A smaller share of households have children in the study area when compared with county and state averages, which appears consistent with age demographics presented earlier in this section. The share of households with children is lowest in Solana Beach (22%), and higher in Encinitas (27%) but still below county and state levels, which are 31% in San Diego County and 33% in the State of California.

Table 2.3-1 Housing Tenure by Family Type

	Encinitas		Solana Beach	
Housing Tenure	Household w/ Children	Household Adult only	Household w/ Children	Household Adult only
Owner-occupied	19%	44%	14%	47%
Renter-occupied	9%	28%	9%	31%
TOTAL[7]	27%	73%	22%	78%

[5] The data for Ethnicity and Age for Encinitas, Solana Beach, and San Diego County was taken from San Diego Association of Governments (SANDAG) 2010 Population Characteristics. The data for the State of California was taken from the 2010 U.S. Census.
[6] 2010 US Census
[7] Percentages may not add to total due to rounding.

Table 2.3-2 Housing Tenure by Ethnic Group

	Encinitas		Solana Beach	
Housing Tenure (within each ethnic group)	**White**	**Latino/ Hispanic**	**White**	**Latino/ Hispanic**
Owner-occupied with lien	58%	37%	52%	20%
Owner-occupied free & clear (no lien)	11%	7%	13%	6%
Renter-occupied	31%	56%	35%	75%
TOTAL	100%	100%	100%	100%

2.4 Employment

In San Diego County, the unemployment rate for December 2011 is 8.9%, while the cities of Solana Beach and Encinitas have lower unemployment rates of 6.0% and 6.3%, respectively. These rates of unemployment are all more favorable than the statewide rate of 11.1%.[8] For those employed, **Table 2.4-1** indicates the predominant sectors of employment for residents of the study area, according to the Profile of Selected Economic Characteristics: 2009 published by the U.S. Census Bureau. As shown in the table, the service industry is important in all regions associated with the study area. The service industry includes: information; professional, scientific, management, administrative and waste management services; educational, health and social services; arts, entertainment, recreation, accommodation and food services; public administration; and other services. **Table 2.4-1** also shows the share (%) of employment by sector. The share of employment across all industry sectors is fairly consistent between the State of California, San Diego County, and the city of Encinitas. Solana Beach is the exception—over 75% of employment is concentrated in services. These services are primarily professional, scientific, educational, and health care. Nearly all the service sector employment in Encinitas is concentrated in these same four segments.

[8] Employment Development Department of California, Labor Market Information Division

Table 2.4-1 Employment Count & Share by Industry. Share percent of employment by sector.

Industry	Encinitas	Solana Beach	San Diego County	California
All-Industry Total	31,886	6,537	1,372,121	16,550,706
Farming & Mining	176	36	9,782	338,102
Construction	2,185	274	103,380	1,224,186
Manufacturing	2,823	427	126,675	1,745,489
Wholesale & Retail Trade	4,364	714	189,218	2,412,171
Transportation & warehousing, and utilities	689	125	50,056	776,881
Finance, insurance & real estate	2,835	593	106,631	1,194,673
Services (incl public)	17,800	4,961	750,473	8,355,058
Industry	**Encinitas**	**Solana Beach**	**San Diego County**	**California**
All-Industry Total	100%	100%	100%	100%
Farming & Mining	1%	1%	1%	2%
Construction	7%	4%	8%	7%
Manufacturing	9%	7%	9%	11%
Wholesale & Retail Trade	14%	11%	14%	15%
Transportation & warehousing, and utilities	2%	2%	4%	5%
Finance, insurance & real estate	9%	9%	8%	7%
Services (incl public)	56%	76%	55%	50%

2.5 Income

In **Table 2.5-1**, summarizing income distribution by number and share of households, there is pertinent information regarding income and effective buying power by household in the study area. Approximately 76% of county workers are listed as private wage and salary workers. Government workers comprise another 15% while another 8.6% are self-employed in non-incorporated businesses. Less than 1% (0.2%) are classified as unpaid family workers. 11.7% of the county population was living below the poverty level in 2009. As shown in **Table 2.5-1** the per capita income and median household income in both study area municipalities are higher than figures for the county and state.

Table 2.5-1 Income Distribution by Number & Share of Households (2009)

Income Distribution	Encinitas	Solana Beach	San Diego County	California
Total Households	23,250	5,773	1,040,945	12,177,852
Less than $15,000	1,530 (7%)	398 (7%)	95,136 (9%)	1,248,099 (10%)
$15,000 – $24,999	1,245 (5%)	528 (9%)	90,109 (9%)	1,141,560 (9%)
$25,000 - $34,999	1,457 (6%)	585 (10%)	92,016 (9%)	1,118,718 (9%)
$35,000 – $49,999	2,420 (10%)	594 (10%)	133,991 (13%)	1,541,545 (13%)
$50,000 - $74,999	3,292 (14%)	488 (8%)	185,522 (18%)	2,164,891 (18%)
$75,000 or more	13,306 (57%)	3,180 (55%)	444,171 (43%)	4,963,039 (41%)
Median Household Income	$87,287	$85,234	$63,727	$61,154
Per Capita Income	$49,341	-------------	$30,898	$29,405

3 EXISTING CONDITIONS

3.1 <u>Beach Profile/Shoreline Retreat</u>

The beach that had provided a natural, protective buffer zone and once protected the base of the coastal bluffs has been significantly depleted. As a result, erosion along the base of the coastal bluffs has occurred under continuous wave and tidal exposure such that notches and sea caves have formed at the toe of the bluff. Some of these notches extend for hundreds and, in some cases, thousands of feet along the bluff base. As a result of this toe erosion, the overall stability of the bluff is threatened and subsequently the upper bluff fails and shears off due to the reduced support at the base. A bluff failure is considered to have occurred when bluff material separates from the bluff and falls landing on the beach face at the bluff toe below.

Figure 3.1-1 shows a typical bluff profile in the study area. Bluffs in the study have been undergoing shoreline retreat. Shoreline retreat is defined as the gradual landward movement of the sea/land boundary as defined by the location of some tidal datum such as mean sea level. In the study area, this retreat is generally caused by shoreline erosion caused by wave attack of the beach and bluffs. Retreat of the coast may occur gradually, at a relatively uniform rate, or episodically, in large increments, followed by long periods of little or no retreat. Gradual retreat is well represented by annualized retreat rates; however, annualized rates do not adequately describe the nearly instantaneous retreat of several feet or tens of feet that may occur episodically. Episodic retreat affects both the sea cliff face and bluff top. The sea cliff is affected by large wave events eroding sea caves at the bluff toe and triggering block topping and block fall, collapsing these “notch caves”. The sub aerial processes (rain, rilling, surficial overslope flow) acting on the bluff surface and crest generally produce a slower, more uniform erosion rate, but may also contribute to episodic failure over the longer term. In addition, deep-seated landslides can cut back into the coastal terrace upwards of 60 to 80 feet in a few hours or days.

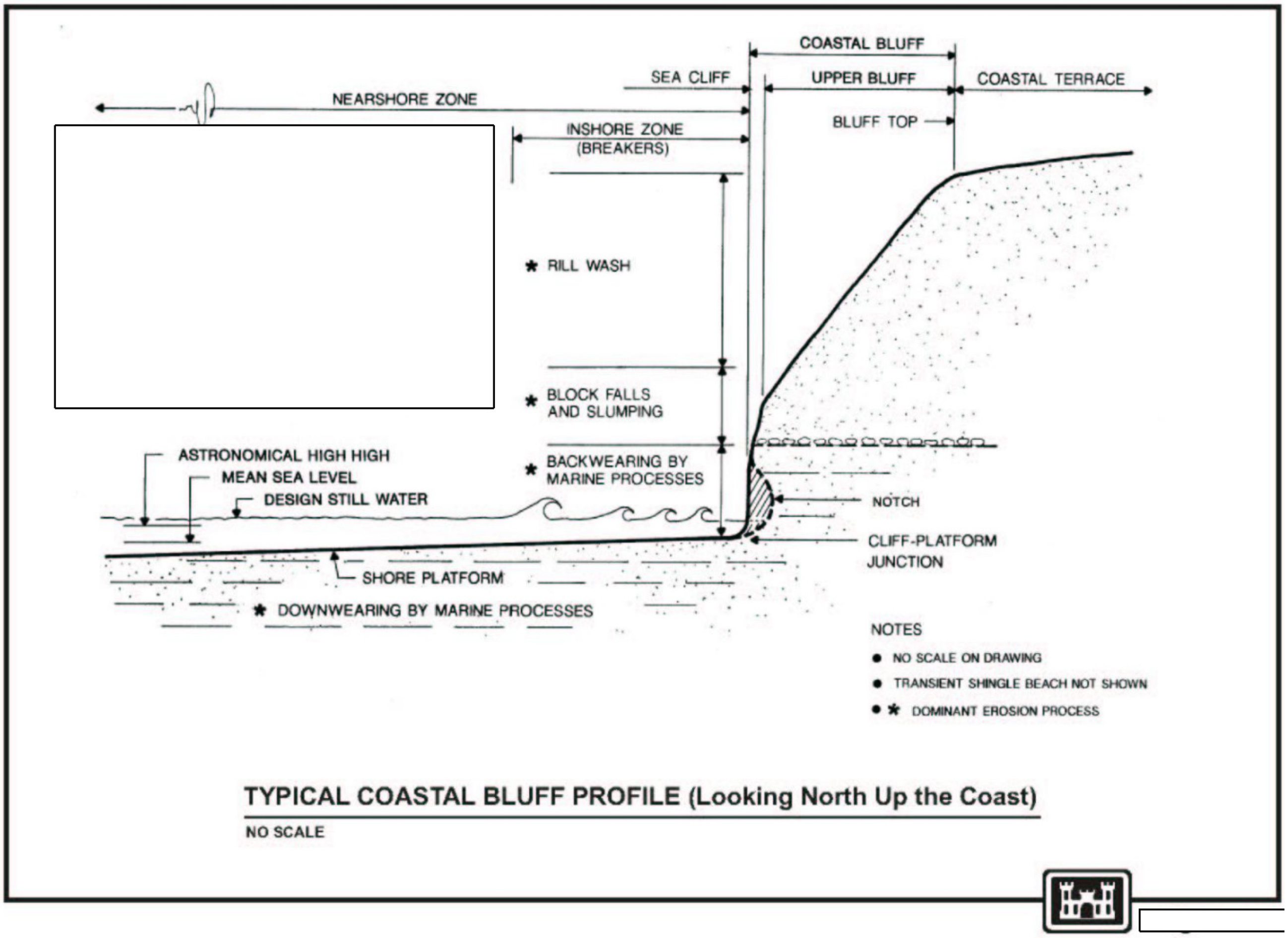


Figure 3.1-1 Typical Coastal Bluff Profile

3.2 Parcel & Structure Characteristics

Characteristics important to modeling the with and without project conditions have been carefully analyzed and catalogued, including those in **Table 3.2-1**. The study area has been broken down by nine reaches. All reaches have been analyzed but for brevity only characteristics for those areas that would be impacted by project alternatives, termed segments 1 & 2, have been broken down in the tables below. Segment 1 is 7,800 linear feet, lies entirely within Encinitas, and encompasses reaches three to five. Segment 2 is 7,200 linear feet, extends from the northern to southern border of Solana Beach, and encompasses reaches eight and nine. The Del Mar reach, immediately south of reach 9, would also receive sand, under all the beach nourishment alternatives, when placed at neighboring Reach 9 and therefore would contribute to the NED benefits calculation.

Table 3.2-1 Parcel Characteristics I

	Encinitas (Segment 1)	Solana Beach (Segment 2)	Study Area (Reaches 1-9)
Parcel Count	138	88	328
Structure Count[9]	112	81	291
Structure Value (Average)[10]	$327,474	$699,339	$407,551
Structure Value (Total in millions $)	$36.7	$56.6	$118.6
Toe Notch (Range)	0-6	0-6	0-6

3.2.1 Structure Count/Valuation

Surveys of the study area show 328 separate parcels and 291 structures. Of these 291 structures two-thirds, or 193 structures, currently do not have private seawalls and would be impacted by the project alternatives. Structure valuation is based on a complete visual survey of all structures in the study area to estimate structure quality and condition. This methodology follows guidelines from the Marshall & Swift Valuation Service and allows the replacement structure value to be estimated at current price levels and then depreciated.[11] Structure values were higher on average in Solana Beach (Segment 2) primarily because structure size tended to be larger. This increased size is primarily a result of the how the analysis was performed since all condominium and apartment complexes were evaluated at the structure level rather than at the individual unit level. Solana Beach has a relatively high share of medium to large condominium and apartment structures while Encinitas has a smaller share. In contrast single family residential structures are of similar size among both communities. Structure values are roughly $400,000 on average in the study area, which can be attributed to good to excellent construction quality, minimal deferred maintenance and repair, and an average structure size of 2,500 square feet for single family residences and 13,700 square feet for condominium structures.

3.2.2 Toe Notch

Toe notches are concave features at the base of the bluff caused by erosion from continuous exposure to wave attack (see **Figure 3.1-1**). As toe notches grow the probability of bluff collapse increases. Typically toe notches have been observed up to six feet in depth; toe notches deeper than six feet are not observed because bluff collapse has been observed occurring before the notch can deepen further.[12] The Bluff Retreat Model generated bluff top erosion rates by modeling toe notch erosion rates among other characteristics. The bluff-erosion events outputted from that model have been transferred to the economic model. Since the frequency and intensity of those bluff-top erosion events are dependent on initial toe notch depth, the economic model retains initial toe notch depth.

[9] Note counts are for structures only and not housing units, which are greater than the number of structures due to multi-family residential structures such as condominiums and duplexes.
[10] Average structure value in Solana Beach is higher primarily because a larger share of structures are multi-family residential.
[11] USACE Blue Book IWR 95-R-9. Significant price appreciation in the study area over the past several decades has created irreconcilable differences between market and assessed value because Proposition 13 limits parcel valuations for assessing property taxes to no more than 2% growth annually; therefore, the Marshall & Swift Valuation method was used to estimate market value of structures.
[12] A recent survey of toe notches in Encinitas showed 2 out of 190 parcels had toe notches of 8-11 feet deep. The other 188 parcels had toe notches of 6 feet or less.

3.2.3 Setback Distance

Setback distance is the shortest distance between the structure and bluff-top edge. For undeveloped parcels it is the span of the parcel from bluff-top edge to the opposite end of the parcel. As episodic events occur, the setback distance shortens and the lost parcel area is noted when modeling. Setback distance varies considerably from as little as one foot between structure and bluff edge to as much as 756 feet, as shown in **Table 3.2-2**. Parcels near the minimum setback distance generally have seawalls, with some exceptions. Parcels near the maximum setback distance are atypical and do not have seawalls. The typical setback distance is around 30 feet and a large share of structures are within 15-40 feet from the bluff-top edge.

Table 3.2-2 Parcel Characteristics II

	Encinitas	Solana Beach	Study Area
Setback Distance[13]			
Average	32 ft	34 ft	33 ft
Minimum	3 ft	1 ft	1 ft
Maximum	192 ft	756 ft	756 ft
Parcel Width[14]			
Average	74 ft	103 ft	78 ft
Minimum	28 ft	19 ft	19 ft
Maximum	784 ft	580 ft	784 ft

3.2.4 Parcel Width

Parcel width, which is the parcel dimension parallel to the bluff edge, is generally 50-100 feet wide for single-family residences and up to several hundred feet for multi-family residences. Solana Beach has larger average structure widths because larger, multi-family residences are concentrated there. However, single family residential parcel in Solana Beach and Encinitas are of similar width.

3.2.5 Seawall Trigger

All seawall permits must be evaluated and approved by the California Coastal Commission (CCC). The CCC is a designated coastal management agency for the purpose of administering the federal Coastal Zone Management Act in California. The CCC provided permitting information for all 48 seawall permits within the study area from 2000 to 2010. Of those 48 permits, 4 were denied, 2 were pending, 2 were withdrawn, and 6 were listed as “no objection” but without setback distances. The remaining 34 permits that were approved, had seawalls constructed, and had setback distances listed on the permit, were analyzed (see **Table 3.2-3**). This analysis showed seawalls have been approved and built when setback distance was as great as 35 feet and as little as -1 feet indicating at least a portion of the structure has been undermined. Three quarters were constructed when the setback distance was between 6 and 25 feet. The average setback distance was 16.2 feet but with considerable variation as shown by the standard deviation and range. No distinction was made between Encinitas and Solana Beach (Segments 1 & 2) because the sample of 34 permits could not be divided into smaller

[13] Initial setback distance from structure to bluff top edge; measurements are the shortest distance between structure and bluff top edge on each parcel.
[14] Distance from the bluff top edge to the end of the parcel; in other words the parcel dimension running perpendicular to the bluff edge

subsamples while retaining statistical significance. As a result the information was used to develop one “seawall trigger” that models the setback distance that triggers parcel owners to seek permits to construct seawalls across the study area. The “seawall trigger” approximates the historic setback distance distribution shown in **Figure 3.2-1**.

Table 3.2-3 Historic Setback Distance Triggering Seawall

Sample Size	34
Years	2000-2010
Average	16.2 ft
Median	15.5 ft
Standard Deviation	9.1 ft
Minimum	-1 ft
Maximum	35 ft

The triggering event (‘seawall trigger’) establishes the setback distances from structure to bluff-top edge that causes the parcel owner to seek a seawall construction permit. Under the *Armoring Scenario* we have assumed that all parcel owners respond to the ‘seawall trigger’ by applying for a permit and all seawall permit applications are approved, although not in that same year. The model follows historical precedent: episodic events eventually threaten the structure; the affected parcel owner seeks a seawall permit; successful permit applications are typically approved in 1-3 years; and a seawall is constructed shortly thereafter. To model the delay between permit application and seawall construction we have added a seawall construction delay of one, two, or three years (i.e. the ‘seawall trigger delay’). In this way the major steps to construct a seawall have been modeled—permit application, application review and approval, and finally seawall construction.

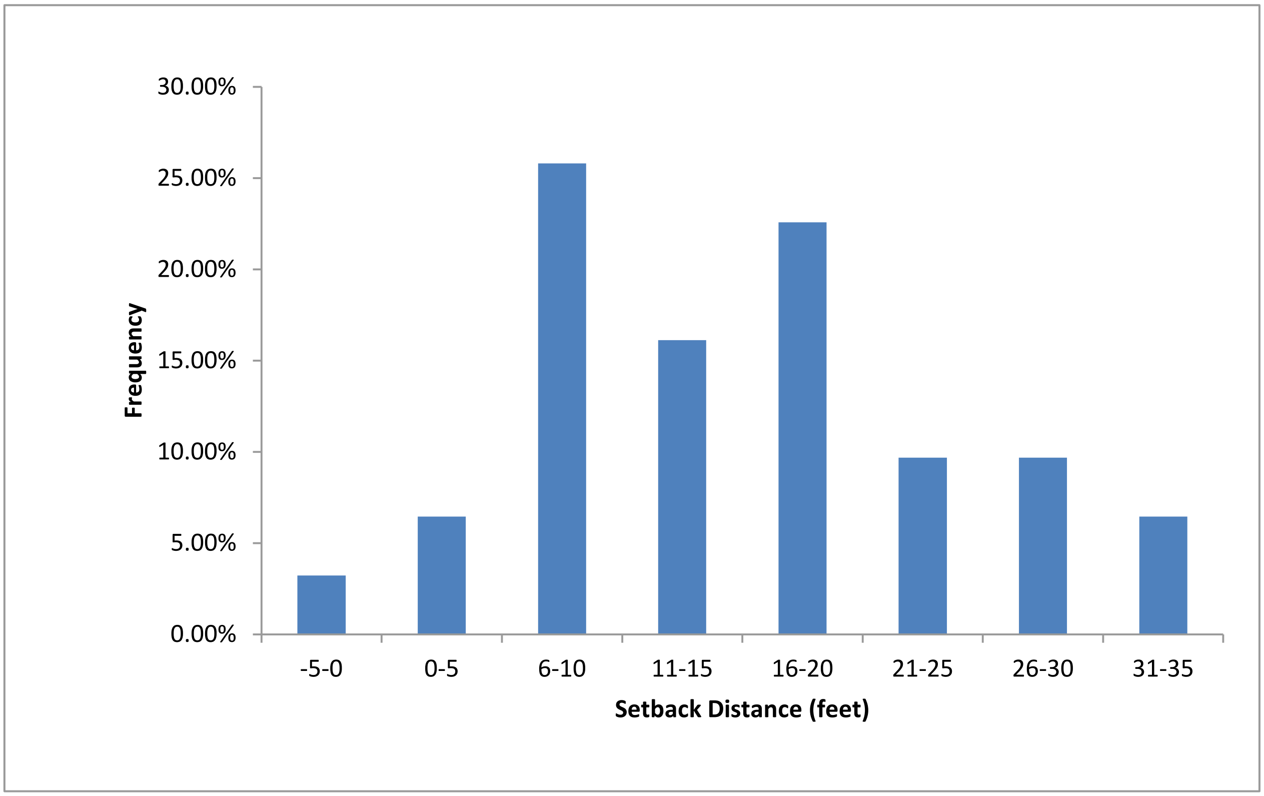


Figure 3.2-1 Historic Setback Distance Distribution

3.2.6 Seawall Costs

Constructing a seawall involves high fixed and variable costs that are paid exclusively by the affected parcel owner. Each seawall permit application involves engineering analysis, legal and consulting services, permit fees, and design plans. This expense ranges from \$96,000 to \$150,000 and averages \$123,000 according to experts who design and build seawalls in the study area. Once permitting is approved two types of variables costs must be paid: construction and mitigation. Variable construction costs, which include materials, labor, and equipment, are generally proportional to the length of the seawall being constructed—the larger the seawall the higher these costs. Variable construction costs are around \$7,400 per linear foot for the type of seawall permitted to be constructed in the study area by the California Coastal Commission (CCC) and local authorities.[15] The other variable cost is assessed by the CCC when seawalls are constructed to compensate the public for lost recreation opportunities and lost sand sedimentation benefits directly related to constructing seawalls at the base of the bluff. This fee is \$3,500 feet per linear foot. When all fixed and variable costs are combined, a 50-foot long "lower" seawall on a single-family residential parcel costs \$668,000, on average, as shown in **Table 3.2-4**[16] A lower seawall two hundred feet in length to protect a large condominium structure costs over \$2.2 million.

[15] Previously seawalls were constructed from rip-rap, wooden planks, and other materials but this is no longer permissible.

[16] Lower seawalls address erosion at the bluff toe. Often additional protection is added at the top of the bluff to aid in stability and protection from bluff failure. This feasibility study only addresses impacts to the bluff toe.

Table 3.2-4 "Typical" Seawall Construction Costs for lower seawall only

Seawall Construction Costs (lower seawall only)	Unit	Cost (Average)	"Typical" Seawall Cost (SFR Parcel -- 50 linear ft)
Construction:			
Fixed Costs[17]	per Parcel	$123,000	$123,000
Variable Costs[18]	per Linear ft	$7,400	$370,000
Variable Costs – Mitigation[19]	per Linear ft	$3,500	$175,000
Total	--	--	**$668,000**
Maintenance & Repair: (every 7 to 8 yrs)			
Fixed Costs[20]	per Parcel	$22,500	$22,500
Variable Costs[21]	per Linear ft	$275	$13,750
Total	--	--	**$36,250**

3.2.7 Maintenance & Repair

The study area bluff toe has minimal protection from wave attack, particularly during the winter when the beach profile is smallest. Under these conditions seawalls constructed with the same strength as the sandstone bluff require maintenance and repair every seven to eight years. Repair and maintenance like seawall construction requires a permit from the CCC. The associated permit and legal/consulting fees have been grouped as fixed costs along with design. Fixed costs are $22,500 and occur every 7 to 8 years typically. In addition variable costs for labor, materials, and equipment needed for repair are $275 per linear foot and are also incurred every 7 to 8 years. Since coastal engineering has determined that the winter beach profile within the study area exposes the bluff toe to continuous wave attack, all seawalls in the study area should be exposed and undergo the same repair and maintenance cycle every 7 to 8 years. When all fixed and variable costs are combined, maintaining a 50-foot long lower seawall on a single-family residential parcel would cost $36,250 every 7 to 8 years. Maintaining a lower seawall two hundred feet in length to protect a large condominium structure would cost $77,500 every 7 to 8 years.

3.2.8 Structure Sales

We analyzed sales data for 478 bluff-top and non bluff-top parcels sold within the study area between 2002 and 2010. Sixty of these sales were bluff-top parcels and the remaining 418 were neighboring, non bluff-top parcels. Bluff-top sales were brought to current price levels then every structure was valued using the methodology from *Marshall Valuation Service*.[22] This

[17] Design, Permitting, Legal/Consulting
[18] Materials, Equipment, and Labor
[19] Sand sedimentation and recreation loss mitigation assessed by the California Coastal Commission
[20] Design, Permitting, Legal/Consulting
[21] Materials, Equipment, and Labor
[22] Structure value (also termed "improvement value") could not be based on assessor data because Proposition 13 limits parcel valuations to no more than 2% growth annually for assessing property taxes. Therefore significant price appreciation over the past several decades has created irreconcilable

method was repeated for non bluff-top parcels and structures. Finally, estimated structure value was subtracted from sales price to determine land value. On average land value is $327 per square foot for bluff-top parcels and $107 per square foot for non bluff-top parcels within the study area, as shown in **Table 3.2-5**. These values were used later to estimate the value of land loss under future without project conditions as bluff failures occur. How land loss was generated and valued is explained in the *Model Methodology* section below.

Table 3.2-5 Structure Sales

	Sales Count (2002-2010)[23]	Land Value per SQFT (Average)	Land Value per SQFT (Range)
Bluff-top	60	$327	$25-$526
Non bluff-top	418	$107	$70-$952
Total	478	--	--

3.3 Regional Beach Sand Project II

3.3.1 Description of Project

Regional Beach Sand Project (RBSP) II is a local, one-time sand nourishment project organized and funded by the San Diego Association of Governments (SANDAG). RBSP II will occur in both study area communities in 2012, three years before the USACE project, and is assumed to be a one-time occurrence. RSPB II was analyzed because it is likely to occur and measurable per ER-1105-2-100 guidelines.

Analysis showed minor impacts to without project conditions, which is consistent with the purpose of RBSP II—recreation improvement rather than coastal storm damage reduction (CSDR). There would also be a modest reduction in the amount of sand the USACE would place during the initial fill (refer to **Table 3.3-1**).

3.3.2 Impact to Without Project Damages and With Project Benefit Analysis

RBSP II impacts Segment 1 and 2 differently. Segment 1 will receive 220,000 cubic yards of beach fill and Segment 2 will receive 146,000 cubic yards in 2012. The initial evaluation of benefits and costs did not account for the impact of the RSBP II Project. This one-time fill provides limited benefits during the initial years of the period of analysis, while the sand remains in the system and has not been lost due to erosion. Hence, the initial results overstated potential benefits for alternatives since they do not account for the residual but temporary sand remaining in the system from the RSBP II project. Therefore, these limited storm damage reduction and recreation benefits associated with the one-time RSBP II fill were quantified and deducted from the initial results. Benefits for alternatives presented later in this report reflect this adjustment.

differences between market and assessed value in the study area. As a result depreciated structure values were estimated using *Marshall Valuation Service*, the nationally recognized appraisal guide.

[23] Sales occurring within Solana Beach and Encinitas between 2002 and 2010 and indexed to current price levels.

3.3.3 Impact to Volume of Alternatives

Sand placed and remaining in the base year from RBSP II lowers the initial sand fill volume for the USACE project alternative modestly (refer to **Table 3.3-1**). This is because sand volume from RBSP II will remain in the system several years beyond 2015, the USACE base year. The exact amount of residual sand volume remaining in 2015 differs by segment and alternative. This extra sand volume in the base year means the USACE project alternative will need less sand volume for the initial fill in 2015 than the volumes established without the impact from RSPB II. To adjust for this, coastal engineering has determined the amount of fill volume remaining from RBSP II at the start of the study period.

The remaining fill volume in 2015, the start of the period of analysis, is subtracted from the amount of initial fill volume needed for the USACE project alternatives. This adjustment is made because the fill volumes provided by coastal engineering do not consider the impacts from RBSP II.

Table 3.3-1 Regional Beach Sand Project Fill Volume

	Encinitas	Solana Beach
Placement in 2013	220,000 cyd	146,000 cyd
Remainder by 2015	8,700 cyd	102,200 cyd

3.3.4 Impact to USACE Project Alternatives

One impact from RBSP II is an additional $67,000-76,700 in annualized coastal storm damage reduction in Segment 1 and $6,300-7,900 in Segment 2 for low and high sea-level rise, respectively, that is not included in the USACE project net benefits. Another impact is less beach fill volume required at the start of the study period. Segment 1 needs 8,700 cubic yards less fill and this partially offsets the effect to coastal storm damage reduction. Segment 2 needs 102,200 cubic yards less fill and this more than offsets the effect to coastal storm damage reduction. Therefore, including the impacts from RBSP II moderately reduces the net annual benefits of the USACE project alternatives for Segment 1 compared to excluding those impacts. In contrast it slightly increases the net benefits for Segment 2. Overall, this analysis determined that the impact from RBSP II is slight and essentially immaterial.

4 WITHOUT PROJECT ANALYSIS

4.1 Layout & Process

Under future without project conditions, coastal engineering analysis has determined that the study area will be represented by the lowest stable nearshore/beach condition, which is defined as the denuded beach condition observed prior to the SANDAG replenishment (a beach replenishment that occurred in 2001). Essentially, only a thin lens of sand topping the natural bedrock platform exists during the summer and fall months. In the winter and spring seasons, a depleted beach condition, exposing the natural bedrock, occurs and is the basis for the Monte Carlo simulation in the Coastal Engineering bluff-erosion model to statistically characterize the episodic bluff failures. In addition, considerations of two sea level rise (SLR) scenarios under the depleted beach conditions were also included in the bluff failure analyses. The two SLR scenarios considered are the historic upward trend of sea level and the projected sea level rise of the NRC-III curve. See the Coastal Engineering Appendix for further details and explanation about sea-level rise and bluff failure modeling.[24]

Future without project conditions in the Economic Model use the erosion data from the Coastal Engineering Model to simulate two distinct behaviors to episodic bluff failure: *Retreat Scenario* and *Armoring (Seawall) Scenario*. For financial, personal, regulatory, or other reasons some owners will not build seawalls before their structures are rendered uninhabitable from bluff-top collapses. This behavior is captured under the *Retreat Scenario*, where all owners do not build seawalls in time to protect their structures. On the other hand many owners will be able to build seawalls before their structures are rendered uninhabitable. This behavior is captured in the *Armoring Scenario*, where all owners do build seawalls in time. In a later step the two scenarios are weighted to determine the expected Without Project Damages. See the *Without Project Damages* section for further explanation.

4.2 Methodology

The following summarizes the economic model used to assess without project conditions. A detailed description is included in the Economic Model Attachment E1 E1. Shoreline retreat has been impacting the study area for at least three decades.[25] This has provided ample opportunity to observe the historical behavior of bluff-top parcel owners, which in turn has informed the modeling for without project conditions. When episodic retreat and failure of the bluff tops occurs, termed an “episodic event”, land is lost and coastal structures are threatened. In response many, but not all, bluff-top property owners seek permission to construct seawalls to protect their property from further erosion and collapse. Others will not or cannot construct a seawall before an episodic event renders their structure unsafe for occupancy. These two distinct responses to the process of wave attack, toe notch erosion, and bluff-top collapse form the basis of the economic modeling done in this study.

The without-project damages to the bluff top are generated because of low nearshore sand deposits (denuded beaches) that lead to toe notch erosion and ultimately bluff-top collapse from

[24] See also EC 1165-2-211 and the white paper *Approach to Incorporate Projected Future Sea Level Change into the Encinitas & Solana Beach Shoreline Protection Feasibility Study* and CEQA and NEPA Compliance Efforts.

[25] The 1982-83 El Nino season stripped away sand from the nearshore and deposited it too far offshore to remain in the system, allowing shoreline retreat to accelerate. See the Coastal Engineering Appendix for further details.

continuous exposure to wave attack. The model estimates the associated damages under the two different scenarios described in the previous section: *Retreat Scenario* and *Armoring (Seawall) Scenario*. Approximately 39% of the study area parcels are already protected to some extent by seawalls. This behavior is captured in the *Armoring Scenario*, where all owners do build seawalls in time. The exact weighting between these two scenarios and how that was derived is explained in the section 4.6.

Retreat Scenario assesses land loss from bluff-top collapse and any associated structure damages, stairway loss, seawall construction to preserve all infrastructure and land interior to the first row of bluff-top parcels but the first row of structures are not protected in time and are rendered uninhabitable. Under the *Retreat Scenario* seawall construction occurs after a structure has been lost to bluff collapse and before nearby roads, sewer lines, and other interior infrastructure has been lost. In this manner seawall construction has been modified from the *Armoring Scenario,* which initiates seawall construction prior to structure damage to the first row of bluff-top parcels rather than after structure damage.

4.3 <u>Comparison: Retreat & Armoring Scenarios</u>

Under the Retreat Scenario when episodic bluff failure occurs, first staircases are lost if present then land near the bluff-top edge is lost; repeated bluff failures could undermine the structure. If that happens the structure value and a portion of the contents inside are lost, the structure is demolished, and land loss continues. Eventually additional episodic bluff failures could threaten major public infrastructure and this would lead to publically financed seawall construction and maintenance since both cities would seek out emergency seawall permits and seek funding to construct public seawalls rather than incur the costs and disruptions of a “true” retreat scenario (financial costs and disruptions necessary to relocate buried and above-ground utility lines, loss of public roadways, and additional demands to acquire and relocate residences interior to the existing bluff-top parcels). The Retreat Scenario has the following damage categories (*asterisks indicates categories not present in Armoring Scenario):

- Staircase Loss
- Land Loss – Bluff-top
- Structure Loss*
- Structure Demolition & Removal*
- Land Loss – Non Bluff-top (interior to the structure)*
- Seawall Construction
- Seawall Maintenance

Under the Armoring Scenario when episodic bluff failure occurs first staircases are lost if present then land near the bluff-top edge is lost. Before the structure can be undermined by repeated bluff failures, a seawall is constructed and maintained by the parcel owner. The Armoring Scenario has the following damage categories:

- Staircase Loss
- Land Loss – Bluff-top
- Seawall Construction
- Seawall Maintenance

Structure loss, structure demolition & removal, and land loss valued at non bluff-top price levels are additional damage categories present in the *Retreat Scenario* but not present in the *Armoring Scenario* because the *Retreat Scenario* models parcel owners that do not or cannot react in time to secure the necessary seawall construction permits, financing, and construction experts prior to structure failure brought about by episodic erosion events. The *Retreat Scenario* also distinguishes between bluff-top and non bluff-top land value to account for land loss that occurs between the bluff edge and structure as well as land loss that occurs after the structure has failed.

4.4 Without Project Damages: Armoring (Seawall) Scenario

4.4.1 Layout & Process

The *Armoring* (Seawall) *Scenario* assesses land loss from bluff-top collapse and any associated stairway loss and seawall construction to preserve the first row of structures on the bluff-top parcels. This component of the model applies a random erosion event to the initial bluff-top setback distance that is dependent on each parcel's initial toe notch depth and location within the study area. After the episodic event is applied a new setback distance is determined--land and staircase losses are calculated, if applicable. The seawall trigger is applied to this new setback. If the seawall trigger is equal to or less than the setback distance, a permit is sought to construct a seawall and a delay of one to three years is applied before it can be constructed. Seawall permits are typically approved only to take emergency measures to protect the threatened structure. A delay between emergency seawall application, approval from the California Coastal Commission (CCC), and then construction is generally one to three years based on seawall permitting data submitted by the cities. Our modeling follows this precedence by allowing the seawall application to occur only when the structure is imminently threatened and construction to follow one to three years later. When a seawall is constructed, the cost of that seawall construction is applied and each subsequent year maintenance costs are assessed. No further damages from episodic events occur. If no seawall is constructed then another random erosion event occurs and the seawall trigger is applied to this new setback distance. This process is laid out in **Figure 4.4-1**.

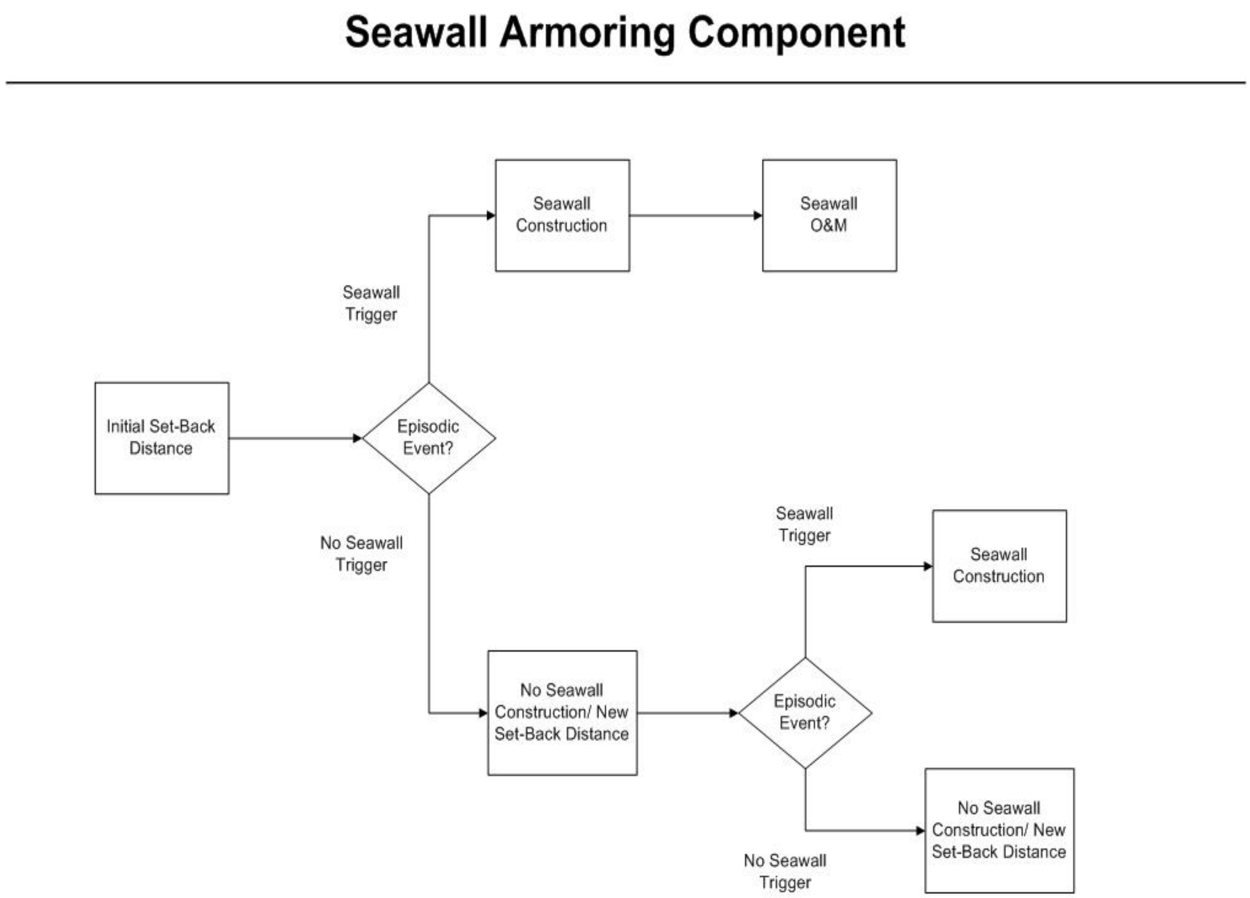


Figure 4.4-1 Seawall/Armoring Scenario Process

4.4.2 Episodic events

Armoring Scenario draws erosion data from a simulation of episodic events that are generated by the Bluff-Erosion Model.[26] This Bluff-Erosion model uses Monte-Carlo methods to combine waves, tides, initial toe notch depths, and empirical relationships of bluff failure geometry, notch depth growth with wave exposure, and bluff instability. Bluff retreat does not tie directly to a single coastal storm event but is caused by consistent wave attack to the base of the bluff during the winter season. The wave conditions used in the model are based on validated wave hindcasts over the period of 1979-2001, hence includes periods of both El Nino and La Nina (severe and mild) winter wave conditions. The simulation is conducted with a 3-hour time step, and through the creation of the frequency distributions, includes storm waves combined with tide and surge levels. The "shoreline", as adopted in this report, is the MSL contour, approximately +2.7 feet above mean lower low water (MLLW). The hardpan elevation at the bluff base ranges from +1.7 to +3.7 ft. The without project beaches within the study area are generally denuded.

The bluff-top erosion rates used for the economic modeling are direct outputs from the Bluff-Erosion Model. These outputs consist of 50 years of episodic events separated by location

[26] For additional explanation of how the erosion data was generated reference the Coastal Engineering Appendix, table 5-5 and the Bluff Erosion Model White Paper.

(study area reach) and initial toe notch depth (0, 2, 4 & 6 feet). Each combination of location and toe notch depth has 1,000 50-year bluff-top erosion events that are randomly drawn to run in the economic model. These episodic events form the basis for all *Armoring Scenario* damages—loss of staircases, land loss, seawall construction, and seawall maintenance. For additional explanation about how these erosion rates are derived refer to the Coastal Engineering Appendix.

4.4.3 Land Loss

Since all land loss under the *Armoring Scenario* occurs between the bluff-top edge and bluff-top structure (or bluff-top parcel demarcation line for undeveloped parcels), land loss is valued at the bluff-top price per square foot since there is no transfer of bluff top value to the interior row of properties when the bluff top structure is protected. The price per square foot was estimated using the methodology outlined in section 3.2.8.

4.4.4 Staircases Loss

Some parcels in the study area have staircases leading from the bluff top to the beach. Over time episodic events have caused several of these staircases to become unsafe or even collapse. Under without project conditions we expect more staircases to be lost. The replacement cost for a private staircase has been estimated at $42,000. Typically, after three feet of bluff-top erosion a staircase can fail. Therefore the "staircase trigger" occurs in the year there is three or more feet of cumulative erosion to the bluff top—in that year the staircase is lost. Since the number of staircases is limited, the impact to without project damages is minimal.

4.4.5 Seawall Construction & Maintenance

Historical seawall permit data in the study area was used to establish a probability distribution of bluff-top to structure setback distances immediately preceding application for a seawall permit, which must be done before a seawall can be legally constructed as explained in sections 3.2.5 and 4.2. Briefly, the triggering event ('seawall trigger') establishes the setback distances from structure to bluff-top edge that causes the parcel owner to seek a seawall construction permit. Under the *Armoring Scenario* we have assumed that all parcel owners respond to the 'seawall trigger' by applying for a permit and all seawall permit applications are approved, although not in that same year. The model follows historical precedent: episodic events eventually threaten the structure; the affected parcel owner seeks a seawall permit; successful permit applications are typically approved in 1-3 years; and a seawall is constructed shortly thereafter. In this way the major steps to construct a seawall have been modeled—permit application, application review and approval, and finally seawall construction. According to local experts who construct and maintain seawalls in the study area, seawall maintenance occurs at regular intervals since seawalls are exposed to recurring wave attacks. This has been modeled also.

4.4.6 Results

As noted previously, separate scenarios were modeled for low and high sea-level rise, as shown in **Table 4.4-1**. Results under the low sea-level rise scenario show that reaches 1 and 2 have moderate damage that is primarily the result of maintenance and repair to existing seawalls. These results were expected given the gentler sloping typical of the bluffs in this area and the propensity for Reach 2 to have landslides limiting the effectiveness of project alternatives that would address coastal erosion at the bluff toe. Reaches 3-5 have significantly more average annual damages due to the large number of unprotected parcels and bluff characteristics more conducive to seawall construction.[27]

Table 4.4-1 Armoring Average Annual Damages by Reach & Segment

Low SLR		
Reach	**Expected Values**	***Std Deviation***
1	$156,000	*4,000*
2	$291,000	*40,000*
3	$558,000	*108,000*
4	$1,124,000	*92,000*
5	$1,510,000	*195,000*
6	$28,000	*18,000*
7	n/a	n/a
8	$1,028,000	*251,000*
9	$1,680,000[28]	*377,000*
Total	**$6,375,000**	
Segment 1	$3,192,000	
Segment 2	$2,708,000	*324,000*
High SLR		
Reach	**Expected Values**	***Std Deviation***
1	$159,000	*5,000*
2	$357,000	*30,000*
3	$534,000	*121,000*
4	$1,200,000	*149,000*
5	$1,682,000	*267,000*
6	$108,000	*15,000*
7	n/a	n/a
8	$987,000	*287,000*
9	$2,177,000	*389,000*
Total	**$7,204,000**	
Segment 1	$3,415,000	*487,000*
Segment 2	$3,164,000	*697,000*

Reach 6 consists predominantly of San Elijo State Park and has few structures. As a result damages are minimal. Reach 7 does not have coastal bluffs and is a low-lying lagoon with several restaurants. It is evaluated for damages from storm surge inundation in a separate section *Without Project Analysis: Overtopping*. Reach 8 and 9 extend the entire coastline of Solana Beach. Reach 8 has a mix of single family residences and multi-family residential structures (condominiums) while Reach 9 is predominantly multi-family residential structures. Damages were substantial in both reaches—about $1 million in average annualized damages—and somewhat lower but still substantial in coastline immediately south of and contiguous to Solana Beach, the Del Mar Reach.

[27] For further details about Reach 1 and 2 refer to the coastal engineering appendix.

[28] Included are damages of $689,000 to parcels with structures contiguous to and immediately south of Reach 9 in the neighboring city of Del Mar. A portion of these damages would be prevented by sand placement alternatives.

Results under the high sea-level rise scenario show a similar pattern—damages are concentrated in reaches 3-5 and 8-9 and the Del Mar Reach. Damages for all reaches are modestly higher under this sea-level rise scenario except for reaches 8 and 9. This occurs at those reaches because more seawalls are constructed before the base year meaning that those damages would occur prior to the study period in the high sea-level rise scenario. In addition, across all reaches the total number of seawalls constructed increases only slightly under the high-sea level rise scenario. This is clear from the seawall counts shown in the table below for Segment 1 and 2. Segment 2, which includes reaches 8-9 and the several parcels contiguous to and immediately south of reach 9 ("Del Mar Reach"), is expected to have only two more seawalls constructed in the high versus low sea-level rise scenario.

The underlying reason for the modest increase to damages under the low sea-level rise scenario is revealed by the number of seawalls and the nominal damages for the study period shown in **Table 4.4-2** and **Table 4.4-3**, respectively. Under the low and high sea-level rise scenarios the number of seawalls constructed and the nominal damages are similar. This is because in general the existing, unprotected parcels that become threatened under either sea level rise scenario are the same; in other words, our modeling shows that for most unprotected parcels the uncertainty is not if a given parcel will need to construct a seawall in the future, but when will it need to do that—sooner under high SLR and later under low SLR. Therefore the difference in average annual damages between the two sea-level scenarios is exclusively the result of the timing of seawall construction (earlier in the study period under high SLR and later in the study period under low SLR) rather than more seawall construction under the high SLR.

Table 4.4-2 Armoring Scenario: Existing vs Future Seawall Construction

Low SLR	Existing Seawall Count (2011)	Existing Seawall Length (2011)	Without Project Seawall Count (2064)[29]	Without Project Seawall Length (2064)
Segment 1	30 seawalls	1,741 linear ft	110 seawalls	6,703 linear ft
Segment 2	46 seawalls	3,476 linear ft	80 seawalls	7,735 linear ft
Total	**76 seawalls**	**5,217 linear ft**	**190 seawalls**	**14,438 linear ft**
High SLR				
Segment 1	30 seawalls	1,741 linear ft	116 seawalls	7,136 linear ft
Segment 2	46 seawalls	3,476 linear ft	82 seawalls	7,735 linear ft
Total	**76 seawalls**	**5,217 linear ft**	**198 seawalls**	**14,871 linear ft**

The majority of damages analyzed occur in reaches 3-5 and 8-9 and the Del Mar Reach, which corresponds with Segment 1 and Segment 2, respectively. Closer examination of these two segments reveals that we expect a large number of seawalls to be constructed in the study area if no project is implemented. Segment 1 and 2 are approximately 15,000 linear feet combined. Under without project conditions we expect 90-95% of the lower bluff to be armored by the end of the study period under low and high sea-level rise scenarios, respectively. The cost of constructing and maintaining these seawalls in Segment 1, shown in **Table 4.4-3**, is on average \$1.9-2.0 million each year of the period of analysis (average annualized value). In Segment 2 this cost is \$1.2 million. Across both Segments the cost would be \$3.1-3.2 million annualized. Land Loss, the other major damage category, amounts to \$2.9-\$3.4 million annual damages.

[29] Average number of seawalls constructed by year 2064 when running 1000 bluff erosion iterations in the Armoring Scenario component of the model

Total annualized damages across all categories are $5.9 million under low sea-level rise scenario and $6.6 million under high sea-level rise scenario.

Table 4.4-3 Armoring Scenario Annualized Damages

Low SLR	Armoring Construction/O&M	Land	Staircases[30]	Total
Segment 1	$1,883,000	$1,314,000	$2,000	$3,199,000
Segment 2	$1,165,000	$1,536,000	$0	$2,701,000
Total	$3,048,000	$2,850,000	$2,000	$5,900,000
High SLR				
Segment 1	$2,000,000	$1,415,000	$500	$3,415,500
Segment 2	$1,177,000	$1,987,000	$0	$3,164,000
Total	$3,177,000	$3,402,000	$500	$6,579,500

4.5 Without Project Damages: Retreat Scenario

4.5.1 Layout & Process

Retreat Scenario assesses land loss from bluff-top collapse and any associated stairway loss, structure loss, structure demolition costs. In addition we have assumed that seawalls are constructed to protect structures and infrastructure beyond the first row of bluff-top parcels to protect a significant amount of municipal infrastructure (roads, power & sewer lines, telecommunications equipment, etc.). Unchecked erosion capable of damaging this municipal infrastructure does occur for some parcels based upon the coastal modeling results, particularly under high sea-level rise. Representatives from the Cities of Solana Beach and Encinitas have specified that they would take proactive action to construct seawalls once such infrastructure is threatened, which is the reason for modifying the *Retreat Scenario* to include seawall construction to protect interior infrastructure.

The *Retreat Scenario*, like the *Armoring Scenario*, draws 50 years of random episodic events (bluff-top erosion) for each simulation. Year-by-year a new bluff-top setback distance is generated and all damages are retained. Damages may include staircase loss, land loss, structure loss, structure demolition, and seawall construction under specific circumstances. Seawall construction occurs only if erosion events cause less than 15% of the original parcel to remain. This ensures interior infrastructure is protected as both cities have indicated. No damages from episodic events occur to land, structures, and infrastructure interior to the first row of bluff-top parcels. Each subsequent year after a seawall is constructed seawall maintenance costs are applied. This process is laid out in **Figure 4.5-1**.

[30] Staircase losses are limited because few existing staircases are unprotected and of those that are unprotected damages tend to occur before the base year.

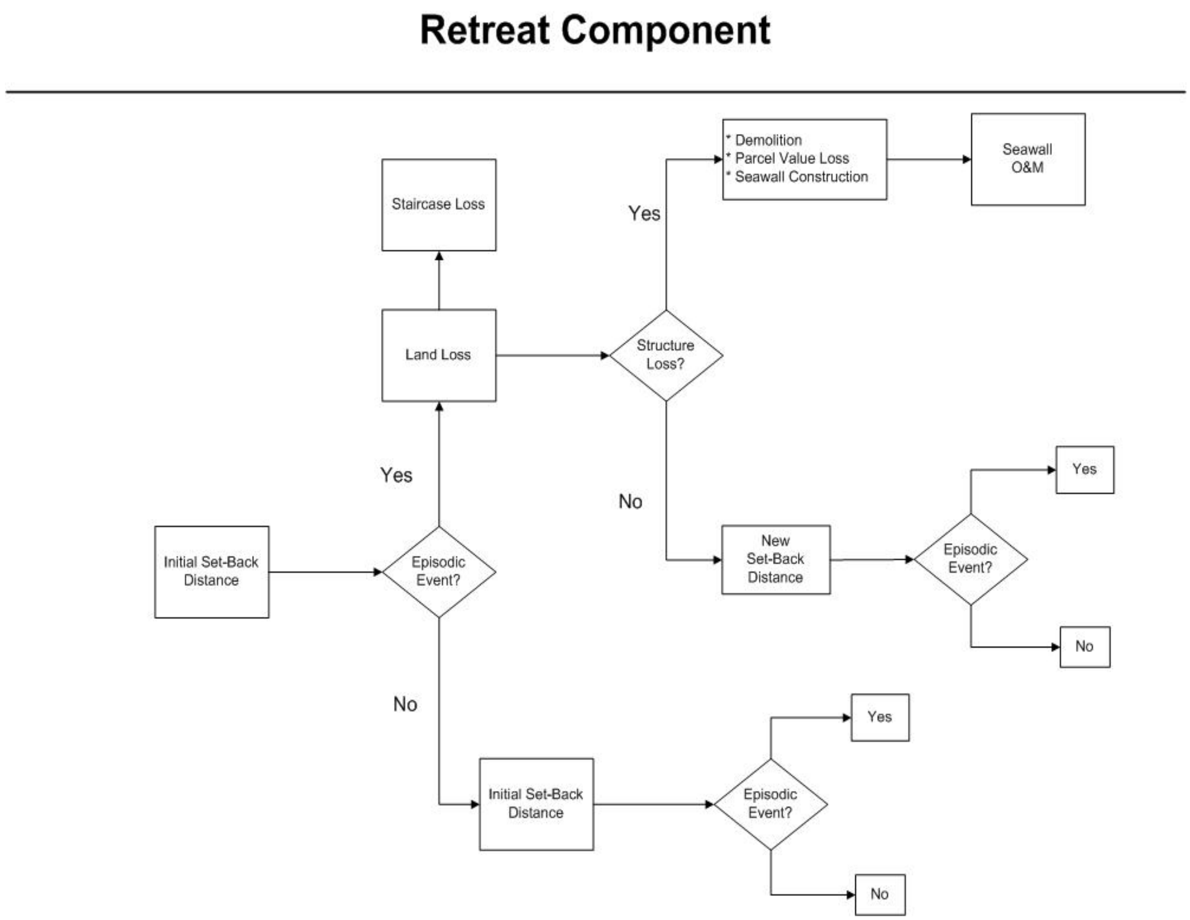


Figure 4.5-1 Retreat Scenario Process

4.5.2 Episodic events

The *Retreat Scenario*, like the *Armoring Scenario*, draws erosion data from a simulation of episodic events that are generated by the Bluff-Erosion Model.[31] See the *Armoring Scenario* section for a full explanation.

4.5.3 Seawall Trigger

Under the *Retreat Scenario* a seawall is constructed after the first row of parcels are lost because further erosion would undermine major public infrastructure such as roads, sewer lines, and power lines without this intervention. Representatives from both cities have informed us that resources would be made available to construct seawalls and prevent this catastrophic scenario. Unlike the *Armoring Scenario,* the seawall trigger for the *Retreat Scenario* has been modified to occur after the structure has been rendered uninhabitable by episodic events and once only 15% of the original parcel area remains. If the parcel does not have a structure, a seawall is constructed once 15% of the original parcel area remains.

[31] For additional explanation of how the erosion data was generated reference the Coastal Engineering Appendix, table 5-5 and the Bluff Erosion Model White Paper.

4.5.4 Structure & Content Damages

The *Retreat Scenario* and *Armoring Scenario* are laid out similarly; however, since the first row of structures can be lost under the *Retreat Scenario*, their value along with content damages and demolition costs have been included in the *Retreat Scenario*. Structure valuation is based on a complete visual survey of all structures in the study area to estimate structure quality and condition. This methodology follows guidelines from the Marshall & Swift Valuation Service and allows the depreciated structure value to be estimated at current price levels.[32] Demolition costs were estimated by a local demolition firm with experience demolishing residential structures. Estimates were given as a range of values per square foot that included both demolition and removal, which were then calculated for each structure in the study area. Content value is a percentage of the depreciated structure value that varies by usage type.

4.5.5 Land Loss Value: Bluff-top & Non Bluff-top

Since land loss under the *Retreat Scenario* occurs across the entire parcel, land value is distinguished by bluff-top and non bluff-top for parcels with structures (undeveloped parcels are only valued as non-bluff top). Land loss occurring between the bluff-top edge and structure is valued as bluff-top to be consistent with land valuation under the *Armoring Scenario*. Land loss occurring after the structure is lost is valued as non bluff-top, consistent with guidelines.[33] Bluff-top and non bluff-top land value was estimated using sales data between 2002 and 2010 for 60 bluff-top parcels and 418 non bluff-top parcels sold within the study area. First all structures were surveyed for structure quality and condition. On average the value of bluff-top land in the study area is $327 per square foot and non bluff-top value is $107 per square foot, as shown in **Table 4.5-1**. These values were applied to the area of bluff-top erosion on each parcel to value land loss.

Table 4.5-1 Sales Count and Land Value

	Sales Count[34]	Land Value per SQFT (Average)
Bluff-top	60	$327
Non bluff-top	418	$107
Total	478	--

4.5.6 Results

Results in **Table 4.5-2** under the low sea-level rise scenario show that reaches 1 and 2 have moderate damage that is primarily the result of maintenance and repair to existing seawalls. These results, which are similar to results in the Armoring Scenario described earlier, were

[32] Structure value (also termed “improvement value”) could not be based on assessor data because Proposition 13 limits parcel valuations to no more than 2% growth annually for assessing property taxes. Therefore significant price appreciation over the past several decades has created irreconcilable differences between market and assessed value in the study area.

[33] ER 1105-2-100 Appendix E

[34] Sales occurring within Solana Beach and Encinitas between 2002 and 2010 and indexed to current price levels

Table 4.5-2 Retreat Average Annual Damages by Reach & Segment

Low SLR		
Reach	**Expected Values**	***Std Deviation***
1	$156,000	*4,000*
2	$162,000	*12,000*
3	$660,000	*36,000*
4	$946,000	*55,000*
5	$1,353,000	*132,000*
6	$13,000	*6,000*
7	n/a	n/a
8	$1,006,000	*72,000*
9	$2,824,000[35]	*226,000*
Total	**$7,120,000**	
Segment 1	$2,959,000	*159,000*
Segment 2	$3,830,000	*292,000*
High SLR		
Reach	**Expected Values**	***Std Deviation***
1	$158,000	*4,000*
2	$289,000	*11,000*
3	$788,000	*42,000*
4	$1,468,000	*78,000*
5	$1,892,000	*154,000*
6	$90,000	*5,000*
7	n/a	n/a
8	$1,257,000	*80,000*
9	$3,599,000[36]	*242,000*
Total	**$9,541,000**	
Segment 1	$4,148,000	*190,000*
Segment 2	$4,856,000	*295,000*

expected given the gentler sloping typical of the bluffs in this area and the propensity for Reach 2 to have landslides limiting the effectiveness of seawalls built at base of the bluff. As under the

[35] Included are damages of $712,000 to parcels and structures contiguous to and immediately south of Reach 9 in the neighboring city of Del Mar. A portion of these damages would be prevented by sand placement alternatives.
[36] Included are damages of $1,224,000 to parcels and structures contiguous to and immediately south of Reach 9 in the neighboring city of Del Mar. A portion of these damages would be prevented by sand placement alternatives.

Armoring Scenario reaches 3-5 have significantly more damage due to the large number of unprotected parcels and bluff characteristics more conducive to seawall construction.[37] Reach 6 consists predominantly of San Elijo State Park.

Damages under the high sea-level rise scenario are significantly higher than the low scenario. The reason is apparent when the structure loss is counted under both scenarios shown in **Table 4.5-3**. The expected number of structure losses under the Retreat Scenario is 72 in Segment 1 (reaches 3-5) and 32 in Segment 2 (reaches 8-9 and the several parcels contiguous to and immediately south of reach 9 referred to as the "Del Mar Reach") under both low and high sea-level rise scenarios—in other words the number of expected structure losses is identical. The undiscounted, nominal value of those structure losses is also similar. This means structure losses tend to occur on the same parcels under low and high sea-level rise scenarios but the timing of structure loss is different. High sea-level rise conditions tend to cause structure losses earlier in the study period compared to low sea-level rise conditions leading to higher annualized damages in the high sea-level rise scenario.

Overall, damages occurring under the Retreat Scenario are modestly greater than those under the Armoring Scenario. As explained earlier in this section the Retreat Scenario is not a "true" managed retreat scenario because officials at both cities (Solana Beach & Encinitas) have explained to USACE that their policy would be to protect public utility lines and roads immediately interior to the bluff top parcels with publically-financed seawalls obtained under emergency permits from the CCC. Therefore Retreat Scenario damages, are limited to structure loss, land loss, and seawall construction affecting the row of bluff top parcels only. This also means the timing of the major damages categories (structure loss and seawall construction) are pushed out further in to the future than the major damage occurring under the armoring scenario, which is seawall construction before the bluff top structure is undermined. This difference in timing, which is impacted by discounting, further diminishes the difference in damages between retreat and armoring scenarios.

Table 4.5-3 Retreat Scenario Structure & Content Loss (nominal values)

Low SLR	Existing Structure Count	Structures Loss Count	Structures Loss Value	Content Loss Value
Segment 1	119	72	$24,708,000	$2,518,000
Segment 2	77	32	$22,794,000	$1,747,000
Total	196	104	$47,502,000	$4,265.00
High SLR				
Segment 1	119	72	$24,708,000	$2,518,000
Segment 2	77	32	$23,361,000	$1,855,000
Total	196	104	$48,069,000	$4,373,000

Table 4.5-4 shows the annualized, discounted damages by category for the portions of the study area where most damages occur—Segment 1 and 2. As expected, more damages occur earlier in the study period so the high sea-level rise scenario has greater average annualized damages compared to low.

[37] For further details about Reach 1 and 2 refer to the coastal engineering appendix.

Table 4.5-4 Retreat Scenario Annualized Losses

Low SLR	Armoring Construction/O&M	Land, Staircase	Structure/Content, Demolition	Total
Segment 1	588,000	1,657,000	713,000	2,959,000
Segment 2	910,000	2,146,000	775,000	3,830,000
Total	1,498,000	3,803,000	1,488,000	6,789,000
High SLR				
Segment 1	1,381,000	1,882,000	856,000	4,148,000
Segment 2	1,442,000	2,517,000	897,000	4,856,000
Total	2,823,000	4,399,000	1,753,000	9,004,000

4.6 Weighting Armoring & Retreat Scenarios

The *Armoring* and *Retreat Scenarios* model two mutually exclusive behavior patterns to impending bluff collapse. We expect each parcel owner to follow one of these two patters: either armor the parcel with a seawall to prevent structure collapse or fail to armor the parcel and allow structure collapse. However we do not know which behavior pattern each individual parcel owner would follow under without project conditions. To assign individual weights to each parcel would require generating @Risk output distribution functions for each parcel and each scenario, and then combining them on an individual basis first before aggregating those results. This would imply a level of detail and certainty for the weighting that does not exist. Instead based on the limited information available on individual property owners, the PDT developed a weighting scheme for armoring and retreat for all of the property owners instead of developing individual probabilities for each homeowner.

The *Armoring Scenario* assumes all owners threatened by structure failure/collapse are able to construct seawalls in time. The *Retreat Scenario* assumes these same owners are unable to construct seawalls in time and the first row of structures collapse given enough bluff erosion. With Project Benefits are determined by the reduction in without project damages. To determine the amount of preventable without project damages (i.e. the with-project maximum benefits) the *Armoring* and *Retreat Scenario* damages have to be combined. Therefore, these scenarios are weighted by the probability of occurrence to determine the expected value.

Determining the probability of occurrence for the *Retreat Scenario* involves establishing the percentage of “unexpected” and “threatening” bluff-top collapses that could lead to structure failures. “Threatening events” are bluff top collapses that occur when the structure setback distance is between 25 and -5 feet, which is a range of distances that leave the structure vulnerable to collapse during the next episodic event. Parcels that experience threatening events may experience erosion events the following year that cause structure failure and these are called “unexpected events,” which by definition cannot be acted upon in time to prevent the structure from failing regardless of parcel owners’ responses. Unexpected events happen when setback distances greater than 0 feet are followed immediately the next year by episodic events that cause the setback distance to be less than -5 feet, which is the minimum setback distance that causes structure failure. The share of “unexpected events” to “threatening” and “unexpected” events is the basis for the minimum possible weighting for *Retreat Scenario*. This is the minimum weighting because all parcels subject to episodic bluff failures in the sequence just described would likely sustain structure failures despite proactive responses from the affected parcel owners. However this minimum weighting does not account for other factors impacting how parcel owners respond to episodic bluff failures. Consequentially, these values are adjusted upward by 15% based on subjective considerations for owners that do not have the financial means or timely construction permits to build seawalls in time as well as those that do not construct seawalls in time for other personal reasons. Therefore the minimum “objective” weighting, which differs by segment and sea-level rise scenario, was increased by 15% based on subjective criteria to finally arrive at the adjusted weighting that is applied to *Retreat & Armoring Scenarios* to calculate the expected without project damages. [38] We recognize the uncertainty associated with these weights and have conducted a sensitivity analysis to show the impact on plan selection and justification when applying a range of weights to the scenarios.[39]

When the “Adjusted Weighting” from **Table 4.6-1** is multiplied by the Armoring and Retreat Scenario Damages, the results are as shown in **Table 4.6-2** below.

Table 4.6-1 Retreat Scenario Weighting

	Minimum/Objective Weighting[40]		Adjusted Weighting[41]	
	Low SLR	**High SLR**	**Low SLR**	**High SLR**
Segment 1 (Encinitas)	2.9%	5.1%	18%	20%
Segment 2 (Solana Beach)	6.9%	14.1%	22%	29%

Table 4.6-2 Weighted Damages Results

Low SLR	Armoring Damages	Retreat Damages	Armoring Weighting %	Retreat Weighting %	Weighted Damages
Segment 1					
Expected Value	$3,199,000	$2,960,000	82%	18%	$3,156,000
Std Deviation	*304,000*	*151,000*			*252,000*
Segment 2					
Expected Value	$2,701,000	$3,831,000	78%	22%	$2,950,000
Std Deviation	*610,000*	*233,000*			*478,000*
High SLR					
Segment 1					
Expected Value	$3,416,000	$4,149,000	80%	20%	$3,548,000
Std Deviation	*466,000*	*180,000*			*383,000*
Segment 2					
Expected Value	$3,164,000	$4,860,000	71%	29%	$3,656,000
Std Deviation	*683,000*	*237,000*			*535,000*

Overall, damages occurring under the *Retreat Scenario* tend to be greater than those under the *Armoring Scenario*. The *Retreat Scenario* is not a “true” managed retreat scenario because officials at both cities (Solana Beach & Encinitas) have explained to USACE that their policy would be to protect public utility lines and roads immediately interior to the bluff top parcels with publically-financed seawalls obtained under emergency permits from the CCC. Therefore *Retreat Scenario* damages are limited to structure loss, land loss, and seawall construction

[38] *Sloughing (Residual) Damages* are subtracted after the expected without project damages have been calculated to arrive at the Remaining Preventable Damages. See the *Sloughing Damage Analysis* section for further details.
[39] See the section on *Risk and Uncertainty* later in this document.

affecting the row of bluff top parcels only. This also means the timing of major damages categories structure loss and seawall construction are pushed out further in to the future than the major damage occurring under the armoring scenario, which is seawall construction before the bluff top structure is undermined. This difference in timing, which is impacted by discounting, further diminishes the difference in damages between *Retreat* and *Armoring Scenarios*.

4.6.1 Sloughing Damages

Although each alternative prevents the storm damage cycle, none are designed to prevent the natural sloughing of the bluff in unstable, unprotected areas. Under the without project analysis the natural sloughing rate for unstable unprotected areas was hidden from direct observation by the bluff failure process but was incorporated into the process. This ensures that land subject to natural sloughing under with-project conditions that was not assessed in the without project conditions due to the process described above is not counted as a benefit.

With any of the alternatives in-place residual sloughing would occur in unstable areas until a stable angle of repose is achieved. Geotechnical analysis estimates the annual natural sloughing rates in unstable, unprotected areas of the study at 0.4 feet in Segment 2 and 0.5 feet to 0.68 feet in Segment 1. To simplify the modeling effort for natural sloughing geotechnical experts assumed that the annual sloughing rate would be prorated by the share of unstable area to total area by reach and applied to all properties in that reach, rather than incorporating a parcel by parcel approach to the model. This simplification returns approximately the same total land loss as a parcel by parcel analysis. The estimated percentages of land area considered unstable by reach are: 20% in Reach 3, 44.5% in Reach 4, 16% in Reach 5 (Segment 1), 28% in Reach 8, and 9.4% in Reach 9 (Segment 2).

Residual sloughing loss is estimated through the risk-based without project model by incorporating sloughing rates specific to each reach from the base operational year until the study ends. Sea-level rise does not affect sloughing because the sloughing process occurs outside of the influences from wave attack and toe notch erosion. These figures apply to all alternatives and all sea-level rise scenarios as all produce the same effect on sloughing. **Table 4.6-3** identifies sloughing damages by reach and segment. The largest share of sloughing damages occur in Reach 4, $200k, while the least occurred in the “Del Mar Reach”, $13k. Episodic events obscure the natural sloughing at the bluff edge. As a result these sloughing damages at the bluff edge have to be subtracted from without project damages to prevent “double counting.” For additional explanation refer to the Economic Model Attachment E1 and the Appendix B.

Table 4.6-3 Sloughing Average Annual Damages

Reach 1	n/a
Reach 2	n/a
Reach 3	$99,000
Reach 4	$202,000
Reach 5	$96,000
Reach 6	n/a
Reach 8	$88,000
Reach 9	$55,000[42]
Total	**$540,000**
Segment 1	$397,000
Segment 2	$143,000

4.6.2 Results

The maximum coastal storm damage reduction benefits, which were determined by taking the weighted damages from the *Armoring* and *Retreat Scenarios* and removing the sloughing damages, are shown below in **Table 4.6-4**. These are the maximum potential benefits that could be realized by alternatives that address coastal storm processes, as sloughing damages would occur under both with and without project conditions. These results from analyzing without project conditions are retained and evaluated under with project conditions to determine the CSDR Benefits (CSDRB) of each project alternative. See Section 5.2.1 for further explanation.

Table 4.6-4 Maximum Coastal Storm Damage Reduction Benefits (Average Annualized)

Low SLR	Armoring Damages	Retreat Damages	Weighted Damages	Residual/Sloughing Damages	Maximum CSDRB
Segment 1	$3,199,000	$2,960,000	$3,156,000	$397,000	**$2,759,000**
std dev	*304,000*	*151,000*	*252,000*	--	*247,000*
Segment 2	$2,701,000	$3,831,000	$2,950,000	$143,000	**$2,807,000**
std dev	*610,000*	*233,000*	*478,000*	--	*437,000*
HIGH SLR					
Segment 1	$3,416,000	$4,149,000	$3,548,000	$397,000	$3,166,000
std dev	*466,000*	*180,000*	*383,000*	--	*251,000*
Segment 2	$3,164,000	$4,860,000	$3,656,000	$143,000	$3,513,000
std dev	*683,000*	*237,000*	*535,000*	--	*478,000*

[42] Included are damages of $13,000 to parcels contiguous to and immediately south of Reach 9 in the neighboring city of Del Mar.

4.7 Without Project Damages: Overtopping

4.7.1 Layout & Process

Damages caused by wave run-up occur along the low-lying section of the study area at Cardiff State Beach within Reach 7, as shown in **Figure 4.7-1**. This reach does not have coastal bluffs; instead coastal storms generate damages in this reach when storm waves overtop Old Highway 101 and the revetments that protect three restaurants located west of Old Highway 101. Damages in this reach are categorized as clean-up costs (debris removal from Old Highway 101 and clean-up costs to the three restaurant interiors), damage costs to the three restaurant interiors, and traffic delay costs that are incurred when Old Highway 101 is closed due to debris in the roadway and clean up operations.

This analysis assesses the expected annual damages from return events (2-year to 100-year) given the probability of each return event occurring when tides are high enough to cause wave-overtopping. The two-year event (50% Annual Chance of Exceedance [ACE]) is considered minor and causes partial road closures and minimal structure content damages. Five and ten-year events (20% and 10% ACE) cause full road closures but minimal structure content damages. All other events are considered major and can cause full road closures and substantial structure and content damage (see **Table 4.7-1**).

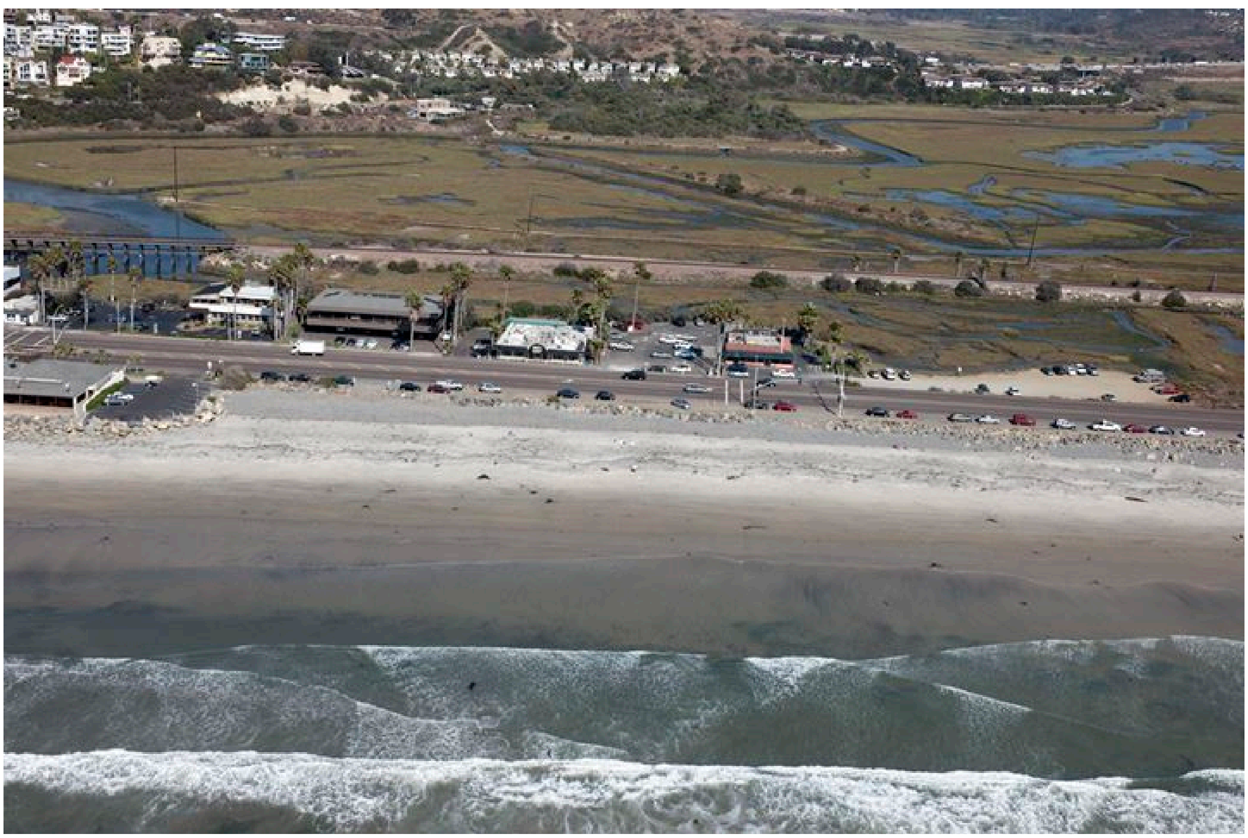


Figure 4.7-1 Reach 7

Table 4.7-1 Damage from Major Overtopping Event

Type	Unit Cost of Restoration	Total Cost
Plate-Glass	$32.99/sqft	$56,218
Carpeting & Fixtures	$14.57/sqft	$315,905
Kitchen	$906/linear ft	$453,095
Clean-up Costs	$896/event	$2,688
Total Cost		**$827,906**

4.7.2 Restaurant Clean-up

Water levels approximately two feet above the parking lot elevation caused by minor storms result in limited water damage to carpets in the restaurant. Moderate storms result in the occasional loss of plate glass walls which shield patio areas, and the restaurants have abandoned using outdoor patio areas, but have left the glass as additional protection for the restaurant windows. Major storms in 1988 and again in 1997 resulted in extensive destruction to the interior of one restaurant, though damage to the kitchen was minimal due to its placement in the building. Given this information a major storm event (4% ACE event or larger) is assumed to cause extensive destruction to the restaurants, but moderate storm events cause damages limited to clean-up costs. A major overtopping event, which can occur during 25-year return (4% ACE) events or greater, cause about $800,000 in damages to three structures in Reach 7. A minor overtopping event, defined as 2 to 10-year return events, causes about $2,700 in damages.

4.7.3 Highway 101 Cleanup

Storm waves deposit cobbles and other debris on the roadway and right-of-way that is routinely removed by the City of Encinitas. Partial or full closure of Old Highway 101 to vehicular traffic is often required during clean up operations (traffic delay damages are discussed in the next section). Roadway cleanup cost is calculated from costs incurred by the City of Encinitas to remove debris from the roadway after storm wave overtopping of Old Highway 101. Data provided by the City of Encinitas indicate that debris removal operations for events that close Old Highway 101 cost approximately $1,299 in labor, staff, and equipment costs.

4.7.4 Travel Delay

Travel delays, shown in **Table 4.7-2**, are caused when storm induced wave run-up deposits cobble and debris on the roadway requiring partial or full roadway closure during clean up operations. Roadway closure data provided by the City of Encinitas was compared to historic storm data to correlate roadway closures with the annual probability of storm events. Travel delay costs are based on the median household income for Encinitas obtained from the US Census Bureau. The amount is $86,131 or $41.41 per hour. Vehicle counts were broken down by trip purpose using the *Survey of California Drivers*. The value of travel time follows guidance from *Value of Time Saved for Use in Corps Planning Studies* IWR 91-R-12.

Table 4.7-2 Travel Delay Severity

	Add'l Travel Distance	Travel Delay	Total Cost
Partial Road Closure (minor event)	0 miles	1 minute	$73
Full Road Closure (major event)	3.5 miles	8 minutes	$9,474

Partial roadway closure will result from a two-year storm (50% ACE) event and that full roadway closure will result from storms ranging from the 25% ACE to the 1% ACE event. Using the man-hour estimates presented in **Table 4.7-2,** and assuming a two-person crew, a partial road closure would be two hours (rounded to the nearest full hour) in duration and a full road closure would be four hours in duration. Each day 21,251 cars travel north and southbound on Highway 101 through Reach 7 daily, which means on average 885 vehicles travel that route each hour. According to city officials vehicle traffic is not expected to increase noticeably during the study period so daily travel was held at 21,251.

Partial closure of the roadway at Old Highway 101 is expected to cause southbound (west side of the roadway) motorists to slow down due to merging traffic. Speed reduction during a partial roadway closure is expected to add negligible travel time (about one minute). Full closure of the roadway will cause northbound and southbound travel interruption.

4.7.5 Total Damages by Return Event

Based on the analyses performed on restaurant cleanup, highway cleanup, and travel delay, damages by return event are as shown in **Table 4.7-3**. Fifty-percent ACE events cause about $4,000 in total damages on average while 4% ACE events and larger cause $840,000 in damages primarily from restaurant cleanup.

Table 4.7-3 Damages by Annual Chance of Exceedance

Return Event	Travel Delay	Highway 101 Cleanup	Restaurant Cleanup	Total Damages
2 year (50% ACE)	$70	$1,300	$2,700	$4,000
5 year (20% ACE)	$9,500	$1,300	$2,700	$13,500
10 year (10% ACE)	$9,500	$1,300	$2,700	$13,500
25 year (4% ACE)	$9,500	$1,300	$827,900	$838,700
50 year (2% ACE)	$9,500	$1,300	$827,900	$838,700
100 year (1% ACE)	$9,500	$1,300	$827,900	$838,700

4.7.6 Expected Annual Damages

In order for an event to cause overtopping it must coincide with tidal conditions in the low-lying areas of Reach 7 only. All other reaches within the study area have bluff tops and are unaffected by overtopping in the manner Reach 7 is impacted. The probability tidal conditions are suitable for a given return event to cause overtopping factor in the share of tidal conditions that meet or exceed the threshold for overtopping given each return event. As would be expected tidal conditions exceed this threshold more frequently under a 1% ACE event

Table 4.7-4 Expected Annual Damages

Year	Low SLR	High SLR
2015	$17,000	$21,000
2025	$18,000	$25,000
2035	$19,000	$30,000
2040	$20,000	$36,000
2055	$21,000	$42,000
2064	$22,000	$48,000

compared to a 50% event and more frequently under the high sea-level rise scenario compared to the low. To determine expected annual damages (EAD), we combined the probability of wave exceedance, damages by return event, and probability of return event to determine EAD. The stream of projected EAD values was discounted to one present value and annualized to derive average annual damages. For instance note the total damages for the 10% ACE event are $13,500 and $838,700 for the 4% ACE event (see **Table 4.7-3**). The probability of tidal conditions exceeding the height that would allow the 10% ACE event to cause flooding is 22.05% in 2015 under the low sea level scenario. This is multiplied by the total damages for the 10% ACE event, $13,500, to derive result, $2,970. This process is repeated for the remaining return events (50%, 20%, 4%, 2%, 1% events). Next the average damages across return events are calculated by finding the difference between the probability of each pair of return event (e.g., the 10% ACE event to 4% ACE event pair is 10% - 4% = 6%) and multiplying this by the average damages between those same pairs of return events (e.g., $217,800/2 + $2,970/2 = $110,400). The sum of this set of calculations is the expected annual damages ($17,200 in 2015). These calculations, shown in **Table 4.7-4**, are done for each return event for all 50 years of the study period, then summed and discounted to determine the net present value and annualized to estimate the equivalent annual damages for low and high sea-level rise scenarios.

4.7.7 Results

As shown in **Figure 4.7-2**, the expected annual damages (EAD) start near $18,000 in the base year and grow gradually under low sea-level rise conditions but accelerate under high sea-level rise conditions. However, even with accelerated growth expected annual damages remain below $50,000 in the final year of the study period, 2064. The average annual damages are $18,692 under the low sea-level rise scenario and $28,985 under the high sea-level rise scenario. This is primarily a result of the limited value of the structures in Reach 7, which is the only low-lying reach in the study area. Since there are only three structures in this reach and lack of space for new development and environmental concerns would likely restrain any future structure growth, the Project Delivery Team determined that the expected annual damages are not large enough to support any project alternatives. Therefore no project alternatives were formulated for detailed analysis to address wave-overtopping in Reach 7.

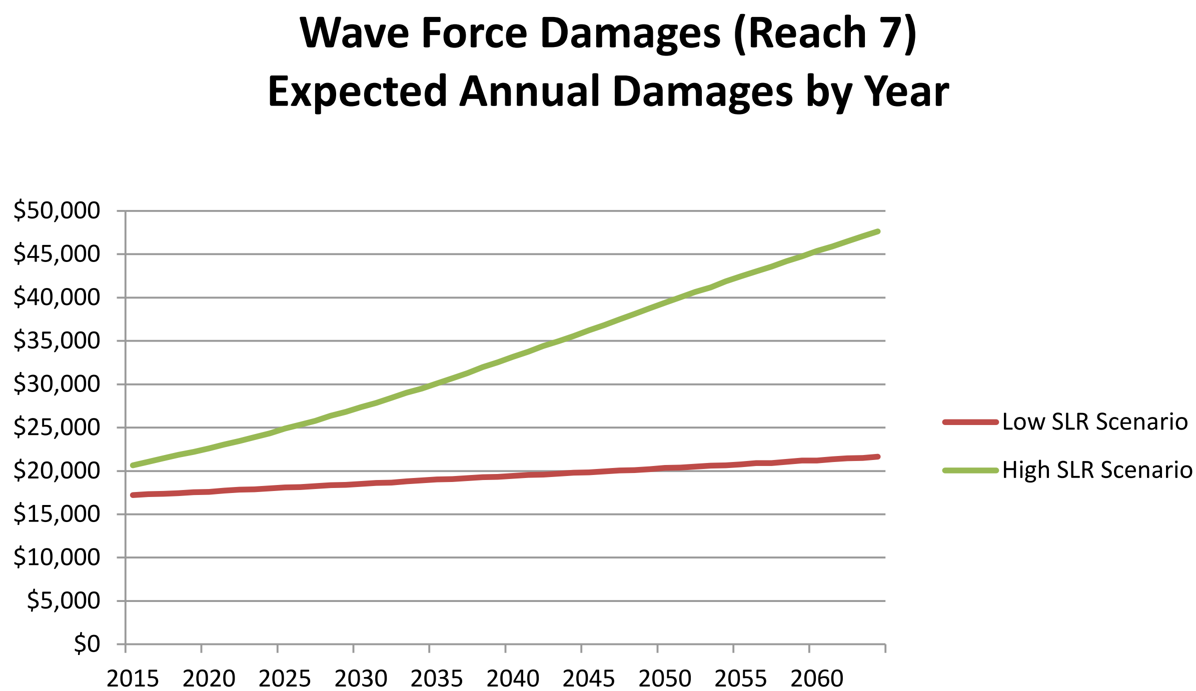


Figure 4.7-2 Expected Annual Damages Reach 7

4.8 Without Project Analysis: Recreation

4.8.1 Public Parking & Access

The city of Encinitas has approximately 2,566 public parking spots including street-side parking within a reasonable walking distance of nine different public access locations.[43] The distance between public access points varies from one-tenth to three-quarters mile. The city of Solana Beach has approximately 2,061 public parking spaces including street-side parking within a reasonable walking distance of four public access points. If only half of these parking spaces are available to beach visitors, over 10,000 daily visitors could arrive by vehicle at each city, which exceeds the current and anticipated future demand.

The study area is also serviced by regular public transit. Buses travel up and down the coastline (north-south) making stops near public access points 28-31 times every day. Buses traveling between the study area and inland communities make between one and two dozen stops daily with limited service on weekends. The study area is also serviced by commuter rail service that connects downtown San Diego and the coastal communities in the northern half of the county. The commuter rail makes stops within two to three blocks of the two most popular public access points within the study area. In addition many individuals have been observed bicycling to the study area beaches and several thousand residents and visitors in the study area reside or stay within walking distance of public access points.

[43] ER 1165-2-130 states parking must be “located reasonably nearby” the project. No specific distance is given; however, we have determined a reasonable walking distance is less than 1/3 of a mile. With the exception Solana Beach transit parking (about 300 lots), street and public parking lots cited are typically 1/10 to ¼ mile from access points.

In sum the amount of parking is adequate to meet current and future peak demands, parking is located within reasonable walking distances from the access points, and if also taking into consideration visitation that is supported by modes other than car (buses, walking, bicycling, train), there is ample parking and other infrastructure to support projected recreation demand.

Solana Beach has implemented Land Use Plan provisions consistent with the California Coastal Management Program to ensure that “the protection, provision, and enhancement of coastal public access and recreation of opportunities in the City of Solana Beach [is] consistent with goals, objectives, and policies of the California Coastal Act. The policies can be broadly summarized as: improving existing public access opportunities by supporting proposals to enhance access-ways; providing objectives, standards, and designated sites for locating visitor serving recreational facilities and commercial uses such as hotels and motels; development of enhanced signage program to better identify public access and use opportunities; identifying and seeking removal of any unauthorized physical development, including signs and fences on the beach, which inhibit public use of public beach areas and state tidelands; and protecting existing and future parking availability near the shoreline and trail-access ways throughout the city.”

Similarly, Encinitas has proposed a draft Comprehensive General Use Plan that includes a Local Coastal Program (LCP) consistent with the California Coastal Management Program. “The goals of the LCP are to protect, maintain and enhance the Coastal Zone environment; ensure balanced utilization and conservation; maximize public access to and along the coast; prioritize coastal dependent and related development; and encourage coordinated state and local initiatives to implement beneficial programs and other educational uses.“

The cities are required by these Land Use Provisions and have intended for their beaches to be accessible to the public despite the unique challenges from bluff-top coastlines. Since public access to the beach along these coastal bluffs generally requires construction of stairways, often armored, on stable portions of the bluff, the paramount consideration and constraint is locating and obtaining easements to construct these stairways in a manner that allows visitors a safe descent to the beach. For this purpose the cities maintain eight public access points along the bluff-top to allow for safe descent to the beach. Two of these are within Segment 1 (Stonesteps and D-street) and three are within Segment 2 (Tide Beach, Seascape Surf, and Del Mar Shores). In addition Segment 1 includes one public access point at beach level (Moonlight) and Segment 2 includes two access points at beach level (San Elijo State Park and Fletcher Cove). Segment 1 includes good public access and sufficient parking but the northern portion of the tentatively selected plan extends approximately 0.4 miles from the nearest public access point. The southern end of Segment 1 extends 0.5 miles from the nearest public access point. The distance between all public access points within Segment 1 is approximately 0.4 miles or less.

In the study area beach visitors have been routinely observed recreating throughout the study area and specifically more than ¼ mile from an access point. This can be partly attributed to the extensive urbanization along the coastline and large number of tourists. Beaches can become crowded throughout the summer and fall causing some beach visitors to walk the extra distance to enjoy open spaces for recreation. Others observed long distances from access points are taking beach walks or seeking out favored surfing and snorkeling spots among other reasons.

Although there are some locations along the project area where the distance between access points is somewhat greater than what the regulation construes to be the effective limit for public use: 1) the Cities have made every effort possible to provide as much beach access as possible given the geographical/physical constraints of the study area and; 2) the effective public use radius as cited in the regulation does not reflect the actual effective radius of public use in the Study Area, as significant recreation occurs throughout both of the Study Area segments, including those portions that exceed the referenced limits. The District believes that consideration should be given to the above factors regarding whether there should be any cost sharing implications relating to parking and access in the study area.

4.8.2 Valuation Process

Recent detailed recreation visitor counts were produced by both cities and reveal that one-third of study area beach visits have occurred in Reaches 3-5 (Segment 1) and about 5% have occurred in reaches 8-9 (Segment 2) out of 3 to 3.3 million visits annually, as shown in **Table 4.8-1**.

Table 4.8-1 Historic Visitor Share by Reach (2005-2009)

Reach	Share of Visitors
1	14%
2	7%
3	5%
4	19%
5	8%
6	23%
7	21%
8	1%
9	4%

Recreation was valued using the Unit Day Value method as outlined by ER 1105-2-100 and IWR Report 86-R-4. Unit Day Values were assigned using the *Guidelines for Assigning Points for General Recreation*[44] and in consideration of expert opinions by local lifeguards from both cities and San Elijo State Park. Moonlight Beach within Encinitas hosts a significant share of the total recreation visits to the study area and has a large number of recreation facilities. Consequently, it was assigned recreation points separately from the rest of the study area beaches. It earned 57 points out of 100 under minimal crowding conditions based upon adequate facilities (restrooms, fire pits, and concessions), good esthetic qualities, superb access pathways and parking, and multiple recreation opportunities (picnicking, walking, sunbathing, beach volleyball). All other beaches in the study area were assigned 45 points under minimal crowding conditions based on good accessibility, good environmental esthetics, and several recreation opportunities (see **Table 4.8-2**). We also adjusted point values downward when crowding occurred. **Figure 4.8-1** shows how crowding levels affect the unit day value. When the square footage per visitor is high, crowding levels are minimal. In that case beach visitors receive all forty-five points. However, crowding lowers the recreation experience and carrying capacity of in particular thereby lowering the point value and unit day value. Crowding becomes an increasing issue during the study period because of beach erosion, which is why it was modeled.

[44] EGM #11-03

Table 4.8-2 Basis for Unit Day Values

Basis for Maximum Unit Day Value (minimal crowding)		
Criteria	Point Value	Description
Recreation Experience	13	hiking/walking, sunbathing--no specialized activities typically
Availability of Opportunity	0	many other beach communities within 30 min drive
Carrying Capacity	9	adequate recreating area, limited restrooms, firepits, and lifeguard off-season (2 of 6 beaches in Encinitas w/ restroom, 1 of 4 Solana Beach, 2 of 2 in Cardiff/San Elijo)
Accessibility	14	good access throughout study area, adequate parking in most access points
Environmental	9	bluff-topped beaches with development apparent
Total Point Value	**45**	**out of 100 possible points (about $7.00 per visitor)**

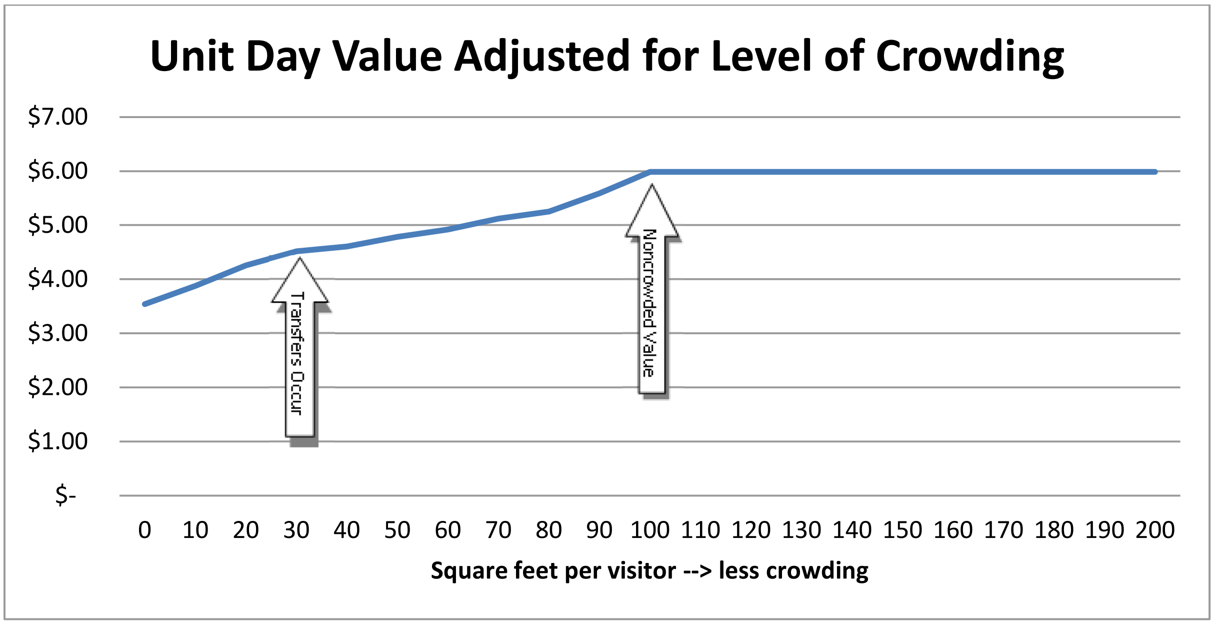


Figure 4.8-1 Unit Day Value Adjusted for Level of Crowding

Recreation demand is met in the following manner (and shown in **Figure 4.8-2**). First demand is met by visitations to the dry beach. These visitations are distributed among off peak days, peak weekdays, and peak weekends and assigned unit day values based on the average level of crowding (square feet per visitor). To derive the crowding level during the off-peak season, for instance, the total visitation demand during the off-peak season is divided by the number of off-peak days to determine the average visitors per day. Then the average visitors per day is divided by the turnover rate to determine the average number of visitors on the beach at any moment. Finally the beach area is divided by the average visitors on the beach at any moment to determine the level of crowding (square feet per visitor). The crowding level is not allowed to fall below 30 square feet per person on the dry beach because previous USACE studies have indicated beach visitors prefer to transfer to another location around this level of crowding. When there is excess demand that would lead to crowding beyond this cut-off, it is transferred to the wet beach.

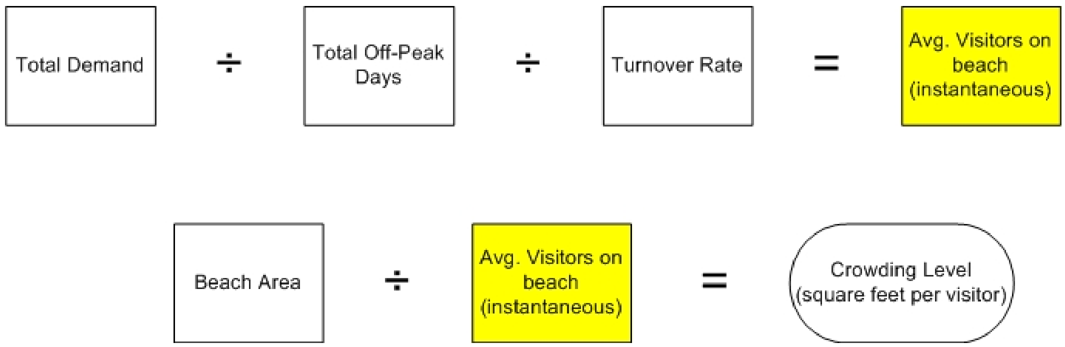


Figure 4.8-2 How to calculate recreation values

Example of how to calculate crowding level for 'off-peak' (winter) days. Calculating 'peak' demand days simply involves adding up the days and replacing *Total Off-Peak Days* with *Total Peak Days*. Once 'crowding level' is calculated the final step to value recreation involves applying the correct Unit Day Value and multiplying it by the number of beach visitors.

4.8.3 Wet Beach Recreation

Visitors transfer to the wet beach rather than go to an off-site dry beach because historical attendance patterns show visitations have occurred on wet beaches, particularly during the winter when the beach area is smaller due to seasonal variations. Once visitors transfer to the wet beach, the same process used on the dry beach is used to determine the level of crowding on the wet beach. However, since wet beach recreation is generally inferior to the opportunity for both dry and wet beach recreation, visits to wet beaches are given one fixed UDV that is below the minimum dry beach UDV. Finally, when overcrowding occurs on the wet beach, potential visitors transfer to an off-site beach. The net benefits from this transfer are assumed to be the lowest unit day value, $3.58, and are applied to all off-site transfers.

4.8.4 Demand & Growth in Demand

Historical beach recreation levels were determined by a system of automatic counters at Encinitas and 13 months of surveying beach visitors in 2009-2010 at Solana Beach.[45] This initial level of recreation demand is grown at the same rate as the population of San Diego County is projected to grow by demographers at the California Department of Finance.[46] Since the California Department of Finance releases growth projection by decade only, the geometric mean for each ten-year period was calculated and applied annually to arrive at the year-over-year increase in recreation demand under without project conditions (see **Table 4.8-3**). Since this growth is based on county-wide projections, both Encinitas and Solana Beach have been modeled with the same growth rates. The results are shown below.

[45] City of Solana Beach Draft Land Lease/Recreation Fee Study, March 2010.
[46] See http://www.dof.ca.gov/research/demographic/

Table 4.8-3 Recreation Growth by Decade

Decade	Decade-over-Decade Growth Rate	Annual Growth Rate (Geometric Mean)
2010-2019	10.3%	0.99%
2020-2029	9.5%	0.91%
2030-2039	7.6%	0.73%
2040-2049	5.3%	0.52%
2050-2059	0%	0.00%
2060-2064	0%	0.00%

Growth rates are highest initially but gradually slow each decade, meaning the population of San Diego County, and therefore demand for recreation, is expected to grow more slowly in coming decades compared to recent increases. The California Department of Finance does not provide growth projections beyond 2050 so a conservative estimate of no additional growth from 2050-2064 was used instead.[47] These growth rates were applied to the most recent visitor data to project recreation demand as shown in **Table 4.8-4**.

Table 4.8-4 Recreation Demand in Study Area Beaches

Year	Segment 1 (Encinitas)	Segment 2 (Solana Beach)
2010	972,000	99,000
2020	1,072,000	109,000
2030	1,174,000	120,000
2040	1,263,000	129,000
2050	1,330,000	136,000
2064	1,330,000	136,000

4.8.5 Sea-Level Rise and Beach Erosion

Sea-level rise reduces the available beach area to recreate throughout time. This impact is addressed through scenario analysis of low and high sea-level rise as explained previously. Beach area has been estimated for all reaches. A distinct 50-year sequence of erosion rates is applied to the beach area for each sea-level rise scenario. Recreation values are captured for each sea-level rise scenario. As expected the high sea-level rise scenario causes more rapid beach loss than the low sea-level rise (see **Table 4.8-5**). With all else held constant, beach erosion causes recreation to transfer from the high-value dry beach to low-value wet beach and then from the low-value beach to an off-site beach, which is termed "transfer."

In the summer, when beach area is largest, the dry beach area is shown in **Table 4.8-5** under low and high sea-level rise scenarios. High sea-level rise has a profound impact on beach erosion compared to low, historic sea-level rise although beach area still is cut by more than 50% under low sea-level rise conditions during the period of analysis.

[47] Had the growth levels from 2040-2049 been applied to the remainder of the study period instead, demand would have increased 8.1% between 2050 and 2064, which is a modest difference from the projections in the model.

Table 4.8-5 Summer Dry Beach Area for Recreation

Low SLR Year	Segment 1 (Encinitas)	Segment 2 (Solana Beach)
2010	239,000 sqft	99,000 sqft
2020	473,000 sqft	251,000 sqft
2030	430,000 sqft	220,000 sqft
2040	387,000 sqft	189,000 sqft
2050	344,000 sqft	158,000 sqft
2064	283,000 sqft	114,000 sqft
High SLR		
2010	229,000 sqft	92,000 sqft
2020	342,000 sqft	156,000 sqft
2030	135,000 sqft	8,000 sqft
2040	13,000 sqft	--
2050	--	--
2064	--	--

4.8.6 Results

The recreation analysis under without project conditions reveals that recreation values peak at around 2050 under low sea-level rise scenario for Reaches 3-5 (Segment 1). This peak is due to the confluence of increasing recreation demand and minimum to moderate crowding levels. Throughout the remainder of the period of analysis, recreation values gradually fall because eroding beaches lead to higher crowding levels, which in turn cause UDV to decrease moderately and some visitors to transfer to offsite beaches. This same process occurs under the high sea-level rise scenario except earlier in the period of analysis, around 2020 when recreation values peak. As expected the beach erosion under the high SLR scenario reduces recreation values sooner and more significantly.

Recreation values in Reaches 8-9 (Segment 2) under the low SLR scenario continue to increase gradually during the period of analysis with the increase in demand. Historically, much of the recreation has occurred on wet beaches in this area and consequently we do not see the drop in recreation values associated with a shift from recreation on a dry beach to recreation on a wet beach.

Historical attendance records show around 1 million visits recently occurred between Reaches 3-5 in Encinitas while approximately 100,000 visits occurred between Reaches 8-9 in Solana Beach. Therefore, recreation values are significantly higher in Reaches 3-5. When broken down in to the segments that were analyzed for project alternatives, Segment 1 (Reach 3-5) peaks around $8.7 million in annual recreation value while Segment 2 (Reaches 8-9) peaks around $800,000 as shown in **Table 4.8-6**. We have recreation data for Reaches 1-2 and Reaches 6-7; however, we were not provided erosion rates owing to the lack of feasible alternatives in those reaches. Recreation values were developed for all reaches that could reasonably be expected to generate sufficient damages to justify project alternatives.

Table 4.8-6 Nominal Recreation Values by Reach by Decade

Low SLR							
	2010	*2015*	*2020*	*2030*	*2040*	*2050*	*2060*
REACH 3	$727,000	$991,000	$1,012,000	$928,000	$995,000	$1,044,000	$994,000
REACH 4	$4,389,000	$4,831,000	$4,993,000	$5,383,000	$5,702,000	$5,900,000	$5,900,000
REACH 5	$1,277,000	$1,709,000	$1,783,000	$1,627,000	$1,665,000	$1,748,000	$1,748,000
…	…	…	…	…	…	…	…
REACH 8	$90,000	$115,000	$121,000	$108,000	$117,000	$123,000	$123,000
REACH 9	$481,000	$616,000	$536,000	$587,000	$628,000	$658,000	$658,000
TOTAL	$6,964,000	$8,262,000	$8,446,000	$8,634,000	$9,107,000	$9,473,000	$9,423,000
Segment 1	$6,393,000	$7,532,000	$7,789,000	$7,938,000	$8,362,000	$8,692,000	$8,642,000
Segment 2	$571,000	$731,000	$658,000	$696,000	$745,000	$781,000	$781,000
High SLR							
	2010	*2015*	*2020*	*2030*	*2040*	*2050*	*2060*
REACH 3	$715,000	$807,000	$845,000	$779,000	$719,000	$757,000	$706,000
REACH 4	$4,312,000	$4,736,000	$4,841,000	$3,965,000	$3,197,000	$3,145,000	$2,921,000
REACH 5	$1,273,000	$1,417,000	$1,413,000	$1,381,000	$1,234,000	$1,299,000	$1,214,000
…	…	…	…	…	…	…	…
REACH 8	$90,000	$94,000	$99,000	$105,000	$81,000	$85,000	$81,000
REACH 9	$481,000	$511,000	$534,000	$414,000	$442,000	$466,000	$441,000
TOTAL	$6,871,000	$7,565,000	$7,732,000	$6,643,000	$5,672,000	$5,752,000	$5,363,000
Segment 1	$6,300,000	$6,960,000	$7,100,000	$6,124,000	$5,150,000	$5,202,000	$4,841,000
Segment 2	$571,000	$605,000	$633,000	$519,000	$523,000	$550,000	$522,000

The average annualized recreation values, which are shown in **Table 4.8-7** below, are $8.1 million for Segment 1 and $700,000 for Segment 2 under the low SLR scenario ($6.2 million and $600,000 under the high SLR scenario, respectively). Reach 4, which includes Moonlight Beach, has the highest value for Encinitas. Reach 9, which includes Fletcher Cove, has the highest value for Solana Beach. The lower recreation values under the high sea-level rise scenario result from higher erosion rates and less beach for recreation rather than changes to demand. We have assumed recreation demand would be unchanged by sea-level rise although the number of visits to the study are would be affected. Due to limited coastal storm damages to Reaches 1-2 and 6-7 no recreation analysis was performed for those reaches only; however, detailed counting by the city of Encinitas shows that 40-50% of total recreation visits occur in those reaches. Further analysis of existing conditions revealed that crowding levels at Reaches 1-2 are similar to Reaches 3-5 while crowding levels at Reach 6, which is situated in a low-lying lagoon, are less.

Table 4.8-7 Annualized Recreation Values by Reach

Low SLR		High SLR	
REACH 3	$980,000	REACH 3	$779,000
REACH 4	$5,357,000	REACH 4	$4,090,000
REACH 5	$1,714,000	REACH 5	$1,339,000
…	…	…	…
REACH 8	$117,000	REACH 8	$91,000
REACH 9	$601,000	REACH 9	$486,000
TOTAL	**$8,769,000**	**TOTAL**	**$6,785,000**
Segment 1	$8,051,000	Segment 1	$6,208,000
Segment 2	$718,000	Segment 2	$577,000

4.9 Without Project Summary of Results

A summary of without project results is presented in **Table 4.9-1**. First damages for the *Armoring* and *Retreat Scenarios* were calculated then weights were applied to each as shown below. The resulting Weighted Damages minus Sloughing Damages to the bluff top edge constitute Preventable Without Project Damages. Only Reach 7 was evaluated for overtopping because it is composed of low-lying areas. Recreation values were developed for all reaches that could reasonably be expected to generate sufficient damages to justify project alternatives. Without project damages are highest under the high sea-level rise scenario due to increased episodic erosion events and recreation values are lowest due to increased beach erosion. However, under the low and high sea-level rise scenarios the number of seawalls constructed and the nominal (undiscounted) damages are similar. This is because in general the existing, unprotected parcels that become threatened under either sea level rise scenario are the same; in other words, our modeling shows that for most unprotected parcels the uncertainty is not if a given parcel will need to construct a seawall in the future but when will it need to do that--sooner under high SLR and later under low SLR. Therefore the difference in average annual damages between the two sea-level scenarios is primarily the result of the timing of seawall construction (earlier in the study period under high SLR and later in the study period under low SLR) rather than more seawall construction under the high SLR. Refer to **Section 4.4.6** for further explanation.

Table 4.9-1 Without Project Summary of Results (Average Annual Values)

Low SLR	Armoring Scenario	Retreat Scenario	Weighted Armoring & Retreat Scenarios			Sloughing	Overtopping (Reach 7 only)	Preventable Without Project Damages	Rec Values
			Armor %	*Retreat %*	*Weighted Damages*				
Reach 1	156,000	156,000	82%	18%	156,000	n/a	n/a	156,000	n/a
Reach 2	291,000	162,000	82%	18%	268,000	n/a	n/a	268,000	n/a
Reach 3	558,000	660,000	82%	18%	576,000	99,000	n/a	477,000	980,000
Reach 4	1,124,000	946,000	82%	18%	1,092,000	202,000	n/a	890,000	5,357,000
Reach 5	1,510,000	1,353,000	82%	18%	1,482,000	96,000	n/a	1,386,000	1,714,000
Reach 6	28,000	13,000	82%	18%	25,000	n/a	n/a	25,000	n/a
Reach 7	n/a	n/a	n/a	n/a	n/a	n/a	19,000	19,000	n/a
Reach 8	1,028,000	1,006,000	78%	22%	1,023,000	42,000	n/a	981,000	117,000
Reach 9[48]	1,680,000	2,824,,000	78%	22%	1,930,000	55,000	n/a	1,875,000	601,000
Total	**6,375,000**	**7,120,000**	**n/a**	**n/a**	**6,552,000**	**992,000**	**19,000**	**6,077,000**	**8,769,000**
Segment 1	3,192,000	2,959,000			3,150,000	397,000		2,753,000	8,051,000
Segment 2	2,708,000	3,830,000			2,953,000	595,000		2,358,000	718,000
High SLR	**Armoring Scenario**	**Retreat Scenario**	**Weighted Armoring & Retreat Scenarios**			**Sloughing**	**Overtopping (Reach 7 only)**	**Preventable Without Project Damages**	**Recreation Values**
			Armor %	*Retreat %*	*Weighted Damages*				
Reach 1	159,000	158,000	80%	20%	159,000	n/a	n/a	159,000	n/a
Reach 2	357,000	289,000	80%	20%	343,000	n/a	n/a	343,000	n/a
Reach 3	534,000	788,000	80%	20%	585,000	99,000	n/a	486,000	779,000
Reach 4	1,200,000	1,468,000	80%	20%	1,254,000	202,000	n/a	1,052,000	4,090,000
Reach 5	1,682,000	1,892,000	80%	20%	1,724,000	96,000	n/a	1,628,000	1,339,000
Reach 6	108,000	90,000	80%	20%	104,000	n/a	n/a	104,000	n/a
Reach 7	n/a	n/a	n/a	n/a	n/a	n/a	29,000	29,000	n/a
Reach 8	987,000	1,257,000	71%	29%	1,066,000	42,000	n/a	1,024,000	91,000
Reach 9[49]	2,177,000	3,599,000	71%	29%	2,590,000	55,000	n/a	2,577,000	486,000
Total	**7,204,000**	**9,541,000**	**n/a**	**n/a**	**7,825,000**	**992,000**	**$29,000**	**7,402,,000**	**6,785,000**
Segment 1	3,416,000	4,148,000	n/a	n/a	3,563,000	397,000	n/a	3,166,000	6,208,000
Segment 2	3,164,000	4,856,000	n/a	n/a	3,656,000	595,000	n/a	3,061,000	577,000

[48] Includes the several parcels and structures contiguous to and immediately south of Reach 9 that would receive some storm damage reduction benefits from any sand placement alternatives. See Armoring Scenario and Retreat Scenario for further details.
[49] Ibid.

5 WITH PROJECT ANALYSIS

5.1 Layout & Process

The with-project alternatives capture the benefits from the reduction in coastal damages modeled under without-project conditions—*Armoring & Retreat Scenarios*—as well as increased recreation benefits, if applicable.[50] Without project damages from the *Armoring* and *Retreat Scenario* are weighted according to the probability of each scenario occurring. This determines the expected without project damages and also the maximum possible coastal storm damage reduction benefits that can be achieved from the array of project alternatives. The maximum benefits may or may not be achieved depending on the amount of coastal storm damage reduction each alternative offers. All project alternatives have been formulated to reduce coastal storm damage caused by wave attack to the base/toe of the exposed bluffs, as shown in **Table 5.1-1**.

Final Array of Project Alternatives Analyzed:

- Seawall/Hard Structure
- Toe Notch/Sea Cave Fill (*Notch Fill Plan)*
- Toe Notch/Sea Cave Fill & Sand Placement (*Hybrid Plan)*
- Sand Placement (*Beach Fill Plan*)

Table 5.1-1 Quantified Benefits by Project Alternative

Alternative	Coastal Storm Damage Reduction	Recreation
Seawall	YES	--
Notch Fill	YES	--
Hybrid	YES	YES
Beach Fill	YES	YES

The Seawall alternative requires constructing a series of seawalls at the base of the bluff from 25-35 feet tall and extending across all unprotected/unarmored parcels in Segment 1 and 2. Only parcels without existing seawalls would be impacted. The other hard structure alternative analyzed is the Notch Fill plan. This alternative requires applying notch fill inside sea caves/toe notches equivalent in strength and durability to the surrounding sandstone bluff. This material erodes when exposed to regular wave attack in the same manner as the surrounding sandstone; therefore, maintenance occurs at regular intervals to lower residual risk. The Notch Fill & Sand Placement alternative, also referred to as the *Hybrid Plan*, requires applying notch fill inside sea caves/toe notches in the same manner as the Notch Fill alternative. In addition sand is placed on the existing beach to enhance the protection offered by filling the toe notches. The Sand Placement alternative, also referred to as the *Beach Fill Only Plan*, requires sand to be placed on the existing beaches without augmentation from any hard structure. The *Hybrid Plans* and *Beach Fill Only Plans* involved analyzing a range of added beach widths and

[50] Wave overtopping impacts several structures in Reach 7 only. The damages from this overtopping were too low to justify any project alternatives; therefore, no project alternative was evaluated for Reach 7.Project alternatives that provide recreation benefits are Beach Fill Only and Hybrid (Beach fill & Toe notch fill) Plans. Projects alternatives that provide no recreation benefits are the Seawall and Toe Notch/Sea Cave Fill plans.

nourishment cycles. Added beach width was analyzed in 50-foot increments from 50 feet to 200 feet (400 feet for Segment 2) and nourishments cycles from 2 years to 16 years for both segments. One hundred-twenty combinations of added beach width and nourishment cycle were evaluated for Segment 2 and sixty were evaluated for Segment 1.

The benefits that have been quantified for the alternatives are shown in **Table 5.1-1**. The seawall alternative offers coastal storm damage reduction but does not include any added recreation benefits. Placing notch fill inside the sea caves at the base of the bluff also offers coastal storm damage reduction without added recreation benefits. However the Hybrid and Beach Fill alternatives both provide coastal storm damage reduction and added recreation benefits. The costs have been quantified for the alternatives as shown in **Table 5.1-2**. The seawall alternative incurs construction, operation & maintenance, and sedimentation & recreation loss fees. These fees are imposed on the local sponsor by the CCC to mitigate for lost sand sediment and recreation value when hard structures are constructed on the coastal bluffs. The notch fill alternative also incurs construction, operation & maintenance, and sand sedimentation & recreation loss fees. The hybrid and beach fill alternatives do not incur these fees but do incur environmental mitigation costs for impacts to near-shore reefs.

Table 5.1-2 Quantified Costs by Project Alternative

Alternative	Construction	O&M	Environmental Mitigation	Sedimentation & Recreation Loss Fee
Seawall	YES	YES	--	YES
Notch Fill	YES	YES	--	YES
Hybrid	YES	YES	YES	--
Beach Fill	YES	YES	YES	--

5.2 <u>Methodology</u>

5.2.1 Project Benefits

<u>Sand Placement/Beach Fill Alternatives</u>

Weighting the *Armoring and Retreat Scenarios* and adjusting for residual sloughing at the bluff edge gives the maximum preventable in coastal damages, while the actual reduction depends on the amount of coastal storm damage reduction each alternative provides. To determine a relationship between beach width and damages prevented, a “Partial Benefit Capture Curve" was developed which defines the relationship between the mean sea level beach width and the percentage of potential benefits realized from protecting the toe of the bluff from coastal storm erosion. Specifically, the Partial Benefit Capture Curve computes the relative reduction in notch erosion during the vulnerable winter season when sand thickness at the base of the bluff is typically exposed. This relative reduction in notch erosion is assumed to be inversely proportional to episodic bluff collapse and the economic damages associated with that bluff collapse (e.g., land loss, private seawall construction, and public and private structure loss). This means that the following relationship has been modeled: given a relative reduction in bluff notch erosion, episodic bluff collapse would be reduced by this same relative amount as would coastal storm damages. Refer to the **Coastal Engineering Appendix Section 6.6** for further explanation and key assumptions used to develop the Benefit Capture Curve.

Applying the "Partial Benefits Capture Curve" requires beach width measurements the entire length of Segments 1 & 2 for the duration of the period of analysis. To accomplish this, beach widths are broken down by increments then the length of beach at each increment of width is measured, which is weighted against the total length of each segment. To determine the benefits from each project alternative we applied the corresponding partial benefits percentage each year of the study period. Then this percentage for each year of the study period is multiplied by the maximum storm damage reduction benefits. Recall the maximum storm damage reduction benefits are the weighted *Retreat and Armoring Scenario* without project damages after accounting for residual sloughing damages at the top of the bluff that would not be impacted by any of the project alternatives.

For clarity a brief example is presented here, but for further explanation refer to the Economic Model Attachment E1. When analyzing the 2-year nourishment interval and the percentage of partial storm damage reduction benefits, the model generates these percentages for year 1 to 6 as shown in **Table 5.2-1**. Since the nourishment occurs every 2 years, the partial benefits percentage repeats every other year throughout the study period.

Table 5.2-1 Sample Calculation of Coastal Storm Damage Reduction Benefits

Added Beach Width	2015 1-yr	2016 2-yr	2017 1-yr	2018 2-yr	2019 1-yr	2020 2-yr	…	2030 2-yr
50-foot	51.63%	44.22%	51.63%	44.22%	51.63%	44.22%	…	44.22%
100-foot	81.30%	77.39%	81.30%	77.39%	81.30%	77.39%	…	77.39%
150-foot	94.10%	91.98%	94.10%	91.98%	94.10%	91.98%	…	91.98%
200-foot	97.71%	96.92%	97.71%	96.92%	97.71%	96.92%	…	96.92%

To turn the partial benefits percentages shown in the table above in to project benefits, the Maximum CSDR benefits are multiplied by the percentages shown for each year of the study period (2015-2064) and then discounted.

This means in 2015 adding 100-feet to the MSL beach would provide $2,589,188 in CSDRB (81.30% x $2,786,220) and $2,464,829 in 2016 (77.39% x $2,786,220). When nourishment occurs at the beginning of 2017 this sequence repeats and so forth for the duration of the period of analysis. This same sequence of calculations was done for nourishment cycles two to sixteen years and added beach widths from 50 to 200 feet in Encinitas and 50 to 400 feet in Solana Beach.

<u>Hybrid Alternatives</u>

The *Hybrid Plan* is analyzed in the same manner as the *Beach-fill/Sand Placement* alternatives described in the previous section. Sand is placed before the base year and at fixed intervals during the period of analysis and benefits are calculated using the same "Partial Benefits Curve." The only difference is the Hybrid Plan includes construction of a toe notch fill applied in the base year along with the initial beach fill. The notch fill would not be maintained, however the beach would be regularly nourished providing protection to the notch fill. Steps to determine the project alternative Net annual benefits, which are identical to the *Beach-Fill* alternatives, are:

1) Apply Benefit Capture Curve (BCC) to determine percent of Maximum CSDRB each alternative captures
2) Add Recreation Benefits
3) Subtract Project Costs
4) Record Project Net Benefits

The only difference between the analysis of the Hybrid and Beach-Fill Only alternatives is the Benefit Capture Curve used in Step 1. We determined that filling sea caves/toe notches in the base year adds 6-9% more CSDRB than adding beach fill alone.[51] The exact reduction in damages is shown in **Table 5.2-2**. The project benefits attributable to the toe notch/sea cave fill occur by applying the notch fill in the base year. The beach is nourished at regular intervals from two to sixteen years with initial added beach width from 50 to 400 feet, mirroring the analysis performed on the *Beach Fill* plan.

Table 5.2-2 Additional Benefits Attributable to Toe Notch Fill

	Low SLR	High SLR
Segment 1	9.4%	6.9%
Segment 2	8.2%	5.9%

When the notch fill is placed, the majority of this benefit occurs when relatively small volumes of beach fill are placed. In contrast large volumes of beach fill provide significant protection to the bluff toe leaving little opportunity for added protection from the notch fill. Coastal engineering determined that the added benefits from the notch fill tend to taper off once the beach width extends approximately 125 feet MSL. In practice this means most of the added benefits from filling the sea caves/toe notches occur when combined with the smallest beach fills, 50-foot and 100-foot added initial width. For comparison the percent of maximum CSDRB for the Hybrid Plan including notch fill and beach fill are shown in **Table 5.2-3**.

[51] Refer to the Economic Model Addendum for an explanation on how benefits from toe notch fills were evaluated.

Table 5.2-3 Percentage of Partial Coastal Storm Damage Reduction Benefits for Hybrid Alternatives

Segment 1								
Added Beach Width	1-yr	2-yr	3-yr	4-yr	5-yr	6-yr	…	16-yr
50-foot	53.17%	45.91%	41.51%	32.53%	26.65%	19.40%	…	11.90%
100-foot	81.60%	77.78%	74.04%	69.66%	64.70%	54.33%	…	17.23%
150-foot	94.10%	91.98%	87.73%	88.87%	85.72%	76.95%	…	19.56%
200-foot	97.71%	96.92%	94.31%	94.61%	93.55%	87.75%	…	30.98%
Segment 2								
Added Beach Width	**1-yr**	**2-yr**	**3-yr**	**4-yr**	**5-yr**	**6-yr**	**…**	**16-yr**
50-foot	15.19%	14.28%	14.33%	13.02%	13.94%	13.44%	…	8.57%
100-foot	34.15%	33.39%	33.42%	33.54%	31.46%	30.05%	…	18.79%
150-foot	51.86%	50.10%	50.21%	50.90%	50.78%	48.02%	…	34.18%
200-foot	65.53%	64.36%	64.42%	63.47%	62.04%	62.08%	…	48.63%
250-foot	76.55%	73.96%	73.57%	72.64%	72.14%	72.04%	…	60.61%
300-foot	83.40%	81.95%	81.06%	78.33%	77.62%	79.93%	…	69.39%
350-foot	88.20%	86.77%	85.67%	82.48%	81.90%	85.36%	…	75.76%
400-foot	91.73%	89.99%	89.96%	85.28%	85.86%	89.69%	…	80.00%

<u>Notch Fill Alternative</u>

The *Notch Fill* alternative was analyzed using the bluff top erosion rates and damage categories also analyzed in the without project conditions. The *Notch Fill* alternative analysis involves placing notch fill in the existing sea caves/toe notches in the base year and evaluating these with-project damages. The difference between these with-project damages and without-project damages is the *Notch Fill* benefit. To arrive at the *Notch Fill* benefits this procedure was followed:

- The difference between damages occurring with the notch fills in place and without project damages are the benefits of the *Notch Fill* alternative.
- Bluff top erosion occurs as if all the study area toe notches are set to zero (flush with the existing sandstone bluffs), which simulates notch fill since it would be similar in strength and durability to the surrounding sandstone. This means all notches have been filled but are allowed to erode during the five years between maintenance cycles.
- Bluff top erosion that occurs during the first five years of the study period after the notch fill has been placed would reoccur in a similar pattern the following five years and all subsequent five year periods between notch fill maintenance.
- If, after filling the sea caves with the notch fill, bluff erosion triggers seawall construction, no more notch fill is placed at those parcels and no more erosion occurs for the remainder of the study period. The damages from seawall construction and associated costs are recorded.
- There are no recreation benefits.

Seawall Alternative

The Seawall Alternative is a series of seawalls constructed at the base of the bluff (lower seawall only) for all unprotected parcels. The existing unprotected parcels proxy for the actual unprotected parcel at the base year, which is a three-year difference but is a reasonable simplification since we expect few private seawalls to be constructed during the interim should the seawall alternative become the recommended plan. The unprotected parcels the seawall would be constructed on are approximately 6,300 linear feet in Segment 1 and 4,300 linear feet in Segment 2. Coastal storm damage reduction benefits are 100% of without project damages net of residual/sloughing damages at the bluff top edge. There are no recreation benefits.

Recreation Values & Benefits

Recreation values for each project alternative are calculated in the same manner as recreation values under without project conditions. First demand and beach area are established to determine the maximum visitation capacity of each dry beach by peak and off-peak seasons. Demand that exceeds this dry beach capacity is transferred to the wet beaches at a lower, fixed unit day value. Finally any excess demand on the wet beaches transfers to an off-site beach and is given the lowest recreation value. Point values and therefore unit day values are the same as without project conditions for a given level of crowding. For a more detailed explanation of how unit day values were developed see **Section 4.8**. This section focuses on how recreation demand grows with each project alternative.

The with-project recreation analysis incorporates increased recreation opportunities and the corresponding increase in recreation demand due to larger, maintained beach areas. Recreation point values are identical to the without project recreation analysis; the project alternatives were only evaluated for reducing crowding level at the beach, which increases recreation values using the same point scale as without project analysis, and increased demand. To model crowding levels and increased demand, two factors were analyzed: *Demand Growth* and *Beach Area Growth*. Demand growth is the projected increase in recreation demand. Based on guidance from IWR Report 86-R-4[52], the *Similar Project Method* was used to estimate additional recreation demand created by the project alternatives. According to this guidance:

> *The similar project method involves comparing certain characteristics of the proposed project with those of a bank of existing water resources projects for which use statistics and other information have been compiled. The most efficient and technically sound similar project techniques are those which provide for the development of per capita use curves from which use estimates are then indirectly derived.*

To this end use statistics for two nearby and similar beaches in Carlsbad and Oceanside were obtained, per capita use curves were created and then adjusted for dissimilarities between these two beaches and the beaches within the study area following guidance from IWR Report 860R-4.[53] The adjustment is necessary due to (1) inherent dissimilarities between these similar-

[52] IWR Report 86-R-4 *National Economic Development Procedures Manual - Recreation Volume I: Recreation Use and Benefit Estimation Techniques*.

[53] “Use Statistics” relevant to this analysis are beach attendance and the share of attendees traveling various distance to get to Carlsbad and Oceanside beaches. Use statistics were obtained for Carlsbad beaches from *The Economics and Fiscal Impact of Carlsbad Beaches* by Dr. Philip King (2005) and for Oceanside beaches from *US Army Corps of Engineers Beach Attendance Survey* (2005)

project beaches and the study area beaches despite close proximity, similar surrounding populations, and similar beach widths with a USACE project alternative in place and (2) insufficient data to develop a gravity model or use other methods of statistical control for dissimilar characteristics. A complete description of the analysis is available in the Economic Model Addendum.

Recreation growth is a result of added recreation capacity at both segments. Existing conditions are characterized by narrow beaches and limited opportunities to recreate on dry beach areas. Project alternatives would extend, and in some study area reaches create, dry beaches for additional recreation activities to occur. We estimate this would result in an additional 300-400 daily visits to each community's beaches depending on the size of the alternative, which is reflected in the recreation demand projections shown in **Table 5.2-4** and **Table 5.2-5**. In addition, recreation projections were informed by interviews with local lifeguards that indicated through anecdotal accounts that noticeably more visitations occurred in the study area beaches during the 1990s when beach widths were larger. Also of importance was an extensive survey done for Oceanside, a beach community immediately to the north of Encinitas, indicating that extensive erosion to those beaches would result in several hundred thousand less visits annually.[54] Although the impact to recreation from reduced beach widths may not be directly comparable to the impact from increasing beach widths, this report provided a better understanding of how and to what extent smaller beach widths such as those in Encinitas and Solana Beach negatively impact the recreational appeal of beaches and thereby suppress demand considerably.

The most obvious factors that could constrain recreation are parking and public access. We did not find either of these factors a constraint on the increased recreation demand we have forecasted during the study period. The city of Encinitas has approximately 2,566 public parking spots including street-side parking within a reasonable walking distance of nine different public access locations.[55] The distance between public access points varies from one-tenth to three-quarters mile. The city of Solana Beach has approximately 2,061 public parking spaces including street-side parking within a reasonable walking distance of four public access points. The distance between access points is approximately ¼ to ½ mile. Even if only half of these parking spaces are available to beach visitors, over 10,000 daily visitors could arrive by vehicle at each city. Therefore each beach has more than sufficient parking capacity near public access points to accommodate the 300-400 increase in daily visitations that have been projected for different beach fill and hybrid (beach fill plus notch fill) alternatives.

Recall only the sand placement and hybrid alternatives provide recreation benefits. The recreation demand under the sand placement and hybrid alternatives is shown in **Table 5.2-4** (note recreation demand is not affected by sea-level rise; only recreation capacity is affected):

[54] *The Economic and Fiscal Impact of Carlsbad's Beaches: A Survey and Estimate of Attendance* by Philip G. King, Ph.D., 2005. Estimates for decreased recreation visits were based on a 50% reduction in existing beach width.

[55] A reasonable walking distance is defined as no more than 1/3 of a mile. Parking and public access at San Elijo lagoon is included in this total. San Elijo lagoon has 835 parking spaces.

Table 5.2-4 Recreation Demand

SEGMENT 1[51] Initial Added Width	**50-foot**	**100-foot**	**150-foot**	**200-foot**
2010	951,886	951,886	951,886	951,886
2015	1,017,615	1,023,568	1,029,520	1,035,473
2020	1,155,792	1,191,509	1,227,226	1,262,943
2030	1,265,322	1,304,424	1,343,526	1,382,628
2040	1,361,346	1,403,415	1,445,484	1,487,553
2050	1,433,662	1,477,966	1,522,270	1,566,574
2064	1,433,662	1,477,966	1,522,270	1,566,574

SEGMENT 2 Initial Added Width	50-foot	100-foot	150-foot	200-foot	250-foot	300-foot	350-foot	400-foot
2010	99,190	99,190	99,190	99,190	99,190	99,190	99,190	99,190
2015	126,503	130,131	133,845	138,972	144,099	149,225	150,847	152,468
2020	243,217	264,988	287,270	318,032	348,793	379,554	389,281	399,008
2030	266,266	290,100	314,494	348,170	381,847	415,523	426,172	436,821
2040	286,473	312,116	338,360	374,592	410,824	447,057	458,513	469,970
2050	301,690	328,696	356,334	394,491	432,648	470,805	482,870	494,936
2064	301,690	328,696	356,334	394,491	432,648	470,805	482,870	494,936

The geometric mean growth rates in with project recreation demand are shown in **Table 5.2-5**. The geometric mean is the compound annual growth rate during the periods shown. For example, in Segment 1 between 2010 and 2015 the geometric growth rate is 1.3%. This means that recreation demand grows on average 1.3% every year from 2010 to 2015. Between 2050 and 2064 recreation demand does not increase so the geometric mean each year from 2050 to 2064 is zero.

Table 5.2-5 Recreation Demand Compound Annual Growth Rate

SEGMENT 1 Initial Added Width	**50-foot**	**100-foot**	**150-foot**	**200-foot**
2010-2014	1.0%	1.0%	1.0%	1.0%
2015-2020	2.6%	3.1%	3.6%	4.1%
2020s	0.9%	0.9%	0.9%	0.9%
2030s	0.7%	0.7%	0.7%	0.7%
2040s	0.5%	0.5%	0.5%	0.5%
2050-2064	0.0%	0.0%	0.0%	0.0%

SEGMENT 2 Initial Added Width	50-foot	100-foot	150-foot	200-foot	250-foot	300-foot	350-foot	400-foot
2010-2014	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
2015-2020	14.0%	15.3%	16.5%	18.0%	19.3%	20.5%	20.9%	21.2%
2020s	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
2030s	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
2040s	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
2050-2064	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

5.2.2 Project Costs

<u>Sand Placement Alternatives</u>

The with-project costs for beach fill alternatives are mobilization and demobilization of equipment, pre-construction engineering & design, supervision & administration, operation & maintenance, monitoring, environmental mitigation, contingency, and cost per cubic yard of sand fill. The initial fill and subsequent nourishment cycles are calculated somewhat differently as shown in **Figure 5.2-1** and **Figure 5.2-2**. These calculations are used for the Sand Placement (Beach Fill Plan) and Hybrid alternatives only.

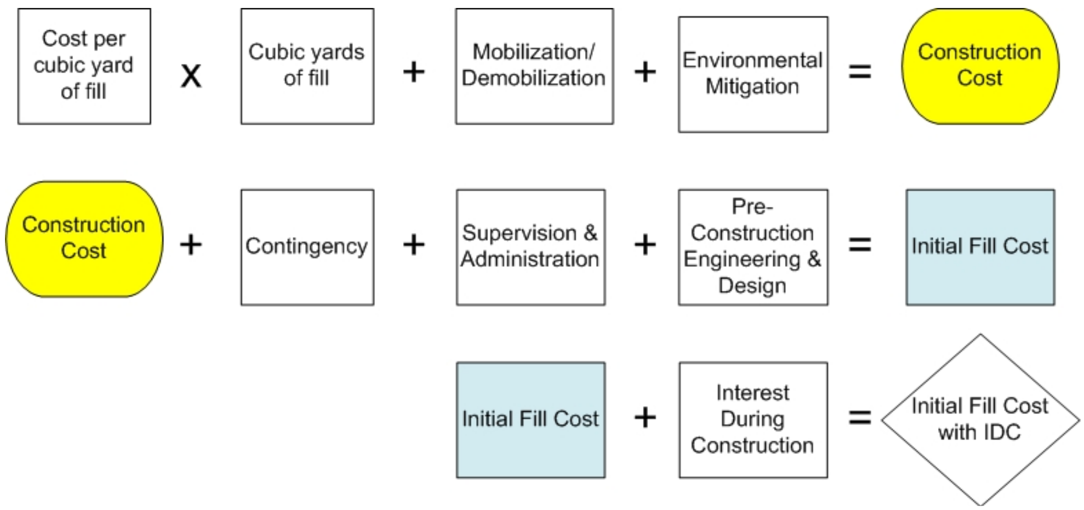


Figure 5.2-1 How to calculate initial fill cost

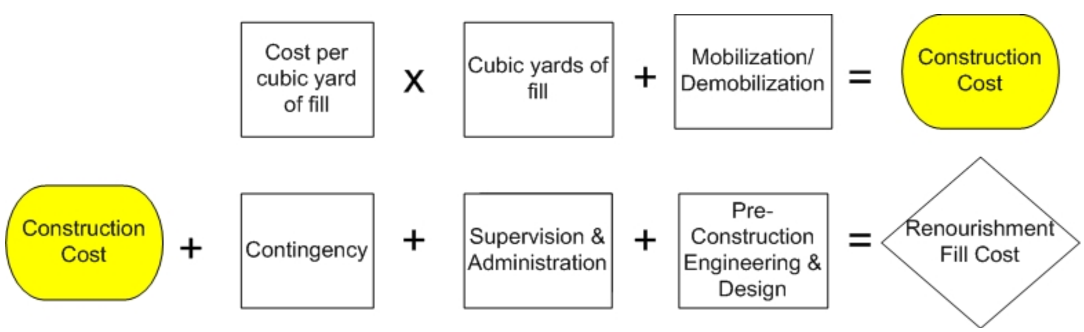


Figure 5.2-2 How to calculate nourishment fill cost

Once the initial fill cost and subsequent nourishment costs have been calculated by year the final step involves discounting all these costs, calculating the present value cost for monitoring and operation & maintenance, and adding each together to determine the net present value for each alternative fill and nourishment cycle combination.[56] This gives the total costs during the study period for each project alternative and nourishment cycle. Note that mobilization/demobilization costs are only shared between the two segments during the initial fill because dredging equipment only has to be mobilized once for both segments. All subsequent

[56] Environmental mitigation costs were provided by the project delivery team biologist.

nourishments are assumed to occur separately, which requires dredging equipment to be mobilized one time for each segment with the cost bore completely by each city, due to difficulty predicting funding and patterns of beach erosion during the 50 year study period. A cost summary for the beach fill and hybrid alternatives can be found in **Table 5.2-6**.

Table 5.2-6 Cost Summary for Beach Fill & Hybrid Alternatives

	Segment 1	Segment 2
Dredging (per cubic yard)	$7.62 (nearest borrow site) $11.43 (add'l borrow sites)	$7.15 (nearest borrow site) $10.75 (add'l borrow sites)
Mobilization/Demobilization	$1,535,050 (initial fill-shared) $2,482,092 (nourishment)	$1,535,050 (initial fill-shared) $2,657,864 (nourishment)
Environmental Mitigation	Varies by beach volume $70,729-$33,813,606 (NPV)	Varies by beach volume $70,729-$12,953,596 (NPV)
Contingency	35% of construction costs	35% of construction costs
Supervision & Administration	6.5% of construction & contingency costs	6.5% of construction & contingency costs
Pre-Construction Engineering & Design	10% of construction & contingency costs ($1 million minimum)	10% of construction & contingency costs ($1 million minimum)
Interest During Construction	Varies by initial construction costs (6-month duration, 4% annually)	Varies by initial construction costs (6-month duration, 4% annually)
Lagoon Sedimentation Fee	Varies by beach volume $24,000-$122,500 annually	Varies by beach volume $19,000-$134,500 annually
Operation & Maintenance	$12,500 annually	$12,500 annually
Construction Monitoring	$100,000 annually (initial) $50,000 annually (nourishment)	$100,000 annually (initial) $50,000 annually (nourishment)

<u>Hybrid Alternatives</u>

The project costs consist of sand placement, which is calculated in the same manner described in the *Sand Placement Alternatives* in section 5.2.2 plus the construction of a toe notch fill to cover exposed toe notches at the base of the bluff with material of equivalent strength and durability to the surrounding sandstone. Affected notches must be prepped and then filled. Sand sedimentation & recreation loss fees have been included at a rate of $3,500 per linear foot, which is the amount applied consistently throughout this appendix when applicable. Construction costs assume filling the notches occurs immediately after sand placement allowing construction to occur regardless of tide cycle. Costs are estimated at $209-$211 per linear foot.

Notch Fill Alternative

The *Notch Fill* alternative analysis involves placing notch fill in the existing sea caves/toe notches in the base year and maintaining the fill at regular intervals. To arrive at the *Notch Fill* costs this procedure was followed:

- Notch fill maintenance occurs every five years.
- The notch fill costs $209-211 per linear foot, the fee to mitigate sand sedimentation and recreation loss (paid by local sponsor) is $3,500 per linear foot, and unprotected parcels receive notch fill.[57]
- Notch fill costs per linear foot are higher under the *Notch Fill* alternative compared to the *Hybrid Plan* because of the narrower beach with limited periods when construction can occur.
- Maintenance and initial fill cost are similar because the notch fill would erode on average 3-4 feet over 5 years (3.23 to 3.90 feet depending on the reach to be exact) and the existing sea caves erode on average 3-4 feet, therefore the notch fill is completely refilled every five years. This means the maintenance cost is the same as the initial notch fill cost.
- Contingency, pre-construction engineering design, and supervision & administration are 35%, 10%, and 6.5% of construction costs respectively.

Seawall Alternative

The unprotected parcels the seawall would be constructed on are approximately 6,300 linear feet in Segment 1 and 4,300 linear feet in Segment 2. Construction costs were developed by cost engineering and are expected to be similar to private seawall construction costs. Construction is $7,400 per linear feet for both segments. Sand sedimentation and recreation mitigation fees assessed by the CCC are $3,500 per linear foot. Contingency, pre-construction engineering design, and supervision & administration are 35%, 10%, and 6.5% of construction costs respectively.

5.3 With Project Results

5.3.1 Coastal Storm Damage Reduction Benefits

Coastal storm damage reduction benefits were evaluated for Beach Fill, Hybrid, Notch Fill, and Seawall alternatives using the steps outlined in the *Methodology* section above.

Sand Placement/Beach Fill Alternative: CSDR Benefits

Beach Fill alternatives generate average annual CSDR benefits as shown in **Table 5.3-1** and **Table 5.3-2**. These benefits range from approximately $600k to $2.4 million at Segment 1 and $200k to $2.3 million at Segment 2 under low SLR. Coastal storm damage reduction benefits are consistently higher when evaluating the high sea-level scenario.

[57] Recreation and sand sedimentation loss fee taken from *City of Solana Beach Draft Land Lease/Recreation Study*, July 2010.

1 **Table 5.3-1 Beach Fill Average Annual Coastal Storm Damage Reduction Benefits for Segment 1**

Low SLR ($1,00s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$1,286	$1,999	$2,327	$2,429
3 yr nourishment	$1,229	$1,956	$2,284	$2,407
4 yr nourishment	$1,140	$1,914	$2,270	$2,398
5 yr nourishment	$1,052	$1,864	$2,247	$2,387
6 yr nourishment	$968	$1,800	$2,200	$2,359
7 yr nourishment	$895	$1,710	$2,139	$2,319
8 yr nourishment	$846	$1,608	$2,089	$2,287
9 yr nourishment	$802	$1,521	$2,035	$2,255
10 yr nourishment	$757	$1,431	$1,960	$2,214
11 yr nourishment	$732	$1,376	$1,912	$2,182
12 yr nourishment	$706	$1,302	$1,849	$2,141
13 yr nourishment	$672	$1,250	$1,792	$2,105
14 yr nourishment	$645	$1,219	$1,743	$2,070
15 yr nourishment	$617	$1,174	$1,679	$2,020
16 yr nourishment	$588	$1,124	$1,613	$1,958
High SLR ($1,000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$1,475	$2,292	$2,668	$2,785
3 yr nourishment	$1,409	$2,243	$2,619	$2,761
4 yr nourishment	$1,307	$2,195	$2,603	$2,750
5 yr nourishment	$1,206	$2,137	$2,577	$2,737
6 yr nourishment	$1,110	$2,064	$2,523	$2,705
7 yr nourishment	$1,027	$1,960	$2,453	$2,660
8 yr nourishment	$970	$1,844	$2,396	$2,623
9 yr nourishment	$920	$1,745	$2,334	$2,586
10 yr nourishment	$868	$1,641	$2,248	$2,539
11 yr nourishment	$840	$1,578	$2,192	$2,502
12 yr nourishment	$810	$1,493	$2,121	$2,456
13 yr nourishment	$771	$1,433	$2,055	$2,414
14 yr nourishment	$740	$1,398	$1,999	$2,373
15 yr nourishment	$708	$1,346	$1,925	$2,316
16 yr nourishment	$675	$1,289	$1,850	$2,245

Table 5.3-2 Beach Fill Average Annual Coastal Storm Reduction Benefits for Segment 2

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$287	$850	$1,309	$1,647	$1,900	$2,090	$2,229	$2,325
3 yr nourishment	$283	$852	$1,305	$1,642	$1,885	$2,073	$2,210	$2,316
4 yr nourishment	$271	$855	$1,304	$1,632	$1,868	$2,045	$2,177	$2,280
5 yr nourishment	$268	$844	$1,303	$1,620	$1,855	$2,024	$2,154	$2,262
6 yr nourishment	$262	$828	$1,293	$1,614	$1,850	$2,024	$2,156	$2,265
7 yr nourishment	$257	$816	$1,275	$1,601	$1,839	$2,011	$2,145	$2,256
8 yr nourishment	$248	$803	$1,264	$1,596	$1,832	$2,003	$2,135	$2,247
9 yr nourishment	$242	$791	$1,247	$1,584	$1,820	$1,992	$2,123	$2,234
10 yr nourishment	$231	$775	$1,229	$1,571	$1,807	$1,979	$2,111	$2,224
11 yr nourishment	$220	$765	$1,217	$1,559	$1,798	$1,970	$2,103	$2,216
12 yr nourishment	$208	$749	$1,203	$1,548	$1,786	$1,957	$2,090	$2,203
13 yr nourishment	$199	$737	$1,190	$1,537	$1,776	$1,946	$2,080	$2,193
14 yr nourishment	$192	$726	$1,176	$1,525	$1,767	$1,940	$2,075	$2,190
15 yr nourishment	$184	$714	$1,162	$1,509	$1,754	$1,928	$2,064	$2,180
16 yr nourishment	$176	$696	$1,144	$1,494	$1,742	$1,918	$2,055	$2,171
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$360	$1,064	$1,637	$2,060	$2,377	$2,614	$2,788	$2,909
3 yr nourishment	$354	$1,066	$1,632	$2,054	$2,357	$2,593	$2,764	$2,897
4 yr nourishment	$339	$1,070	$1,631	$2,041	$2,336	$2,558	$2,723	$2,852
5 yr nourishment	$335	$1,056	$1,630	$2,025	$2,320	$2,532	$2,694	$2,829
6 yr nourishment	$328	$1,035	$1,617	$2,018	$2,314	$2,531	$2,696	$2,834
7 yr nourishment	$322	$1,021	$1,595	$2,003	$2,300	$2,516	$2,683	$2,821
8 yr nourishment	$311	$1,004	$1,581	$1,996	$2,291	$2,505	$2,671	$2,811
9 yr nourishment	$303	$990	$1,560	$1,981	$2,277	$2,492	$2,655	$2,795
10 yr nourishment	$289	$969	$1,537	$1,965	$2,260	$2,475	$2,641	$2,782
11 yr nourishment	$276	$957	$1,522	$1,950	$2,249	$2,464	$2,630	$2,772
12 yr nourishment	$260	$938	$1,505	$1,935	$2,234	$2,448	$2,615	$2,756
13 yr nourishment	$249	$922	$1,488	$1,922	$2,222	$2,434	$2,602	$2,743
14 yr nourishment	$241	$909	$1,472	$1,908	$2,210	$2,426	$2,595	$2,739
15 yr nourishment	$231	$893	$1,453	$1,888	$2,194	$2,412	$2,582	$2,727
16 yr nourishment	$220	$871	$1,431	$1,869	$2,179	$2,399	$2,571	$2,715

These Coastal Storm Damage Reduction Benefits can be compared to the hypothetical preventable coastal storm damage, which are the weighted Armoring and Retreat Scenario damages minus the residual sloughing damages at the top of the bluff. For example the maximum/hypothetical coastal storm damage reduction benefits for Segment 1 are $2.76 million in average annual benefits under low sea-level rise and the table above shows that the 150-foot & 10-year nourishment interval alternative provides $1.96 million in average annual benefits. Dividing these two values shows that 71% of the preventable coastal storm damages are averted. This has been done for all beach fill alternatives and graphed in **Figure 5.3-1** and **Figure 5.3-2**.[58]

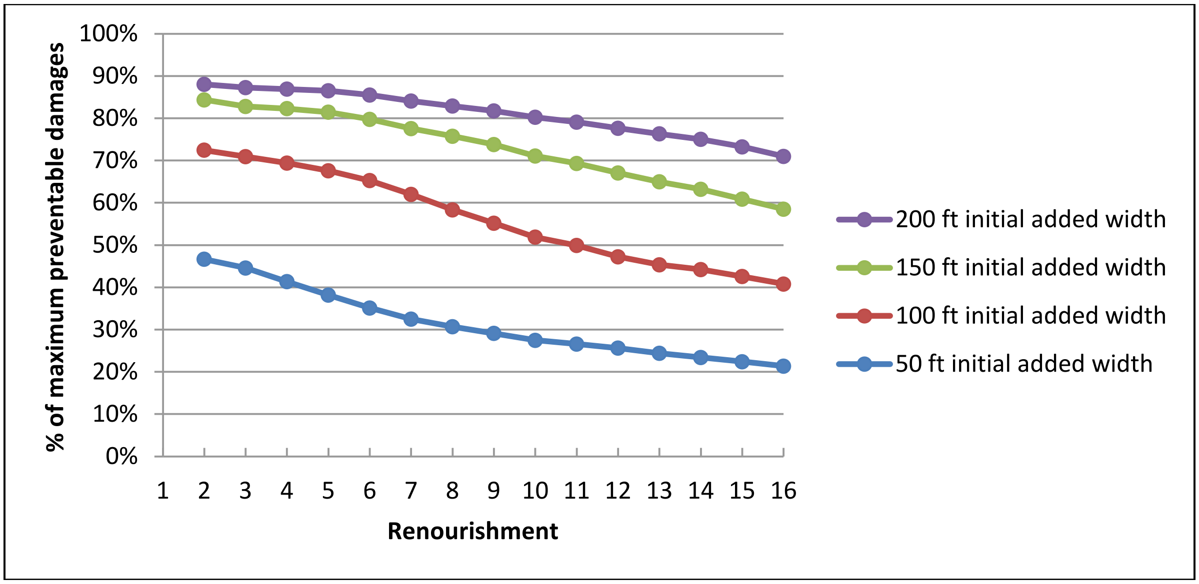


Figure 5.3-1 Share of Benefits Captured at Segment 1

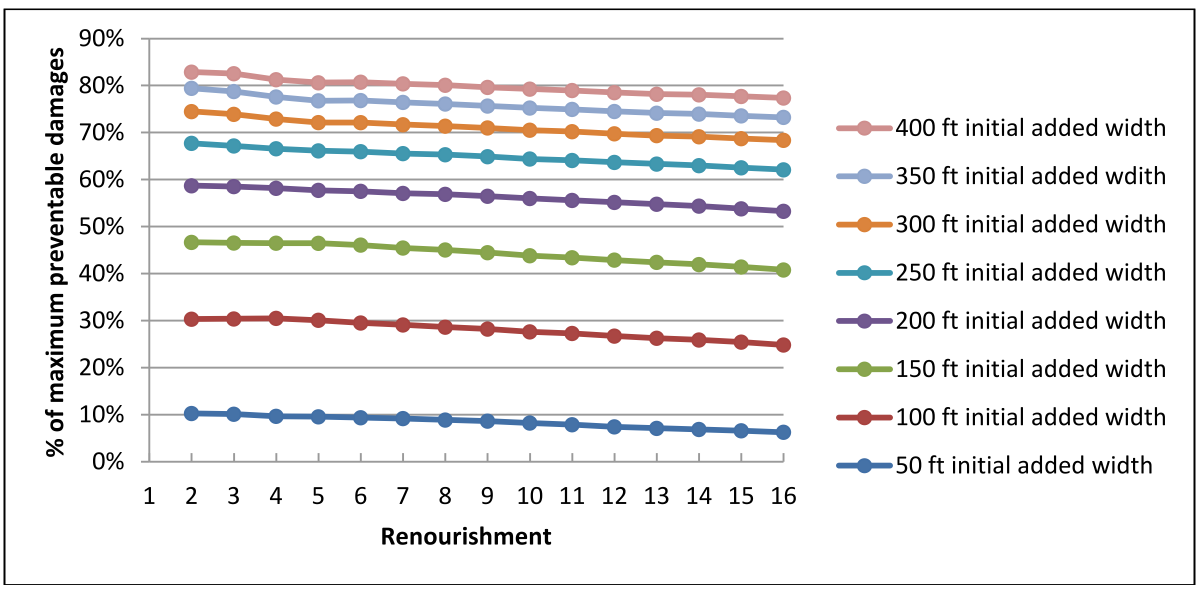


Figure 5.3-2 Share of Benefits Captured at Segment 2

<u>Hybrid Alternatives: CSDR Benefits</u>

Hybrid alternatives generate average annual CSDR benefits from approximately $700k to $2.4 million at Segment 1 and $400k to $2.3 million at Segment 2 under low SLR (**Table 5.3-3** and

[58] Additional sand placement occurs according to the sea-level rise to compensate for erosion due to sea-level rise. In this way the *Level of Protection* is nearly identical under both low and high sea-level rise so for brevity only the low sea-level scenario has been graphed below.

Table 5.3-4). Coastal storm damage reduction benefits are consistently higher when evaluating the high sea-level scenario. In addition constructing notch fill increases CSDR benefits more noticeably for smaller added beach widths and extended periods between nourishments compared to alternatives that only include sand placement. However, this difference diminishes when larger sand placements occur, since notch fill becomes redundant to some extent as the sand footprint increases.

Table 5.3-3 Hybrid Average Annual Coastal Storm Damage Reduction Benefits for Segment 1

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$1,334	$2,011	$2,330	$2,431
3 yr nourishment	$1,278	$1,970	$2,289	$2,410
4 yr nourishment	$1,198	$1,929	$2,275	$2,400
5 yr nourishment	$1,119	$1,881	$2,251	$2,389
6 yr nourishment	$1,044	$1,819	$2,207	$2,363
7 yr nourishment	$982	$1,733	$2,148	$2,325
8 yr nourishment	$938	$1,640	$2,100	$2,294
9 yr nourishment	$901	$1,560	$2,047	$2,262
10 yr nourishment	$862	$1,477	$1,976	$2,222
11 yr nourishment	$842	$1,428	$1,929	$2,191
12 yr nourishment	$820	$1,361	$1,870	$2,152
13 yr nourishment	$791	$1,314	$1,816	$2,117
14 yr nourishment	$770	$1,286	$1,771	$2,083
15 yr nourishment	$748	$1,247	$1,712	$2,035
16 yr nourishment	$725	$1,203	$1,652	$1,977
High SLR ($1,000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$1,557	$2,521	$2,946	$3,081
3 yr nourishment	$1,475	$2,464	$2,892	$3,051
4 yr nourishment	$1,366	$2,403	$2,874	$3,038
5 yr nourishment	$1,261	$2,335	$2,844	$3,023
6 yr nourishment	$1,163	$2,245	$2,784	$2,987
7 yr nourishment	$1,082	$2,123	$2,703	$2,937
8 yr nourishment	$1,026	$1,994	$2,635	$2,897
9 yr nourishment	$978	$1,884	$2,560	$2,855
10 yr nourishment	$928	$1,770	$2,459	$2,801
11 yr nourishment	$903	$1,704	$2,393	$2,757
12 yr nourishment	$875	$1,615	$2,309	$2,703
13 yr nourishment	$840	$1,550	$2,235	$2,654
14 yr nourishment	$816	$1,513	$2,173	$2,604
15 yr nourishment	$791	$1,462	$2,092	$2,537
16 yr nourishment	$763	$1,403	$2,009	$2,456

Table 5.3-4 Hybrid Average Annual Coastal Storm Damage Reduction Benefits for Segment 2

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$420	$917	$1,340	$1,664	$1,907	$2,089	$2,224	$2,321
3 yr nourishment	$417	$916	$1,335	$1,661	$1,894	$2,075	$2,206	$2,312
4 yr nourishment	$406	$918	$1,336	$1,653	$1,880	$2,051	$2,178	$2,279
5 yr nourishment	$404	$908	$1,336	$1,642	$1,869	$2,033	$2,157	$2,261
6 yr nourishment	$401	$895	$1,326	$1,636	$1,864	$2,031	$2,158	$2,264
7 yr nourishment	$398	$887	$1,312	$1,625	$1,854	$2,020	$2,148	$2,254
8 yr nourishment	$392	$876	$1,301	$1,620	$1,848	$2,012	$2,139	$2,246
9 yr nourishment	$387	$867	$1,287	$1,610	$1,838	$2,003	$2,128	$2,234
10 yr nourishment	$379	$853	$1,271	$1,597	$1,825	$1,991	$2,117	$2,225
11 yr nourishment	$372	$845	$1,260	$1,587	$1,817	$1,983	$2,110	$2,217
12 yr nourishment	$363	$831	$1,248	$1,576	$1,806	$1,971	$2,099	$2,206
13 yr nourishment	$357	$820	$1,236	$1,566	$1,797	$1,962	$2,090	$2,197
14 yr nourishment	$352	$812	$1,224	$1,555	$1,788	$1,955	$2,084	$2,193
15 yr nourishment	$346	$801	$1,212	$1,541	$1,776	$1,945	$2,075	$2,184
16 yr nourishment	$340	$786	$1,196	$1,527	$1,765	$1,935	$2,066	$2,176
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$463	$1,155	$1,772	$2,266	$2,633	$2,896	$3,066	$3,185
3 yr nourishment	$458	$1,152	$1,763	$2,260	$2,613	$2,877	$3,045	$3,174
4 yr nourishment	$445	$1,151	$1,764	$2,248	$2,595	$2,844	$3,008	$3,130
5 yr nourishment	$442	$1,136	$1,763	$2,232	$2,580	$2,819	$2,980	$3,107
6 yr nourishment	$438	$1,119	$1,749	$2,222	$2,571	$2,817	$2,983	$3,113
7 yr nourishment	$433	$1,108	$1,731	$2,206	$2,556	$2,800	$2,970	$3,101
8 yr nourishment	$425	$1,092	$1,715	$2,198	$2,547	$2,790	$2,959	$3,091
9 yr nourishment	$419	$1,080	$1,696	$2,183	$2,532	$2,776	$2,944	$3,076
10 yr nourishment	$409	$1,061	$1,673	$2,165	$2,513	$2,759	$2,929	$3,063
11 yr nourishment	$399	$1,050	$1,659	$2,150	$2,501	$2,747	$2,919	$3,053
12 yr nourishment	$387	$1,030	$1,640	$2,134	$2,485	$2,730	$2,904	$3,038
13 yr nourishment	$378	$1,015	$1,623	$2,119	$2,471	$2,716	$2,891	$3,027
14 yr nourishment	$372	$1,002	$1,606	$2,103	$2,458	$2,706	$2,884	$3,022
15 yr nourishment	$365	$987	$1,588	$2,083	$2,440	$2,690	$2,870	$3,011
16 yr nourishment	$357	$967	$1,566	$2,062	$2,423	$2,676	$2,859	$3,000

Notch Fill Alternative: CSDR Benefits

The Notch Fill Alternative provides coastal storm damage reduction benefits, as shown in **Table 5.3-5**, by reducing the frequency of bluff top erosion compared to without project conditions. This is achieved by constructing toe notch fills at the base of the bluff and maintaining these at regular intervals. The reduction in damages provided by the *Notch Fill* alternative (i.e. the notch fill benefits) is adjusted to remove residual/sloughing damages at the top of the bluff. There are no recreation benefits.

Table 5.3-5 Notch Fill Alternative Average Annual Benefits

Segment 1 *Notch Fill Alternative*			Segment 2 *Notch Fill Alternative*		
	Low SLR	High SLR[59]		Low SLR	High SLR
Benefits	$2,119,000	$1,840,000	Benefits	$797,000	$1,336,000
Std Deviation[60]	*474,000*	*896,000*	*Std Deviation*	*763,000*	*819,000*

Seawall Alternative: CSDR Benefits

The Seawall Alternative benefits, as shown in **Table 5.3-6**, are 100% of without project damages net of residual/sloughing damages. In other words, the seawall alternative is expected to protect against all without project damages excluding residual sloughing damages. There are no recreation benefits.

Table 5.3-6 Seawall Alternative Average Annual Benefits

Segment 1 *Seawall Alternative*			**Segment 2 *Seawall Alternative***		
	Low SLR	High SLR		Low SLR	High SLR
Benefits	2,786,000	3,185,000	Benefits	2,826,000	3,527,000
Std Deviation	*396,000*	*811,000*	*Std Deviation*	*590,000*	*638,000*

5.3.2 Recreation Values & Benefits

Sand placement and hybrid alternatives require beach fill that increases the quality and intensity of recreation. The hard structural alternatives by themselves produce no additional recreation benefits (e.g., seawall and notch fill alternatives). With project unit day values are identical to without project unit day values for the same level of crowding on the beach. For a description of how without project recreation values were derived review section 4.8. Sand placement and

[59] Reduction in damages occurring before the base year were not counted, resulting in lower “counted” benefits under the high sea-level rise scenario even though the total reduction in damages is greater than under the low sea-level rise.

[60] In the absence of correlation coefficients between with and without project damages these standard deviations assume perfect correlation, which leads to the largest estimate of the project standard deviations.

hybrid alternatives were evaluated to extend the mean-sea level (MSL) beach width 50 to 200 feet in Segment 1 and 50 to 400 feet in Segment 2 with nourishments occurring every 2 to 16 years.

Table 5.3-7 has been presented for illustrative purposes. It shows nominal recreation values by reach and segment decade with the base year and final year of the period of analysis added for comparison assuming the sand placement/hybrid alternative that extends the beach 200 feet MSL with nourishments occurring every 16 years. Values increase moderately by decade due to the initial increase in recreation demand following project construction but in tandem with county-wide population growth rates after initial construction. This means a sizeable increase occurs around 2015—the base year—then modest increases at the same rate as without project conditions for the remainder of the period of analysis. The values are presented in nominal amounts (i.e., not discounted).

Table 5.3-7 Calculation Example for 200-foot/16 yr Alternative

Nominal Recreation Values by Decade for Sand Placement and Hybrid Alternatives ($1000s)								
Low SLR	2010	2015	2020	2030	2040	2050	2060	2064
REACH 3	$715	$1,064	$1,298	$1,366	$1,517	$1,611	$1,575	$1,611
REACH 4	$4,389	$5,088	$6,207	$6,373	$7,189	$7,699	$7,221	$7,699
REACH 5	$1,273	$1,825	$2,224	$2,337	$2,610	$2,759	$2,728	$2,759
…								
REACH 8	$90	$154	$352	$385	$415	$437	$437	$437
REACH 9	$481	$843	$1,928	$2,102	$2,271	$2,392	$2,381	$2,392
TOTAL	$6,948	$8,974	$12,010	$12,563	$14,002	$14,898	$14,342	$14,898
Segment 1	$6,377	$7,978	$9,730	$10,076	$11,317	$12,069	$11,524	$12,069
Segment 2	$571	$996	$2,280	$2,487	$2,686	$2,829	$2,818	$2,829

With-project average annual recreation values, which have been discounted and rounded to thousands, are given in **Table 5.3-8** and **Table 5.3-9**. To generate these tables, we calculated recreation values for the entire period of analysis for all combinations of nourishment interval (2-16 years) and added beach width (50-200/400 ft MSL) then discounted. The results for the Beach Fill & Hybrid Alternatives are shown below in **Table 5.3-10** and **Table 5.3-11**. Note the seawall and notch fill alternatives do not generate any recreation benefits so no recreation values were calculated for those two alternatives.

Table 5.3-8 Recreation Average Annual Values for Beach Fill & Hybrid Alternatives Segment 1

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$9,430	$9,900	$10,180	$10,460
3 yr nourishment	$9,380	$9,890	$10,180	$10,460
4 yr nourishment	$9,330	$9,880	$10,180	$10,460
5 yr nourishment	$9,180	$9,870	$10,180	$10,460
6 yr nourishment	$9,060	$9,840	$10,180	$10,460
7 yr nourishment	$8,950	$9,790	$10,170	$10,460
8 yr nourishment	$8,860	$9,750	$10,150	$10,450
9 yr nourishment	$8,780	$9,640	$10,130	$10,450
10 yr nourishment	$8,680	$9,550	$10,110	$10,440
11 yr nourishment	$8,640	$9,480	$10,090	$10,440
12 yr nourishment	$8,570	$9,400	$10,060	$10,420
13 yr nourishment	$8,460	$9,300	$10,020	$10,400
14 yr nourishment	$8,480	$9,290	$9,980	$10,390
15 yr nourishment	$8,450	$9,220	$9,920	$10,360
16 yr nourishment	$8,390	$9,140	$9,850	$10,340
High SLR ($1,000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$9,350	$9,890	$10,180	$10,460
3 yr nourishment	$9,290	$9,880	$10,180	$10,460
4 yr nourishment	$9,090	$9,860	$10,180	$10,460
5 yr nourishment	$8,950	$9,840	$10,180	$10,460
6 yr nourishment	$8,850	$9,810	$10,170	$10,460
7 yr nourishment	$8,680	$9,760	$10,160	$10,450
8 yr nourishment	$8,540	$9,630	$10,130	$10,450
9 yr nourishment	$8,400	$9,540	$10,110	$10,450
10 yr nourishment	$8,270	$9,440	$10,080	$10,430
11 yr nourishment	$8,210	$9,370	$10,060	$10,420
12 yr nourishment	$8,120	$9,230	$10,020	$10,400
13 yr nourishment	$7,960	$9,080	$9,930	$10,380
14 yr nourishment	$7,980	$9,060	$9,890	$10,370
15 yr nourishment	$7,930	$8,960	$9,820	$10,340
16 yr nourishment	$7,870	$8,860	$9,740	$10,270

Table 5.3-9 Recreation Average Annual Values for Beach Fill & Hybrid Alternatives Segment 2

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$1,790	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
3 yr nourishment	$1,790	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
4 yr nourishment	$1,790	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
5 yr nourishment	$1,780	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
6 yr nourishment	$1,780	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
7 yr nourishment	$1,740	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
8 yr nourishment	$1,710	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
9 yr nourishment	$1,690	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
10 yr nourishment	$1,660	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
11 yr nourishment	$1,640	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
12 yr nourishment	$1,620	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
13 yr nourishment	$1,580	$1,950	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
14 yr nourishment	$1,590	$1,950	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
15 yr nourishment	$1,570	$1,950	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
16 yr nourishment	$1,550	$1,940	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$1,780	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
3 yr nourishment	$1,780	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
4 yr nourishment	$1,770	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
5 yr nourishment	$1,770	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
6 yr nourishment	$1,720	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
7 yr nourishment	$1,680	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
8 yr nourishment	$1,660	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
9 yr nourishment	$1,630	$1,950	$2,120	$2,340	$2,560	$2,770	$2,770	$2,770
10 yr nourishment	$1,600	$1,950	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
11 yr nourishment	$1,590	$1,950	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
12 yr nourishment	$1,560	$1,950	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
13 yr nourishment	$1,520	$1,950	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
14 yr nourishment	$1,520	$1,940	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
15 yr nourishment	$1,510	$1,940	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770
16 yr nourishment	$1,480	$1,930	$2,110	$2,340	$2,560	$2,770	$2,770	$2,770

Similarly, with project benefits were generated for beach fill & hybrid alternatives to extend the mean-sea level (MSL) beach width 50 to 200 feet in Segment 1 and 50 to 400 feet in Segment 2 with nourishments occurring every 2 to 16 years. With-project recreation benefits, which equal with- minus without-project values, are given in **Table 5.3-12** . As expected recreation benefits increase with larger beach fills and shorter intervals between nourishments. Average annual recreation benefits range from approximately $400k to $2.4 million at Segment 1 and $800k to $2.1 million at Segment 2 under low SLR. Recreation benefits nearly double under high SLR at Segment 1. At a later stage the recreation benefits from these tables are paired with the coastal storm damage reduction benefits presented in Section 5.3.1 up to 50% of total benefits to calculate each alternative's net benefit.[61] Again note the seawall and notch fill alternatives do not generate recreation benefits.

Table 5.3-10 Full Recreation Average Annual Benefits for Beach Fill & Hybrid Alternatives Segment 1[62]

Low SLR ($1000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$1,380	$1,840	$2,130	$2,410
3 yr nourishment	$1,330	$1,840	$2,130	$2,410
4 yr nourishment	$1,270	$1,830	$2,130	$2,410
5 yr nourishment	$1,130	$1,820	$2,130	$2,410
6 yr nourishment	$1,010	$1,790	$2,130	$2,400
7 yr nourishment	$900	$1,740	$2,120	$2,400
8 yr nourishment	$810	$1,700	$2,100	$2,400
9 yr nourishment	$720	$1,590	$2,080	$2,400
10 yr nourishment	$630	$1,500	$2,060	$2,390
11 yr nourishment	$580	$1,430	$2,040	$2,380
12 yr nourishment	$520	$1,350	$2,010	$2,370
13 yr nourishment	$410	$1,240	$1,960	$2,350
14 yr nourishment	$430	$1,240	$1,930	$2,340
15 yr nourishment	$390	$1,160	$1,860	$2,310
16 yr nourishment	$340	$1,090	$1,800	$2,280
High SLR ($1000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$3,140	$3,690	$3,970	$4,250
3 yr nourishment	$3,080	$3,670	$3,970	$4,250
4 yr nourishment	$2,880	$3,650	$3,970	$4,250
5 yr nourishment	$2,740	$3,630	$3,970	$4,250
6 yr nourishment	$2,640	$3,600	$3,970	$4,250
7 yr nourishment	$2,470	$3,550	$3,950	$4,250
8 yr nourishment	$2,330	$3,430	$3,930	$4,240
9 yr nourishment	$2,200	$3,330	$3,900	$4,240
10 yr nourishment	$2,060	$3,230	$3,870	$4,230
11 yr nourishment	$2,000	$3,160	$3,850	$4,210
12 yr nourishment	$1,910	$3,020	$3,810	$4,190
13 yr nourishment	$1,750	$2,870	$3,720	$4,170
14 yr nourishment	$1,770	$2,850	$3,680	$4,160
15 yr nourishment	$1,730	$2,750	$3,620	$4,130
16 yr nourishment	$1,660	$2,650	$3,540	$4,060

[61] ER 1105-2-100 section 3-4

[62] Full recreation benefits shown. Actual recreation benefits used for plan selection are the lesser of recreation benefits shown or 50% of total benefits.

Table 5.3-11 Full Recreation Average Annual Benefits for Beach Fill & Hybrid Alternatives Segment 2[63]

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$1,070	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
3 yr nourishment	$1,070	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
4 yr nourishment	$1,070	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
5 yr nourishment	$1,060	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
6 yr nourishment	$1,060	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
7 yr nourishment	$1,020	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
8 yr nourishment	$990	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
9 yr nourishment	$970	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
10 yr nourishment	$940	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
11 yr nourishment	$920	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
12 yr nourishment	$900	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
13 yr nourishment	$860	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
14 yr nourishment	$870	$1,230	$1,400	$1,620	$1,840	$2,060	$2,060	$2,060
15 yr nourishment	$850	$1,230	$1,390	$1,620	$1,840	$2,060	$2,060	$2,060
16 yr nourishment	$830	$1,220	$1,390	$1,620	$1,840	$2,060	$2,060	$2,060
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$1,200	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
3 yr nourishment	$1,200	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
4 yr nourishment	$1,190	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
5 yr nourishment	$1,190	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
6 yr nourishment	$1,140	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
7 yr nourishment	$1,110	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
8 yr nourishment	$1,080	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
9 yr nourishment	$1,060	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
10 yr nourishment	$1,030	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
11 yr nourishment	$1,010	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
12 yr nourishment	$980	$1,370	$1,540	$1,760	$1,980	$2,200	$2,200	$2,200
13 yr nourishment	$940	$1,370	$1,530	$1,760	$1,980	$2,200	$2,200	$2,200
14 yr nourishment	$940	$1,370	$1,530	$1,760	$1,980	$2,200	$2,200	$2,200
15 yr nourishment	$930	$1,360	$1,530	$1,760	$1,980	$2,200	$2,200	$2,200
16 yr nourishment	$910	$1,360	$1,530	$1,760	$1,980	$2,200	$2,200	$2,200

5.3.3 Total Project Benefits

The Beach Fill, Hybrid, Notch Fill, and Seawall alternatives include coastal storm damage reduction benefits described in section 5.3.1. The Beach Fill and Hybrid alternatives include the recreation benefits as described in section 5.3.2, while Seawall and Notch Fill alternatives do not include any recreation benefits because none are generated by either alternative. Whenever applicable recreation benefits have been capped at 50% percent of total benefits per guidance.[64]

[63] Larger alternatives
[64] ER 1105-2-100 section 3-4

Sand Placement/Beach Fill Alternatives: Total Benefits

Beach Fill alternatives generate total average annual benefits, inclusive of the 50% cap on recreation benefits, as shown in **Table 5.3-12** and **Table 5.3-13**. Total benefits range from approximately $1.0 to $4.6 million at Segment 1 and $400k to $4.3 million at Segment 2 under low SLR. Total benefits are consistently higher when evaluating the high sea-level scenario.

Table 5.3-12 Total Average Annual Benefits for Beach Fill Alternatives at Segment 1

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$2,402	$3,660	$4,301	$4,633
3 yr nourishment	$2,301	$3,601	$4,246	$4,604
4 yr nourishment	$2,148	$3,538	$4,224	$4,589
5 yr nourishment	$1,994	$3,461	$4,190	$4,574
6 yr nourishment	$1,815	$3,362	$4,126	$4,535
7 yr nourishment	$1,662	$3,220	$4,041	$4,478
8 yr nourishment	$1,546	$3,052	$3,964	$4,429
9 yr nourishment	$1,443	$2,904	$3,877	$4,378
10 yr nourishment	$1,341	$2,723	$3,758	$4,311
11 yr nourishment	$1,258	$2,602	$3,673	$4,257
12 yr nourishment	$1,201	$2,466	$3,568	$4,188
13 yr nourishment	$1,121	$2,351	$3,466	$4,123
14 yr nourishment	$1,012	$2,258	$3,375	$4,057
15 yr nourishment	$1,000	$2,193	$3,262	$3,972
16 yr nourishment	$940	$2,089	$3,135	$3,858
High SLR ($1,000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$3,039	$5,026	$5,892	$6,162
3 yr nourishment	$2,872	$4,909	$5,781	$6,102
4 yr nourishment	$2,640	$4,786	$5,746	$6,076
5 yr nourishment	$2,414	$4,646	$5,684	$6,047
6 yr nourishment	$2,201	$4,463	$5,560	$5,972
7 yr nourishment	$2,023	$4,211	$5,396	$5,870
8 yr nourishment	$1,900	$3,940	$5,257	$5,787
9 yr nourishment	$1,795	$3,708	$5,104	$5,702
10 yr nourishment	$1,683	$3,467	$4,897	$5,591
11 yr nourishment	$1,627	$3,326	$4,761	$5,503
12 yr nourishment	$1,564	$3,134	$4,588	$5,393
13 yr nourishment	$1,484	$2,997	$4,433	$5,293
14 yr nourishment	$1,425	$2,918	$4,303	$5,192
15 yr nourishment	$1,365	$2,806	$4,133	$5,054
16 yr nourishment	$1,300	$2,678	$3,958	$4,885

Table 5.3-13 Total Average Annual Benefits for Beach Fill Alternatives at Segment 2

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$573	$1,656	$2,430	$3,021	$3,501	$3,897	$4,139	$4,319
3 yr nourishment	$565	$1,658	$2,423	$3,014	$3,479	$3,875	$4,113	$4,306
4 yr nourishment	$540	$1,662	$2,421	$3,000	$3,457	$3,837	$4,071	$4,260
5 yr nourishment	$534	$1,642	$2,420	$2,984	$3,440	$3,808	$4,039	$4,235
6 yr nourishment	$523	$1,615	$2,405	$2,975	$3,432	$3,805	$4,040	$4,239
7 yr nourishment	$513	$1,595	$2,382	$2,958	$3,416	$3,788	$4,024	$4,225
8 yr nourishment	$496	$1,572	$2,365	$2,951	$3,407	$3,775	$4,010	$4,213
9 yr nourishment	$483	$1,552	$2,342	$2,935	$3,391	$3,760	$3,994	$4,195
10 yr nourishment	$460	$1,522	$2,315	$2,917	$3,372	$3,741	$3,977	$4,181
11 yr nourishment	$440	$1,505	$2,298	$2,901	$3,360	$3,728	$3,965	$4,169
12 yr nourishment	$415	$1,476	$2,276	$2,885	$3,343	$3,709	$3,947	$4,151
13 yr nourishment	$396	$1,452	$2,256	$2,869	$3,329	$3,693	$3,933	$4,138
14 yr nourishment	$384	$1,433	$2,236	$2,853	$3,316	$3,683	$3,924	$4,132
15 yr nourishment	$368	$1,410	$2,213	$2,830	$3,298	$3,666	$3,909	$4,118
16 yr nourishment	$350	$1,378	$2,186	$2,808	$3,280	$3,651	$3,896	$4,105
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$685	$2,185	$3,280	$4,006	$4,600	$5,088	$5,331	$5,519
3 yr nourishment	$675	$2,184	$3,272	$3,998	$4,579	$5,068	$5,309	$5,509
4 yr nourishment	$644	$2,186	$3,271	$3,985	$4,558	$5,031	$5,268	$5,462
5 yr nourishment	$637	$2,154	$3,270	$3,968	$4,541	$5,003	$5,239	$5,438
6 yr nourishment	$624	$2,112	$3,255	$3,958	$4,533	$5,002	$5,242	$5,445
7 yr nourishment	$612	$2,084	$3,233	$3,940	$4,516	$4,985	$5,228	$5,432
8 yr nourishment	$591	$2,048	$3,217	$3,932	$4,507	$4,973	$5,216	$5,422
9 yr nourishment	$576	$2,019	$3,195	$3,916	$4,490	$4,959	$5,201	$5,406
10 yr nourishment	$548	$1,976	$3,170	$3,897	$4,471	$4,940	$5,185	$5,393
11 yr nourishment	$524	$1,951	$3,153	$3,881	$4,458	$4,927	$5,174	$5,382
12 yr nourishment	$493	$1,909	$3,133	$3,864	$4,441	$4,909	$5,157	$5,366
13 yr nourishment	$472	$1,875	$3,114	$3,848	$4,427	$4,894	$5,144	$5,354
14 yr nourishment	$456	$1,847	$3,095	$3,831	$4,413	$4,884	$5,136	$5,350
15 yr nourishment	$437	$1,814	$3,075	$3,809	$4,394	$4,868	$5,122	$5,337
16 yr nourishment	$416	$1,769	$3,032	$3,787	$4,376	$4,853	$5,110	$5,326

Hybrid Alternatives: Total Benefits

Hybrid alternatives generate total average annual benefits, inclusive of the 50% cap on recreation benefits, as shown in **Table 5.3-14** and **Table 5.3-15**. Total benefits range from approximately $1.1 to $4.6 million at Segment 1 and $700k to $4.3 million at Segment 2 under low SLR. Total benefits are consistently higher when evaluating the high sea-level scenario.

Table 5.3-14 Total Average Annual Benefits for Hybrid Alternatives at Segment 1

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$2,471	$3,672	$4,301	$4,633
3 yr nourishment	$2,374	$3,616	$4,249	$4,604
4 yr nourishment	$2,235	$3,553	$4,226	$4,589
5 yr nourishment	$2,099	$3,481	$4,192	$4,574
6 yr nourishment	$1,934	$3,384	$4,131	$4,537
7 yr nourishment	$1,794	$3,250	$4,050	$4,482
8 yr nourishment	$1,684	$3,095	$3,975	$4,434
9 yr nourishment	$1,586	$2,959	$3,890	$4,385
10 yr nourishment	$1,490	$2,790	$3,776	$4,320
11 yr nourishment	$1,405	$2,676	$3,695	$4,268
12 yr nourishment	$1,350	$2,553	$3,595	$4,201
13 yr nourishment	$1,272	$2,445	$3,500	$4,138
14 yr nourishment	$1,160	$2,354	$3,415	$4,074
15 yr nourishment	$1,159	$2,298	$3,311	$3,992
16 yr nourishment	$1,104	$2,201	$3,192	$3,885
High SLR ($1,000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$3,114	$5,042	$5,892	$6,162
3 yr nourishment	$2,950	$4,927	$5,784	$6,102
4 yr nourishment	$2,732	$4,806	$5,748	$6,076
5 yr nourishment	$2,523	$4,670	$5,687	$6,047
6 yr nourishment	$2,326	$4,489	$5,567	$5,975
7 yr nourishment	$2,163	$4,246	$5,406	$5,875
8 yr nourishment	$2,051	$3,988	$5,270	$5,794
9 yr nourishment	$1,957	$3,769	$5,120	$5,710
10 yr nourishment	$1,856	$3,540	$4,918	$5,602
11 yr nourishment	$1,807	$3,409	$4,785	$5,515
12 yr nourishment	$1,750	$3,229	$4,617	$5,406
13 yr nourishment	$1,681	$3,101	$4,469	$5,309
14 yr nourishment	$1,631	$3,027	$4,346	$5,209
15 yr nourishment	$1,582	$2,925	$4,185	$5,074
16 yr nourishment	$1,526	$2,806	$4,019	$4,912

Table 5.3-15 Total Average Annual Benefits for Hybrid Alternatives at Segment 2

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$841	$1,779	$2,483	$3,053	$3,517	$3,903	$4,139	$4,319
3 yr nourishment	$834	$1,775	$2,474	$3,048	$3,498	$3,883	$4,115	$4,306
4 yr nourishment	$812	$1,777	$2,475	$3,037	$3,481	$3,852	$4,078	$4,264
5 yr nourishment	$809	$1,760	$2,475	$3,022	$3,466	$3,827	$4,050	$4,240
6 yr nourishment	$802	$1,740	$2,461	$3,013	$3,458	$3,822	$4,049	$4,243
7 yr nourishment	$796	$1,727	$2,443	$2,998	$3,444	$3,807	$4,035	$4,229
8 yr nourishment	$783	$1,708	$2,427	$2,992	$3,436	$3,796	$4,023	$4,218
9 yr nourishment	$774	$1,693	$2,408	$2,978	$3,422	$3,783	$4,008	$4,202
10 yr nourishment	$759	$1,670	$2,385	$2,962	$3,405	$3,766	$3,992	$4,188
11 yr nourishment	$744	$1,657	$2,371	$2,948	$3,394	$3,754	$3,982	$4,177
12 yr nourishment	$726	$1,633	$2,352	$2,932	$3,379	$3,738	$3,966	$4,162
13 yr nourishment	$713	$1,613	$2,335	$2,918	$3,366	$3,723	$3,953	$4,149
14 yr nourishment	$704	$1,597	$2,318	$2,903	$3,353	$3,713	$3,945	$4,143
15 yr nourishment	$693	$1,578	$2,299	$2,884	$3,337	$3,698	$3,931	$4,131
16 yr nourishment	$681	$1,552	$2,276	$2,863	$3,321	$3,683	$3,919	$4,119
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$926	$2,309	$3,311	$4,026	$4,611	$5,092	$5,331	$5,519
3 yr nourishment	$917	$2,303	$3,302	$4,019	$4,591	$5,073	$5,311	$5,509
4 yr nourishment	$890	$2,302	$3,303	$4,008	$4,573	$5,040	$5,273	$5,465
5 yr nourishment	$884	$2,273	$3,302	$3,992	$4,558	$5,015	$5,246	$5,441
6 yr nourishment	$876	$2,238	$3,288	$3,982	$4,549	$5,013	$5,248	$5,448
7 yr nourishment	$867	$2,216	$3,269	$3,965	$4,534	$4,997	$5,235	$5,435
8 yr nourishment	$850	$2,184	$3,253	$3,958	$4,525	$4,986	$5,224	$5,425
9 yr nourishment	$838	$2,159	$3,233	$3,943	$4,510	$4,973	$5,209	$5,410
10 yr nourishment	$818	$2,122	$3,211	$3,925	$4,491	$4,955	$5,195	$5,398
11 yr nourishment	$797	$2,099	$3,195	$3,909	$4,479	$4,943	$5,184	$5,388
12 yr nourishment	$774	$2,061	$3,176	$3,893	$4,463	$4,927	$5,169	$5,373
13 yr nourishment	$757	$2,029	$3,159	$3,877	$4,450	$4,912	$5,157	$5,361
14 yr nourishment	$745	$2,005	$3,141	$3,862	$4,436	$4,902	$5,149	$5,357
15 yr nourishment	$730	$1,975	$3,123	$3,841	$4,418	$4,887	$5,135	$5,345
16 yr nourishment	$714	$1,934	$3,100	$3,819	$4,401	$4,873	$5,124	$5,334

<u>Notch Fill & Seawall Alternatives: Total Benefits</u>

The total benefits for the Notch Fill and Seawall alternatives are the same as the Coastal Storm Damage Reduction Benefits shown in section 5.3.1 since neither alternative offers recreation benefits.

5.3.4 Project Costs

<u>Sand Placement Alternatives: Costs</u>

Table 5.3-16 and **Table 5.3-17** list average annualized costs in thousands for all combinations of nourishment interval (2-16 years) and added beach widths (50-200/400 feet MSL) for the sand placement alternatives.

Table 5.3-16 Sand Placement Alternatives Average Annual Costs for Segment 1

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$3,178	$3,620	$5,501	$7,599
3 yr nourishment	$2,484	$2,964	$4,786	$6,769
4 yr nourishment	$2,137	$2,576	$4,298	$6,163
5 yr nourishment	$1,821	$2,259	$3,962	$5,826
6 yr nourishment	$1,691	$2,222	$3,930	$5,740
7 yr nourishment	$1,602	$2,242	$3,997	$5,851
8 yr nourishment	$1,454	$2,102	$3,828	$5,653
9 yr nourishment	$1,331	$1,935	$3,679	$5,490
10 yr nourishment	$1,205	$1,803	$3,605	$5,289
11 yr nourishment	$1,160	$1,759	$3,566	$5,266
12 yr nourishment	$1,114	$1,726	$3,510	$5,197
13 yr nourishment	$1,023	$1,543	$3,315	$4,978
14 yr nourishment	$994	$1,503	$3,275	$5,172
15 yr nourishment	$968	$1,469	$3,244	$5,172
16 yr nourishment	$943	$1,426	$3,195	$5,121
High SLR ($1,000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$3,393	$3,879	$5,890	$8,280
3 yr nourishment	$2,727	$3,235	$5,174	$7,455
4 yr nourishment	$2,396	$2,839	$4,693	$6,941
5 yr nourishment	$2,068	$2,572	$4,383	$6,534
6 yr nourishment	$1,973	$2,537	$4,387	$6,577
7 yr nourishment	$1,888	$2,600	$4,388	$6,579
8 yr nourishment	$1,728	$2,463	$4,352	$6,381
9 yr nourishment	$1,583	$2,291	$4,206	$6,218
10 yr nourishment	$1,478	$2,091	$4,018	$6,248
11 yr nourishment	$1,424	$2,044	$3,977	$6,236
12 yr nourishment	$1,375	$2,128	$3,922	$6,172
13 yr nourishment	$1,271	$1,939	$3,728	$5,957
14 yr nourishment	$1,247	$1,893	$3,687	$5,943
15 yr nourishment	$1,226	$1,857	$3,657	$5,946
16 yr nourishment	$1,208	$1,812	$3,612	$5,901

Table 5.3-17 Sand Placement Alternatives Average Annual Costs for Segment 2

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$2,864	$3,366	$4,266	$4,971	$5,832	$6,622	$7,224	$7,827
3 yr nourishment	$2,030	$2,424	$3,192	$3,804	$4,568	$5,212	$5,725	$6,258
4 yr nourishment	$1,627	$1,968	$2,658	$3,226	$3,935	$4,624	$5,154	$5,589
5 yr nourishment	$1,391	$1,711	$2,343	$2,826	$3,521	$4,117	$4,606	$5,129
6 yr nourishment	$1,274	$1,597	$2,196	$2,613	$3,194	$3,770	$4,204	$4,679
7 yr nourishment	$1,179	$1,492	$2,081	$2,484	$3,068	$3,586	$3,993	$4,450
8 yr nourishment	$1,084	$1,390	$1,973	$2,335	$2,885	$3,387	$3,785	$4,241
9 yr nourishment	$1,008	$1,313	$1,888	$2,256	$2,774	$3,247	$3,621	$4,053
10 yr nourishment	$935	$1,234	$1,804	$2,145	$2,647	$3,100	$3,444	$3,859
11 yr nourishment	$915	$1,217	$1,784	$2,117	$2,640	$3,118	$3,391	$3,805
12 yr nourishment	$890	$1,187	$1,753	$2,104	$2,611	$3,096	$3,372	$3,795
13 yr nourishment	$823	$1,123	$1,686	$2,014	$2,500	$2,965	$3,224	$3,627
14 yr nourishment	$798	$1,115	$1,680	$2,007	$2,485	$2,929	$3,171	$3,556
15 yr nourishment	$776	$1,108	$1,669	$1,996	$2,468	$2,914	$3,157	$3,535
16 yr nourishment	$756	$1,092	$1,651	$1,975	$2,441	$2,874	$3,239	$3,493
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$3,034	$3,607	$4,534	$5,291	$6,125	$6,879	$7,485	$8,096
3 yr nourishment	$2,204	$2,646	$3,444	$4,117	$4,809	$5,536	$6,083	$6,545
4 yr nourishment	$1,804	$2,177	$2,909	$3,536	$4,225	$4,892	$5,441	$6,016
5 yr nourishment	$1,572	$1,919	$2,584	$3,162	$3,764	$4,389	$4,893	$5,431
6 yr nourishment	$1,458	$1,817	$2,438	$2,938	$3,471	$4,039	$4,490	$4,983
7 yr nourishment	$1,367	$1,717	$2,329	$2,825	$3,369	$3,944	$4,279	$4,757
8 yr nourishment	$1,276	$1,611	$2,231	$2,667	$3,180	$3,741	$4,071	$4,551
9 yr nourishment	$1,204	$1,538	$2,133	$2,569	$3,069	$3,602	$3,909	$4,366
10 yr nourishment	$1,135	$1,465	$2,068	$2,506	$2,940	$3,457	$3,882	$4,176
11 yr nourishment	$1,118	$1,450	$2,042	$2,471	$2,973	$3,404	$3,832	$4,123
12 yr nourishment	$1,097	$1,427	$2,009	$2,439	$2,947	$3,386	$3,821	$4,117
13 yr nourishment	$1,034	$1,367	$1,970	$2,348	$2,837	$3,256	$3,676	$3,951
14 yr nourishment	$1,013	$1,363	$1,964	$2,340	$2,822	$3,219	$3,620	$3,882
15 yr nourishment	$995	$1,363	$1,953	$2,404	$2,806	$3,355	$3,612	$3,864
16 yr nourishment	$981	$1,355	$1,937	$2,383	$2,780	$3,316	$3,573	$3,827

Hybrid Alternatives: Costs

Table 5.3-18 and **Table 5.3-19** list average annualized costs rounded to thousands for all combinations of nourishment interval (2-16 years) and added beach widths (5-200/400 feet MSL) for the hybrid alternatives.

Table 5.3-18 Hybrid Alternatives Average Annual Costs for Segment 1

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	$3,276	$3,718	$5,599	$7,697
3 yr nourishment	$2,581	$3,062	$4,883	$6,867
4 yr nourishment	$2,234	$2,674	$4,395	$6,260
5 yr nourishment	$1,918	$2,357	$4,059	$5,923
6 yr nourishment	$1,789	$2,320	$4,028	$5,838
7 yr nourishment	$1,699	$2,340	$4,094	$5,949
8 yr nourishment	$1,551	$2,199	$3,926	$5,751
9 yr nourishment	$1,429	$2,033	$3,777	$5,588
10 yr nourishment	$1,303	$1,900	$3,703	$5,386
11 yr nourishment	$1,257	$1,856	$3,664	$5,364
12 yr nourishment	$1,212	$1,823	$3,608	$5,295
13 yr nourishment	$1,120	$1,640	$3,412	$5,075
14 yr nourishment	$1,092	$1,601	$3,373	$5,270
15 yr nourishment	$1,065	$1,567	$3,341	$5,269
16 yr nourishment	$1,040	$1,524	$3,293	$5,218
High SLR ($1000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	$3,490	$3,976	$5,988	$8,377
3 yr nourishment	$2,825	$3,333	$5,271	$7,553
4 yr nourishment	$2,494	$2,937	$4,791	$7,039
5 yr nourishment	$2,166	$2,670	$4,480	$6,632
6 yr nourishment	$2,070	$2,634	$4,484	$6,675
7 yr nourishment	$1,986	$2,698	$4,486	$6,677
8 yr nourishment	$1,826	$2,560	$4,449	$6,478
9 yr nourishment	$1,680	$2,389	$4,303	$6,315
10 yr nourishment	$1,575	$2,189	$4,115	$6,346
11 yr nourishment	$1,522	$2,141	$4,074	$6,334
12 yr nourishment	$1,472	$2,225	$4,020	$6,270
13 yr nourishment	$1,369	$2,036	$3,825	$6,054
14 yr nourishment	$1,344	$1,991	$3,784	$6,040
15 yr nourishment	$1,323	$1,955	$3,754	$6,044
16 yr nourishment	$1,306	$1,910	$3,709	$5,998

Table 5.3-19 Hybrid Alternatives Costs for Segment 2

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$2,930	$3,432	$4,332	$5,037	$5,898	$6,688	$7,290	$7,893
3 yr nourishment	$2,096	$2,490	$3,259	$3,870	$4,634	$5,278	$5,791	$6,324
4 yr nourishment	$1,693	$2,034	$2,725	$3,292	$4,002	$4,690	$5,220	$5,655
5 yr nourishment	$1,457	$1,777	$2,410	$2,892	$3,587	$4,183	$4,672	$5,195
6 yr nourishment	$1,340	$1,663	$2,262	$2,680	$3,261	$3,837	$4,270	$4,745
7 yr nourishment	$1,245	$1,559	$2,147	$2,550	$3,134	$3,652	$4,060	$4,516
8 yr nourishment	$1,150	$1,456	$2,039	$2,401	$2,951	$3,453	$3,851	$4,307
9 yr nourishment	$1,075	$1,380	$1,954	$2,323	$2,840	$3,314	$3,688	$4,119
10 yr nourishment	$1,001	$1,301	$1,871	$2,211	$2,713	$3,166	$3,510	$3,926
11 yr nourishment	$981	$1,283	$1,850	$2,183	$2,706	$3,184	$3,458	$3,872
12 yr nourishment	$956	$1,254	$1,820	$2,171	$2,677	$3,162	$3,438	$3,861
13 yr nourishment	$889	$1,189	$1,752	$2,080	$2,566	$3,032	$3,290	$3,693
14 yr nourishment	$865	$1,182	$1,747	$2,073	$2,552	$2,995	$3,237	$3,622
15 yr nourishment	$842	$1,174	$1,735	$2,062	$2,534	$2,980	$3,223	$3,601
16 yr nourishment	$822	$1,158	$1,718	$2,041	$2,508	$2,940	$3,305	$3,559
High SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	$3,101	$3,673	$4,601	$5,357	$6,191	$6,945	$7,551	$8,162
3 yr nourishment	$2,271	$2,713	$3,511	$4,183	$4,875	$5,602	$6,150	$6,611
4 yr nourishment	$1,871	$2,243	$2,976	$3,602	$4,291	$4,958	$5,507	$6,082
5 yr nourishment	$1,638	$1,985	$2,650	$3,228	$3,830	$4,455	$4,959	$5,497
6 yr nourishment	$1,524	$1,884	$2,504	$3,004	$3,537	$4,105	$4,556	$5,049
7 yr nourishment	$1,433	$1,783	$2,395	$2,891	$3,435	$4,010	$4,345	$4,823
8 yr nourishment	$1,342	$1,677	$2,297	$2,733	$3,247	$3,807	$4,137	$4,617
9 yr nourishment	$1,270	$1,604	$2,199	$2,636	$3,135	$3,668	$3,975	$4,432
10 yr nourishment	$1,201	$1,531	$2,134	$2,573	$3,006	$3,523	$3,948	$4,243
11 yr nourishment	$1,184	$1,517	$2,108	$2,537	$3,039	$3,470	$3,898	$4,189
12 yr nourishment	$1,164	$1,493	$2,075	$2,506	$3,013	$3,452	$3,887	$4,183
13 yr nourishment	$1,100	$1,433	$2,037	$2,415	$2,903	$3,323	$3,742	$4,018
14 yr nourishment	$1,079	$1,430	$2,030	$2,407	$2,888	$3,285	$3,687	$3,948
15 yr nourishment	$1,061	$1,429	$2,019	$2,471	$2,872	$3,421	$3,679	$3,931
16 yr nourishment	$1,047	$1,421	$2,003	$2,449	$2,846	$3,382	$3,640	$3,894

<u>Notch Fill Alternative: Costs</u>

The Notch Fill Alternative provides coastal storm damage reduction benefits by reducing the frequency of bluff top erosion compared to without project conditions. The costs, shown in **Table 5.3-20**, include placement of notch fill to unprotected parcels at $209-$211 per linear foot plus sand mitigation & recreation loss fess of $3,500 per linear foot.[65]

[65] A sensitivity analysis was done to determine impact to plan selection if only half of the linear length of unprotected parcels needed notch fill across the entire period of analysis. The results show Segment 1 with $1,042,948 & $764,560 and Segment 2 at $63,281 & $603,312 net benefits for low and high sea-level rise, respectively. Under this less rigorous assumption the Notch Fill alternative continues to not maximize net benefits among the range of alternatives analyzed.

Table 5.3-20 Notch Fill Alternative Average Annual Costs

Segment 1 *Notch Fill Alternative*			Segment 2 *Notch Fill Alternative*		
	Low SLR	High SLR		Low SLR	High SLR
Cost	$2,252,000	$2,252,000	**Cost**	$1,535,000	$1,535,000

Seawall Alternative: Costs

The Seawall Alternative benefits are 100% of without project damages net of residual/sloughing damages. In other words, the seawall alternative is expected to protect against all without project damages excluding residual sloughing damages. There are no recreation benefits. Construction is $7,400 per linear feet for both segments. Sand sedimentation and recreation mitigation fees assessed by the CCC are $3,500 per linear foot. Contingency, pre-construction engineering design, and supervision & administration are 35%, 10%, and 6.5% of construction costs respectively.

Table 5.3-21 Seawall Alternative Average Annual Costs

Segment 1 *Seawall Alternative*			Segment 2 *Seawall Alternative*		
	Low SLR	High SLR		Low SLR	High SLR
Cost	$4,845,000	$4,845,000	**Cost**	$3,837,000	$3,837,000

5.3.5 Net Benefits

Sand Placement/Beach Fill Alternatives: Net Benefits with Limited Recreation Benefits[66]

Based on the coastal storm damage reduction benefits shown in **Section 5.3.1** and associated costs in **Section 5.3.4** no alternative was economically justified on coastal storm damage reduction benefits only. Recreation benefits are limited to 50% of the total benefits required for justification to ensure recreation is incidental to plan formulation.[67] Consequently, recreation benefits, not to exceed coastal storm damage reduction benefits, were included to determine the alternatives that are economically justified (net benefits greater than zero). All alternatives economically justified with limited recreation benefits are analyzed in a later step with full recreation benefits to determine the National Economic Development (NED) Plan.

Based on this threshold 50-foot, 100-foot, and 150-foot added beach width MSL alternatives were economically justified at Segment 1. No 200-foot added beach width alternatives were justified at Segment 1 using limited recreation benefits. See **Figure 5.3-3** and **Figure 5.3-4**.

Based on this threshold 100-foot through 400-foot added beach width MSL alternatives were economically justified at Segment 2. No 50-foot added beach width alternatives were justified at Segment 2 using limited recreation benefits. See **Figure 5.3-5** and **Figure 5.3-6**. All alternatives that were economically justified (BCR greater than or equal to 1.0) were evaluated with full recreation benefits to select the NED Plans in the next section.

[66] Recreation benefits up to 50% of total benefits.
[67] ER 1105-2-100 section 3-4b.(4)(a)

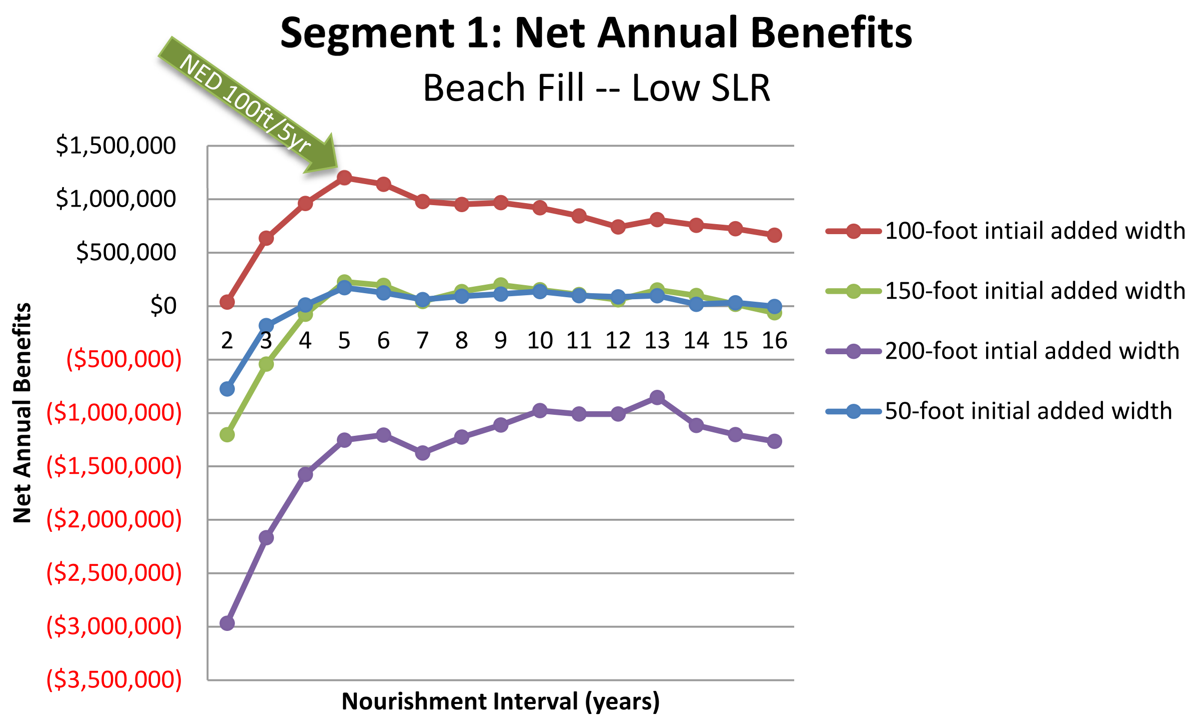


Figure 5.3-3 Net Annual Benefits for Segment 1 Beach Fill Alternatives with Limited Recreation Benefits (Low Sea-level Rise)

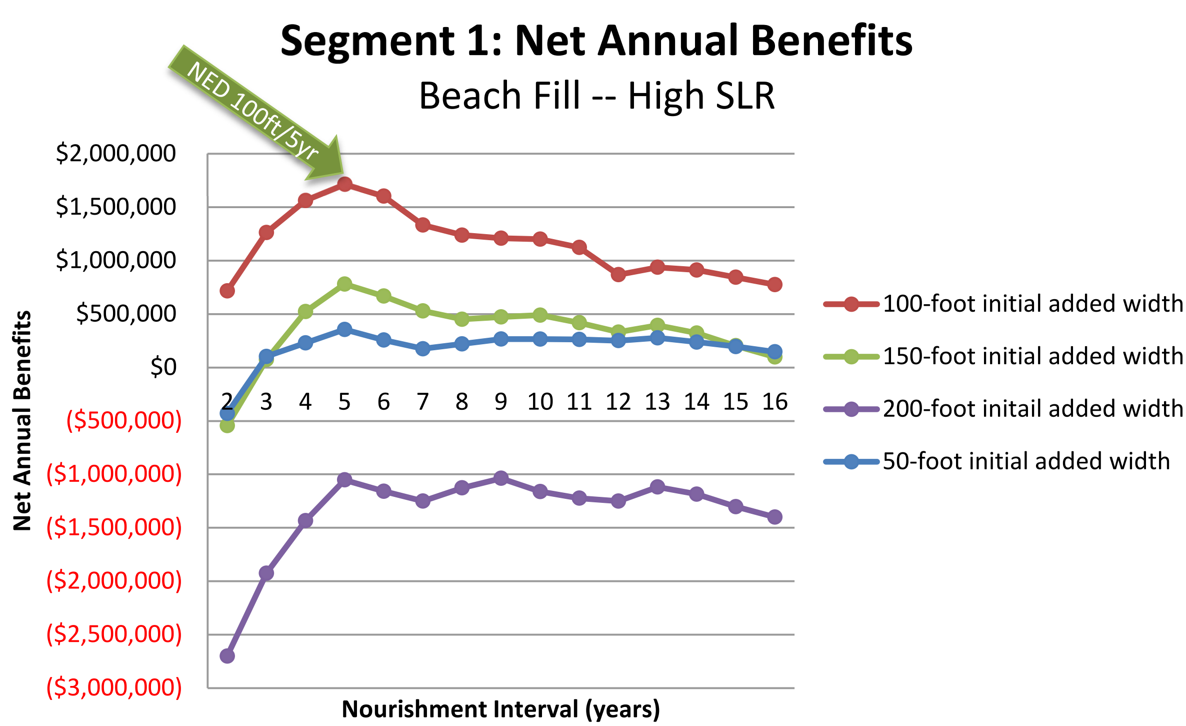


Figure 5.3-4 Net Annual Benefits for Segment 1 Beach Fill Alternatives with Limited Recreation Benefits (High Sea-level Rise)

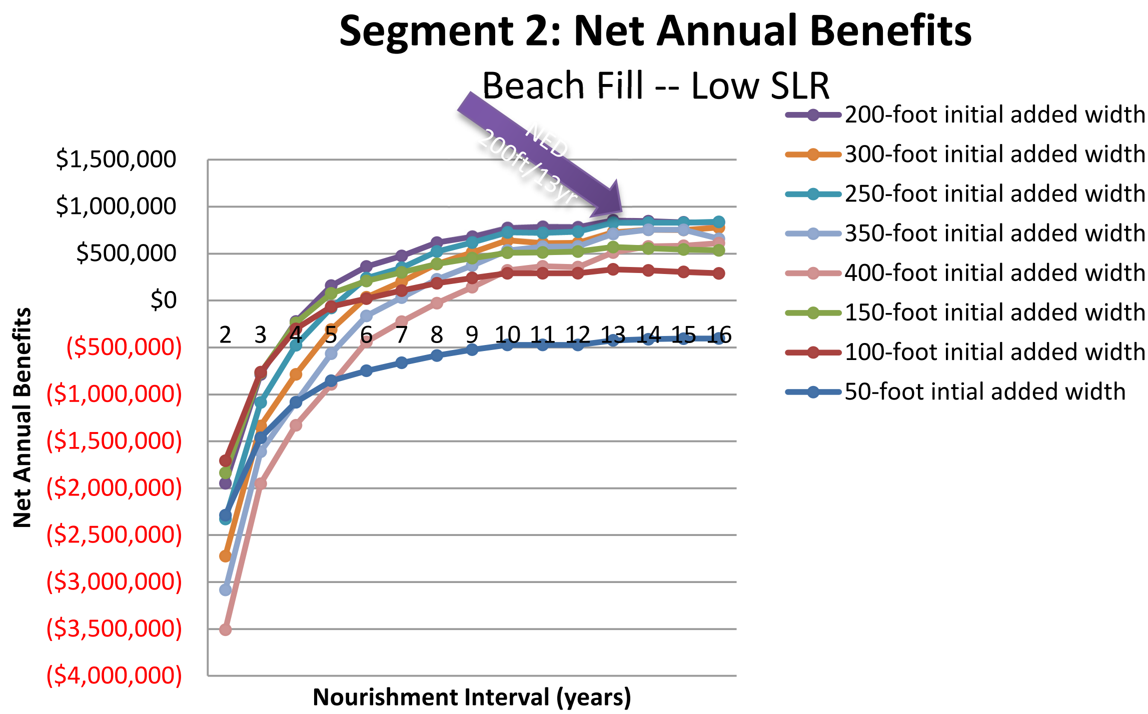


Figure 5.3-5 Net Annual Benefits for Segment 2 Beach Fill Alternatives with Limited Recreation Benefits (Low Sea-level Rise)

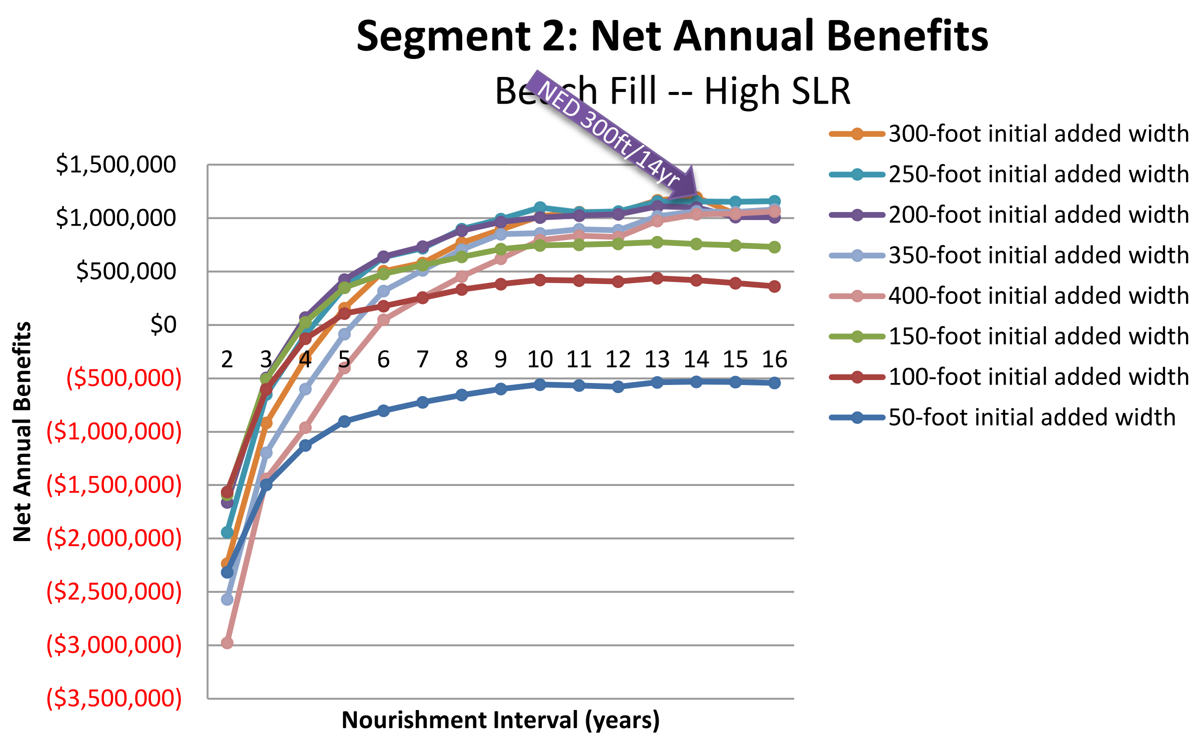


Figure 5.3-6 Net Annual Benefits for Segment 2 Beach Fill Alternatives With Limited Recreation Benefits (High Sea-level Rise)

Hybrid Alternatives: Net Benefits with Limited Recreation Benefits[68]

The net annual benefits for the Hybrid Alternatives, which include toe notch fill & sand placement, were analyzed for 50 to 400 feet of added beach width (200 feet for Encinitas) and two to sixteen year nourishment intervals. The results for all *Hybrid* alternatives broken down by Segment 1 & 2 as well as high and low sea-level rise scenarios are shown below. Note the hybrid alternatives with the highest net benefits are moderately lower than comparable beach fill alternatives.

When evaluated with limited recreation benefits the 100-foot, 150-foot, and 200-foot added beach width MSL alternatives were economically justified at Segment 1. No 200-foot added beach width alternatives were justified. See **Figure 5.3-7** and **Figure 5.3-8**.

When evaluated with limited recreation benefits the 100-foot through 400-foot added beach width MSL alternatives were economically justified at Segment 2. No 50-foot added beach width alternatives were justified. See **Figure 5.3-9** and **Figure 5.3-10**.

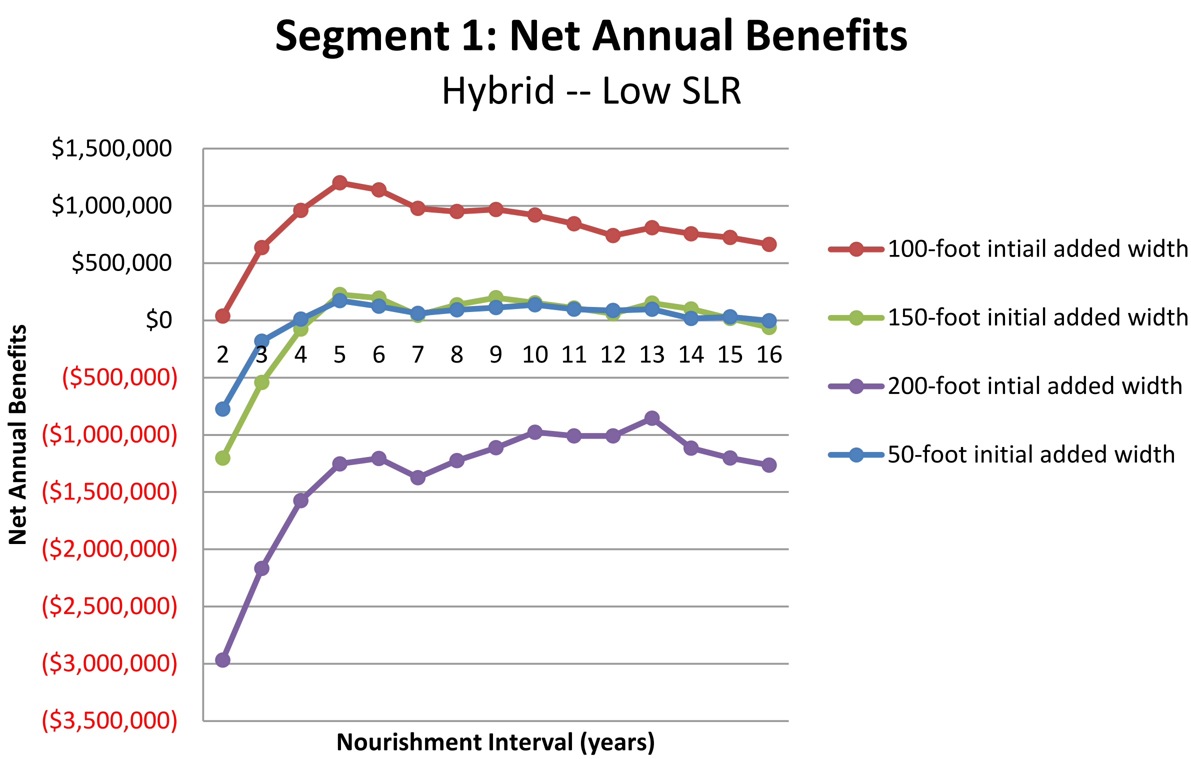


Figure 5.3-7 Net Annual Benefits for Hybrid Alternatives with Limited Recreation Benefits (Low Sea-Level Rise)

[68] Recreation benefits up to 50% of total benefits

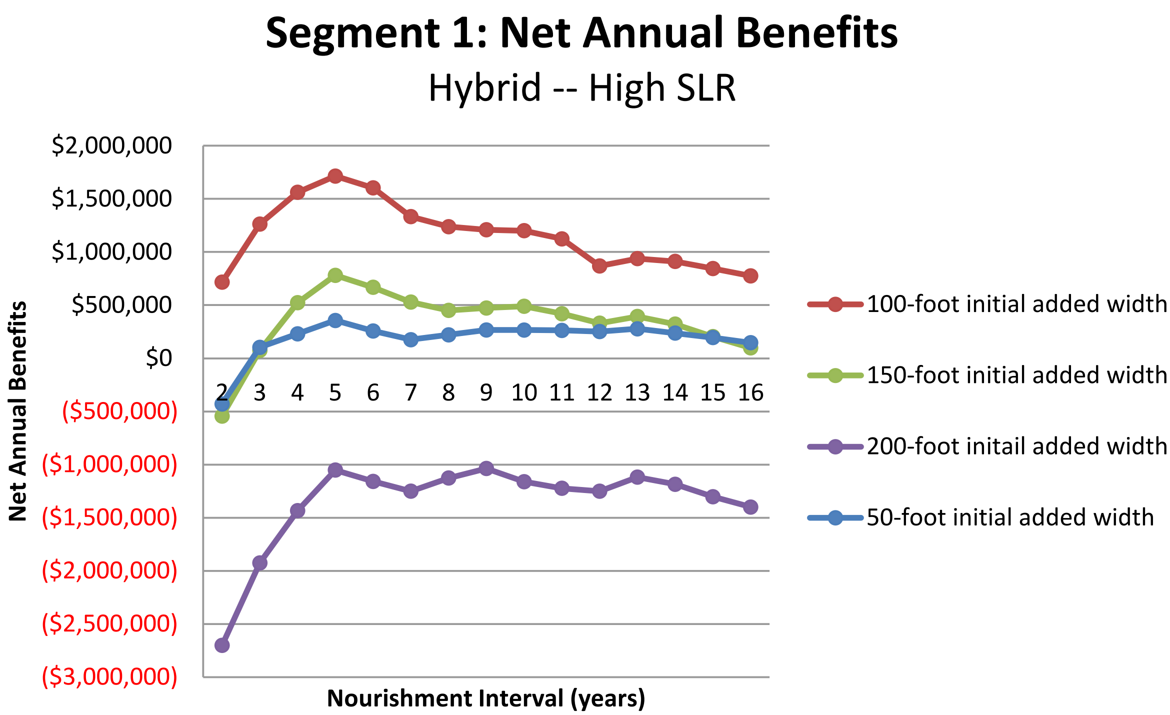


Figure 5.3-8 Net Annual Benefits for Hybrid Alternatives with Limited Recreation Benefits (High Sea-level Rise)

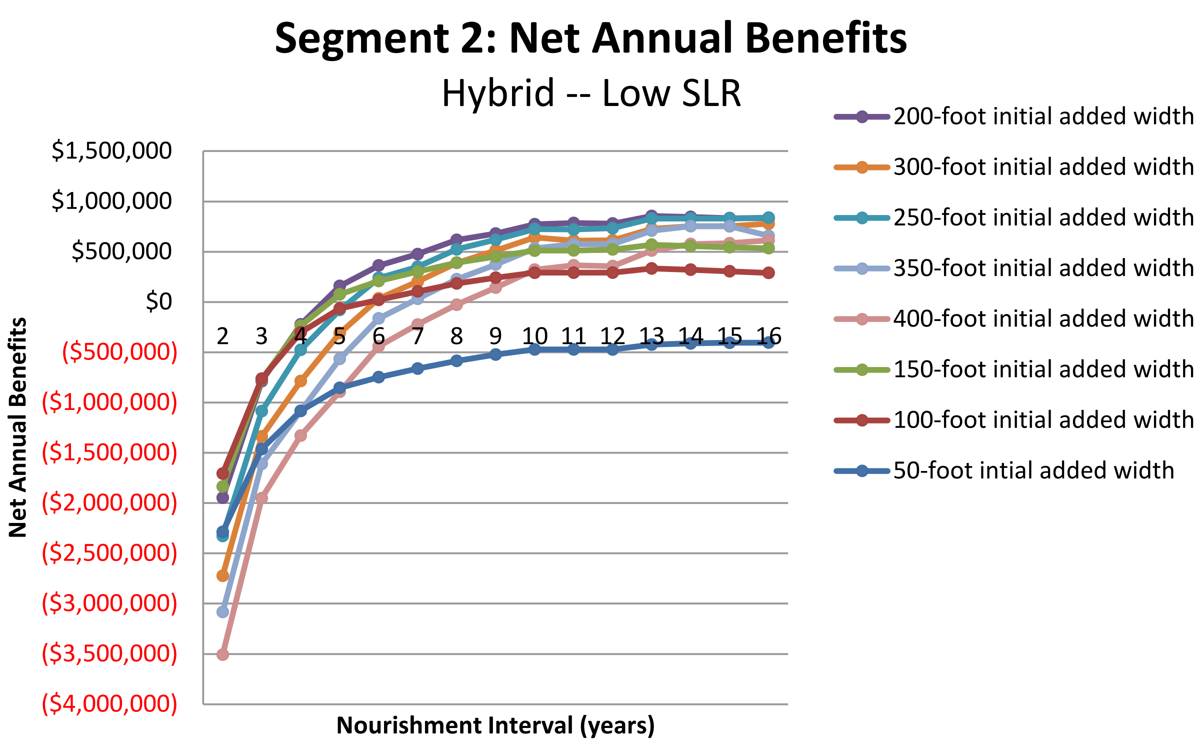


Figure 5.3-9 Net Annual Benefits for Hybrid Alternatives with Limited Recreation Benefits (Low Sea-Level Rise)

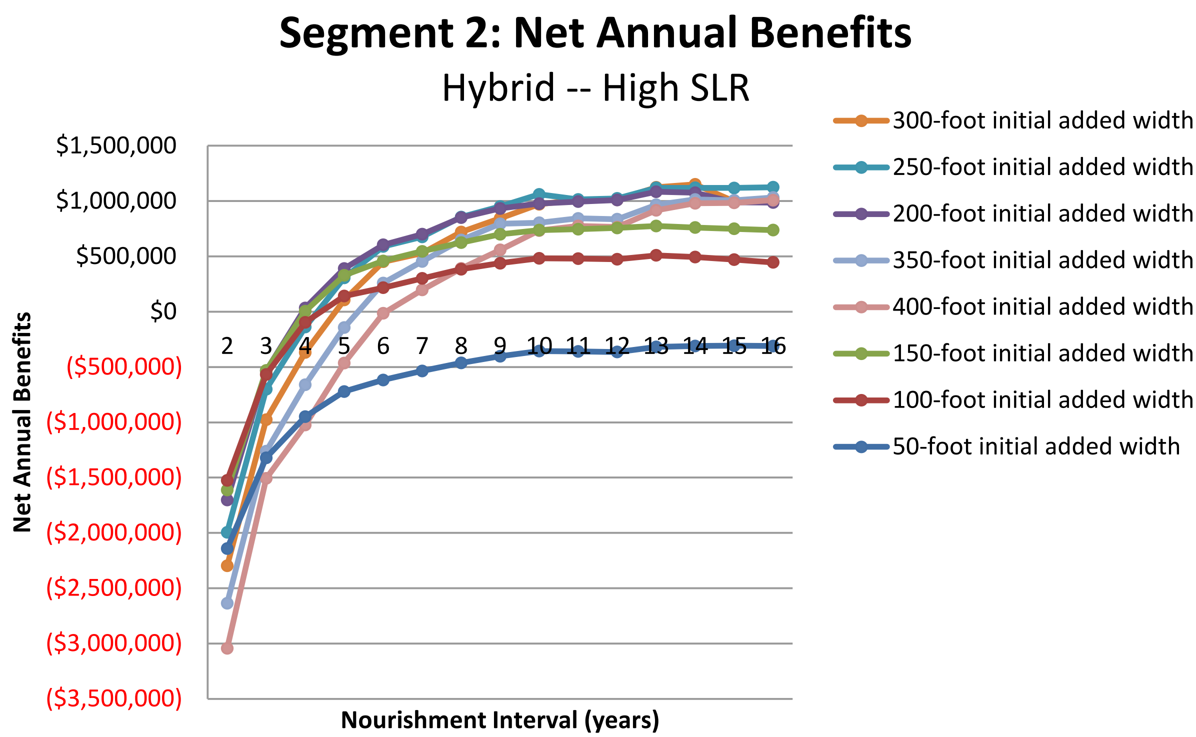


Figure 5.3-10 Net Annual Benefits for Hybrid Alternatives with Limited Recreation Benefits (High Sea-level Rise)

<u>Beach Fill Alternatives: Net Annual Benefits with Full Recreation Benefits</u>

The Beach Fill alternatives that are economically justified with limited recreation benefits (up to 50% of total benefits) were evaluated with full recreation benefits in **Table 5.3-22** and **Table 5.3-23** to select the NED Plans. Among the beach fill alternatives evaluated at Segment 1, extending the beach 100 feet MSL and nourishing every 5 years maximizes NED net annual benefits. This result is consistent under low and high sea-level rise scenarios.

Table 5.3-22 Segment 1: Beach Fill Alternatives Net Annual Benefits with Full Recreation Benefits

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	--	$225	--	--
3 yr nourishment	--	$836	--	--
4 yr nourishment	$332	$1,178	--	--
5 yr nourishment	$507	**$1,435**	$413	--
6 yr nourishment	$409	$1,393	$396	--
7 yr nourishment	$306	$1,257	$267	--
8 yr nourishment	$295	$1,250	$377	--
9 yr nourishment	$279	$1,283	$456	--
10 yr nourishment	$276	$1,220	$438	--
11 yr nourishment	$199	$1,114	$404	--
12 yr nourishment	$177	$1,010	$377	--
13 yr nourishment	$170	$1,054	$482	--
14 yr nourishment	$58	$960	$433	--
15 yr nourishment	$82	$940	$363	--
16 yr nourishment	--	$863	--	--
High SLR ($1000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	--	$2,102	--	--
3 yr nourishment	--	$2,694	--	--
4 yr nourishment	$1,996	$3,028	--	--
5 yr nourishment	$2,020	**$3,217**	$2,165	--
6 yr nourishment	$1,881	$3,159	$2,105	--
7 yr nourishment	$1,782	$2,962	$2,032	--
8 yr nourishment	$1,715	$2,931	$1,992	--
9 yr nourishment	$1,668	$2,879	$2,055	--
10 yr nourishment	$1,586	$2,878	$2,136	--
11 yr nourishment	$1,477	$2,766	$2,091	--
12 yr nourishment	$1,432	$2,524	$2,046	--
13 yr nourishment	$1,408	$2,517	$2,136	--
14 yr nourishment	$1,245	$2,376	$2,032	--
15 yr nourishment	$1,256	$2,343	$1,952	--
16 yr nourishment	--	$2,231	--	--

Among the beach fill alternatives evaluated with full recreation benefits at Segment 2, extending the beach 200 feet MSL and nourishing every 13 years maximizes NED net annual benefits. Under the high sea-level rise scenario the alternative that maximizes NED net annual benefits is 300-feet added beach width nourished every 14 years.

Table 5.3-23 Segment 2: Beach Fill Alternatives Net Annual Benefits with Full Recreation Benefits

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	--	--	--	--	--	--	--	--
3 yr nourishment	--	--	--	--	--	--	--	--
4 yr nourishment	--	--	--	--	--	--	--	--
5 yr nourishment	--	--	$362	$415	--	--	--	--
6 yr nourishment	--	$465	$498	$622	$496	$312	--	--
7 yr nourishment	--	$558	$596	$739	$611	$484	$279	--
8 yr nourishment	--	$646	$692	$883	$787	$674	$478	--
9 yr nourishment	--	$711	$760	$950	$887	$803	$629	$377
10 yr nourishment	--	$773	$825	$1,048	$1,000	$937	$795	$561
11 yr nourishment	--	$780	$833	$1,064	$998	$911	$839	$606
12 yr nourishment	--	$793	$849	$1,065	$1,016	$919	$846	$604
13 yr nourishment	--	$844	$903	**$1,144**	$1,116	$1,039	$984	$762
14 yr nourishment	--	$841	$894	$1,140	$1,122	$1,069	$1,031	$830
15 yr nourishment	--	$835	$891	$1,134	$1,126	$1,072	$1,035	$841
16 yr nourishment	--	$832	$890	$1,140	$1,140	$1,103	$944	$874
High SLR ($1000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**	**250 ft**	**300 ft**	**350 ft**	**400 ft**
2 yr nourishment	--	--	--	--	--	--	--	--
3 yr nourishment	--	--	--	--	--	--	--	--
4 yr nourishment	--	--	--	--	--	--	--	--
5 yr nourishment	--	--	$584	$622	--	--	--	--
6 yr nourishment	--	$589	$717	$840	$820	$688	--	--
7 yr nourishment	--	$675	$804	$937	$908	$767	$668	--
8 yr nourishment	--	$764	$887	$1,087	$1,088	$960	$864	--
9 yr nourishment	--	$822	$965	$1,171	$1,185	$1,085	$1,011	$763
10 yr nourishment	--	$874	$1,006	$1,217	$1,297	$1,214	$1,023	$939
11 yr nourishment	--	$876	$1,016	$1,238	$1,252	$1,255	$1,063	$982
12 yr nourishment	--	$879	$1,031	$1,255	$1,264	$1,258	$1,058	$973
13 yr nourishment	--	$923	$1,053	$1,331	$1,362	$1,373	$1,191	$1,126
14 yr nourishment	--	$912	$1,042	$1,325	$1,365	**$1,403**	$1,240	$1,191
15 yr nourishment	--	$895	$1,034	$1,241	$1,365	$1,253	$1,234	$1,197
16 yr nourishment	--	$879	$1,028	$1,243	$1,375	$1,279	$1,262	$1,222

<u>Hybrid Alternatives: Net Annual Benefits with Full Recreation Benefits</u>

The Hybrid alternatives that are economically justified with limited recreation benefits (up to 50% of total benefits) were evaluated with full recreation benefits in **Table 5.3-24** and **Table 5.3-25**. Among the Hybrid alternatives evaluated at Segment 1, extending the beach 100 feet MSL and nourishing every 5 years maximizes NED net annual benefits. This result is consistent under low and high sea-level rise scenarios.

1 **Table 5.3-24 Segment 1: Hybrid Alternatives Net Annual Benefits with Full Recreation Benefits**

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft
2 yr nourishment	--	--	--	--
3 yr nourishment	--	$750	--	--
4 yr nourishment	$290	$1,092	--	--
5 yr nourishment	$474	**$1,352**	$317	--
6 yr nourishment	$386	$1,311	$302	--
7 yr nourishment	$293	$1,181	--	--
8 yr nourishment	$288	$1,181	$287	--
9 yr nourishment	$278	$1,222	$368	--
10 yr nourishment	$282	$1,166	$353	--
11 yr nourishment	$209	$1,066	$321	--
12 yr nourishment	$191	$969	--	--
13 yr nourishment	$189	$1,018	$406	--
14 yr nourishment	$83	$927	$360	--
15 yr nourishment	$114	$914	--	--
16 yr nourishment	$78	$842	--	--
High SLR ($1000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**
2 yr nourishment	--	--	--	--
3 yr nourishment	--	$2,606	--	--
4 yr nourishment	$1,944	$2,940	--	--
5 yr nourishment	$1,977	**$3,131**	$2,069	--
6 yr nourishment	$1,846	$3,074	$2,011	--
7 yr nourishment	$1,755	$2,882	--	--
8 yr nourishment	$1,693	$2,857	$1,901	--
9 yr nourishment	$1,651	$2,812	$1,966	--
10 yr nourishment	$1,575	$2,817	$2,049	--
11 yr nourishment	$1,469	$2,709	$2,005	--
12 yr nourishment	$1,428	$2,474	--	--
13 yr nourishment	$1,409	$2,471	$2,056	--
14 yr nourishment	$1,251	$2,333	$1,956	--
15 yr nourishment	$1,267	$2,305	--	--
16 yr nourishment	$1,208	$2,198	--	--

Among the Hybrid alternatives evaluated with full recreation benefits at Segment 2, extending the beach 200 feet MSL and nourishing every 13 years maximizes NED net annual benefits. Under the high sea-level rise scenario the alternative that maximizes NED net annual benefits is 300-feet added beach width nourished every 14 years.

Table 5.3-25 Segment 2: Hybrid Alternatives Net Annual Benefits with Full Recreation Benefits

Low SLR ($1,000s)	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft
2 yr nourishment	--	--	--	--	--	--	--	--
3 yr nourishment	--	--	--	--	--	--	--	--
4 yr nourishment	--	--	--	--	--	--	--	--
5 yr nourishment	--	--	$332	$375	--	--	--	--
6 yr nourishment	--	$469	$469	$583	$449	--	--	--
7 yr nourishment	--	$565	$570	$701	$565	$431	--	--
8 yr nourishment	--	$655	$667	$845	$742	$623	$420	--
9 yr nourishment	--	$723	$737	$913	$842	$753	$572	$315
10 yr nourishment	--	$787	$804	$1,012	$957	$888	$739	$499
11 yr nourishment	--	$796	$813	$1,030	$956	$862	$784	$546
12 yr nourishment	--	$811	$831	$1,031	$974	$872	$793	$545
13 yr nourishment	--	$864	$886	**$1,111**	$1,075	$993	$932	$704
14 yr nourishment	--	$862	$879	$1,107	$1,081	$1,023	$979	$771
15 yr nourishment	--	$858	$878	$1,104	$1,087	$1,027	$984	$784
16 yr nourishment	--	$858	$879	$1,110	$1,102	$1,058	$893	$817
High SLR ($1000s)	**50 ft**	**100 ft**	**150 ft**	**200 ft**	**250 ft**	**300 ft**	**350 ft**	**400 ft**
2 yr nourishment	--	--	--	--	--	--	--	--
3 yr nourishment	--	--	--	--	--	--	--	--
4 yr nourishment	--	--	--	--	--	--	--	--
5 yr nourishment	--	--	$551	$580	--	--	--	--
6 yr nourishment	--	$586	$683	$797	$771	--	--	--
7 yr nourishment	--	$675	$773	$896	$860	$713	--	--
8 yr nourishment	--	$766	$857	$1,047	$1,041	$906	$806	--
9 yr nourishment	--	$826	$937	$1,131	$1,138	$1,033	$954	$701
10 yr nourishment	--	$880	$980	$1,179	$1,251	$1,163	$967	$878
11 yr nourishment	--	$883	$992	$1,200	$1,208	$1,205	$1,008	$921
12 yr nourishment	--	$889	$1,008	$1,217	$1,220	$1,208	$1,004	$913
13 yr nourishment	--	$934	$1,031	$1,295	$1,319	$1,325	$1,137	$1,067
14 yr nourishment	--	$925	$1,022	$1,289	$1,322	**$1,355**	$1,186	$1,132
15 yr nourishment	--	$909	$1,016	$1,206	$1,323	$1,205	$1,182	$1,138
16 yr nourishment	--	$896	$1,011	$1,210	$1,334	$1,232	$1,210	$1,164

Notch Fill Alternative: Net Annual Benefits

The Notch Fill Alternative provides coastal storm damage reduction benefits by reducing the frequency of bluff top erosion compared to without project conditions. This is achieved by constructing toe notch fills at the base of the bluff and maintaining these at regular intervals. There are no recreation benefits. The costs include placement of notch fill to unprotected parcels.[69]

Table 5.3-26 Notch Fill Alternative Net Annual Benefits

Segment 1 *Notch Fill Alternative*			**Segment 2 *Notch Fill Alternative***		
	Low SLR	High SLR		Low SLR	High SLR
Benefits	$2,119,000	$1,840,000	Benefits	$797,000	$1,336,000
Costs	$2,252,000	$2,252,000	Costs	$1,535,000	$1,535,000
Net Benefits	**$(133,000)**	**$(411,000)**	**Net Benefits**	**$(738,000)**	**$(198,000)**
Std Deviation[70]	*474,000*	*896,000*	*Std Deviation*	*763,000*	*819,000*

Seawall Alternative: Net Annual Benefits

Alternative benefits are 100% of with-out pro-ject damages net of residual/sloughing damages. In other words, the seawall alternative is expected to protect against all without project damages excluding residual sloughing damages. There are no recreation benefits. The costs include construction with all associated costs and sand sedimentation & recreation loss fees for all unprotected parcels at a rate of $3,500 per linear foot, which is the amount applied consistently throughout this report when applicable.

Table 5.3-27 Seawall Alternative Net Annual Benefits

Segment 1 *Seawall Alternative*			**Segment 2 *Seawall Alternative***		
	Low SLR	High SLR		Low SLR	High SLR
Benefits	2,786,000	3,185,000	Benefits	2,826,000	3,527,000
Costs	4,845,000	4,845,000	Costs	3,837,000	3,837,000
Net Benefits[71]	**$(2,059,000)**	**$(1,660,000)**	**Net Benefits**	**$(1,011,000)**	**$(310,000)**
Std Deviation	*396,000*	*811,000*	*Std Deviation*	*590,000*	*638,000*

[69] A sensitivity analysis was done to determine impact to plan selection if only half of the linear length of unprotected parcels needed notch fill across the entire study period. The results show Segment 1 with $1,042,948 & $764,560 and Segment 2 at $63,281 & $603,312 net benefits for low and high sea-level rise, respectively. Under this less rigorous assumption the Notch Fill alternative continues to not maximize net benefits among the range of alternatives analyzed.

[70] In the absence of correlation coefficients between with and without project damages these standard deviations assume perfect correlation, which leads to the largest estimate of the project standard deviations.

[71] Standard deviation for Segment 1 net benefits is $395,732 low SLR and $811,413 high SLR. Segment 2 is $590,455 low SLR and $637,897 high SLR.

6 SELECTION OF THE NED PLANS

6.1 Alternatives Analyzed

The NED Plans for Segment 1 and 2 were selected among all the alternatives considered to "reasonably maximize net national economic development benefits, consistent with the Federal objective…"[72] All alternatives economically justified (BCR greater than one) with limited recreation benefits up to 50% of total benefits, were also analyzed with full recreation benefits to determine the NED Plans. Consequently, the benefits quantified to determine the NED Plan were Coastal Storm Damage Reduction (CSDR) and full recreation if applicable. The costs included construction and related activities, monitoring, environmental mitigation if applicable, sand sedimentation & recreation loss fee, and lagoon sedimentation fees. All alternatives assume joint construction of Segments 1 and 2 with commensurate savings for the initial fill/construction if applicable but no joint construction during any subsequent beach nourishments. In other words, we have assumed dredging equipment only needs to be mobilized one time to construct the initial project at both segments (Hybrid and Beach Fill alternatives only). All later nourishments would be constructed separately meaning dredging equipment would need to be mobilized once for each segment. For a complete and detailed listing of benefits and costs see the *Project Benefits* and *Project Costs* sections earlier in this appendix.

Alternatives analyzed:

- Seawall/Hard Structure
- Toe Notch/Sea Cave Fill
- Toe Notch/Sea Cave Fill & Sand Placement (*Hybrid Plan)*
- Sand Placement (*Beach Fill Plan*)

Once the net annual benefits for the *Seawall*, *Notch Fill*, *Hybrid*, and *Beach Fill* alternatives were compared, the Beach Fill alternatives, which have the highest net benefits, were selected as the NED Plan for Segment 1 and Segment 2 because among the alternatives analyzed, the *Beach Fill* alternatives maximize net benefits for both segments.

[72] *Economic and Environmental Principles for Water and Related Land Resources Implementation Studies*

Table 6.1-1 Selection of the NED Plan: Average Annual Benefits

Low SLR	SEGMENT 1		SEGMENT 2		
Alternative	**CSDR Benefits**	**Recreation Benefits (Full/Limited)**[73]		**CSDR Benefits**	**Recreation Benefits**
Seawall			**Seawall**		
Exp Value	$2,786,000	n/a	Exp Value	$2,826,000	n/a
Std Dev	*396,000*		*Std Dev*	*590,000*	
Notch Fill			**Notch Fill**		
Exp Value	$2,119,000	n/a	Exp Value	$797,000	n/a
Std Dev	*474,000*		*Std Dev*	*762,000*	
Hybrid (5yr/100 ft)			**Hybrid (13yr/200 ft)**		
Exp Value	$1,878,000	$1,831,000 /$1,604,000	Exp Value	$1,570,000	$1,619,000 /$1,353,000
Std Dev	*618,000*		*Std Dev*	*644,000*	--
Beach Fill (5yr/100 ft)			**Beach Fill (13yr/200 ft)**		
Exp Value	$1,865,000	$1,831,000 /$1,598,000	Exp Value	$1,537,000	$1,619,000 /$1,337,000
Std Dev	*618,000*		*Std Dev*	*642,000*	--
High SLR					
Seawall			**Seawall**		
Exp Value	$3,185,000	n/a	Exp Value	$3,527,000	n/a
Std Dev	*811,000*		*Std Dev*	*638,000*	
Notch Fill			**Notch Fill**		
Exp Value	$1,840,000	n/a	Exp Value	$1,337,000	n/a
Std Dev	*896,000*		*Std Dev*	*819,000*	
Hybrid (5yr/100 ft)			**Hybrid (14yr/300 ft)**		
Exp Value	$2,151,000	$3,651,000 /$2,150,000	Exp Value	$2,442,000	$2,197,000 /$1,995,000
Std Dev	*722,000*	--	*Std Dev*	*755,000*	--
Beach Fill (5yr/100 ft)			**Beach Fill (14yr/300 ft)**		
Exp Value	$2,141,000	$3,651,000 /$2,141,000	Exp Value	$2,424,000	$2,197,000 /$1,992,000
Std Dev	*722,000*	--	*Std Dev*	*$754,000*	--

[73] Expected values shown for Limited Recreation Benefits because CSDR Benefits are non-deterministic. This is the reason why limited recreation benefits can be lower than full recreation benefits when full recreation benefits are in turn lower than expected CSDR benefits. Consequently, the expected values for CSDB are a little higher than the limited recreation benefits.

Table 6.1-2 Selection of the NED Plan: Average Annual Costs

Segment 1 Low SLR	Initial Construct	Nourishment Construct	Environ Mitigation	Monitoring/ O&M	Lagoon Sedimentation Fee	Sediment/ Recreation Loss Fees
Seawall	3,818,000	n/a	n/a	n/a	n/a	1,027,000
Notch Fill	720,000	n/a	n/a	505,000	n/a	1,027,000
Hybrid (5yr/100ft)	674,000	1,551,000	3,000	73,000	56,000	n/a
Beach Fill (5yr/100ft)	576,000	1,551,000	3,000	73,000	56,000	n/a
High SLR						
Seawall	3,818,000	n/a	n/a	n/a	n/a	1,027,000
Notch Fill	720,000	n/a	n/a	505,000	n/a	1,027,000
Hybrid (5yr/100ft)	706,000	1,832,000	3,000	73,000	56,000	n/a
Beach Fill (5yr/100ft)	608,000	1,832,000	3,000	73,000	56,000	n/a
Segment 2 **Low SLR**						
Seawall	3,134,000	n/a	n/a	n/a	n/a	703,000
Notch Fill	492,000	n/a	n/a	340,000	n/a	703,000
Hybrid (13yr/200ft)	1,009,000	523,000	357,000	86,000	105,000	n/a
Beach Fill (13yr/200ft)	943,000	523,000	357,000	86,000	105,000	n/a
High SLR						
Seawall	3,134,000	n/a	n/a	n/a	n/a	703,000
Notch Fill	492,000	n/a	n/a	340,000	n/a	703,000
Hybrid (14yr/300ft)	1,706,000	885,000	615,000	87,000	119,000	n/a
Beach Fill (14yr/300ft)	1,640,000	885,000	615,000	87,000	119,000	n/a

Table 6.1-3 NED Plan Selection: Net Annual Benefits[74]

Low SLR		SEGMENT 1				SEGMENT 2	
Alternative	**Benefits**	**Costs**	**Net Benefits**	**Alternative**	**Benefits**	**Costs**	**Net Benefits**
Seawall	2,786,000	4,845,000	$(2,059,000)	**Seawall**	2,826,000	3,837,000	$(1,011,000)
Notch Fill	2,119,000	2,252,000	$(133,000)	**Notch Fill**	797,000	1,535,000	$(738,000)
Hybrid (5yr/100ft)				**Hybrid (13yr/200ft)**			
Exp Value	3,708,000	2,357,000	$1,352,000	Exp Value	3,191,000	2,080,000	$1,110,000
Std Dev			983,000	*Std Dev*			*1,004,000*
Prob NB>0[75]			*85%*	*Prob NB>0*			*80%*
Beach Fill (5yr/100ft)				**Beach Fill (13yr/200ft)**			
Exp Value	3,694,000	2,259,000	$1,435,000	Exp Value	3,158,000	2,014,000	$1,144,000
Std Dev			*987,000*	*Std Dev*			*1,103,000*
Prob NB>0			*86%*	*Prob NB>0*			80%
High SLR							
Seawall	3,185,000	4,845,000	$(1,660,000)	**Seawall**	3,527,000	3,837,000	$(310,000)
Notch Fill	1,840,000	2,252,000	$(411,000)	**Notch Fill**	1,336,000	1,535,000	$(310,000)
Hybrid (5yr/100ft)				**Hybrid (14yr/300ft)**			
Exp Value	5,801,000	2,669,000	$3,131,000	Exp Value	4,639,000	3,283,000	$1,355,000
Std Dev			*1,469,000*	*Std Dev*			*1,119,000*
Prob NB>0			*85%*	*Prob NB>0*			*86%*
Beach Fill (5yr/100ft)				**Beach Fill (14yr/300ft)**			
Exp Value	5,789,000	2,571,000	$3,217,000	Exp Value	4,621,000	3,219,000	$1,403,000
Std Dev			*1,468,000*	*Std Dev*			*1,165,000*
Prob NB>0			*85%*	*Prob NB>0*			85%

6.2 Results

Table 6.2-1 below highlights key characteristics of the NED Plans for Segment 1 and 2.

- The NED Plan for Segment 1 is the Beach Fill Alternative with an initial dredged volume of 820,000 cubic yards (890,000 cubic yards under high SLR) that extends the base year beach width at mean-sea level approximately 100 feet. Nourishments would occur every 5 years and require dredging 340,000 cubic yards of material (400-480,000 cubic yards under high SLR). Net annual benefits are expected to be $1.44 million annually ($3.22 million under high SLR).
- The NED Plan for Segment 2 is the Beach Fill Alternative with an initial dredged volume of 1,117,000 cubic yards (2,070,000 cubic yards under high SLR) that extends the base year beach width at mean-sea level approximately 200 feet (300 feet under high SLR). Nourishments would occur every 13 years (14 years under high SLR) and require dredging 500,000 cubic yards of material (1-1.1 million cubic yards under high SLR). Net annual benefits are expected to be $1.11 million annually ($1.67 million under high SLR).

[74] Totals may not add up due to rounding. Full recreation benefits included where applicable.
[75] Long-run probability net benefits would be greater than zero.

Table 6.2-1 NED Plan Specifications

Low SLR	SEGMENT 1	SEGMENT 2
Type	Beach Fill	Beach Fill
Initial Added Width	100 ft	200 ft
Initial Volume Dredged	819,000 cyd	1,177,000 cyd
Nourishment Interval	5 yr	13 yr
Nourishment Volume Dredged	336,000 cyd	500,000 cyd
Net Annual Benefits		
Expected Value (full Recreation Benefits)	$1,435,000	$1,114,000
Expected Value (up to 50% Rec Benefits)[76]	$1,201,000	$860,000
Expected Value (CSDR Benefits only)	-$234,000	-$345,000
Standard Deviation	*988,000*	*1,103,000*
Long-run probability Net Benefits >0	86%	80%
BCR (incl full Recreation Benefits)	1.71	1.63
BCR (incl Rec Benefits up to 50% of CSDR Benefits)	1.53	1.43
BCR (CSDR Benefits only)	0.83	0.76
High SLR	**SEGMENT 1**	**SEGMENT 2**
Type	Beach Fill	Beach Fill
Initial Added Width	100 ft	300 ft
Initial Volume Dredged	885,000 cyd	2,070,000 cyd
Nourishment Interval	5 yr	14 yr
Nourishment Volume Dredged	403-476,000 cyd	998-1,119,000 cyd
Net Annual Benefits		
Expected Value (full Recreation Benefits)	$3,217,000	$1,665,000
Expected Value (up to 50% Rec Benefits)	$1,700,000	$1,196,000
Expected Value (CSDR Benefits only)	-$249,000	-$531,000
Standard Deviation	*1,468,000*	*1,165,000*
Long-run probability Net Benefits >0	85%	86%
BCR (incl full Recreation Benefits)	2.32	1.52
BCR (incl Rec Benefits up to 50% of CSDR Benefits)	1.66	1.37
BCR (CSDR Benefits only)	0.83	0.75

6.3 Detailed Cost Estimate for Tentatively Recommended Plans

Cost engineering performed a formal risk analysis in compliance with *Engineer Regulation (ER) 1110-2-1302 Civil Works Cost Engineering* for the tentatively recommended plans shown in Section 6.2 and Table 6.2-1. The purpose is to identify and measure cost and schedule impact of project uncertainties. This analysis determined construction cost risk is the main source of uncertainty and specifically sand volumes, fuel prices, mitigation, and bidding

[76] To follow guidance on risk and uncertainty, Coastal Storm Damage Reduction (CSDR) benefits were evaluated as a dynamic (random) number. Since recreation benefits had to be equal to or less than CSDR benefits, some Monte Carlo Simulations resulted in higher CSDR benefits than recreation benefits. Consequently, the expected values for CSDB are a little higher than the limited recreation benefits.

climate. More information about the project risk and schedule analysis is available in *Appendix F – Cost Engineering*.

For the purposes of the Economic Analysis the formal risk analysis and Total Project Cost Summary, also performed by Cost Engineering, provide detailed project costs and contingency costs for the tentatively recommended plans. The overall contingency value is $38 million, or 29% of most likely project costs. Most likely project costs are $133 million. Project cost plus contingency totals approximately $171 million—$108 million at Segment 1 (Encinitas) and $63 million at Segment 2 (Solana Beach). Overall, these costs are slightly lower than preliminary estimates used in plan formulation due to lower contingency and mitigation cost estimates.

The economic project costs include Interest During Construction (IDC). The revised project cost estimate including IDC for initial fill is $14.2 million at Segment 1 and $23.2 million at Segment 2 and total initial nourishment cost of $37.5 million. Total cost for Segment 1 is $62.9 million and $107.8 million for Segment 2 shown below.

Table 6.3-1 Detailed Cost Estimate for the Tentatively Recommended Plans[77]

	Segment 1 (Encinitas)	Segment 2 (Solana Beach)	Total
Sand Replenishment	$72,579,000	$36,052,000	$108,631,000
Mitigation & Monitoring	$4,021,000	$8,031,000	$12,052,000
Lagoon Sedimentation	$4,141,000	$7,612,000	$11,753,000
Land Damages	$154,000	$64,000	$218,000
Pre-Engieering & Design	$21,748,000	$8,164,000	$29,912,000
Construction Management	$5,179,000	$2,842,000	$8,021,000
Interest During Construction	101,000	124,000	$225,000
Total	$107,922,000	$62,888,000	$170,810,000

These costs, which occur throughout the study period, were separated in to the year incurred, discounted at the current federal discount rate of 3.75%, and the Net Present Value (NPV) was calculated. Finally, the NPV was annualized (amortized) and presented in **Table 6.3-2.**

[77] FY 2013 price levels, undiscounted

Table 6.3-2 ER 1105-2-100 Appendix H - Economic Table[78]

Equivalent Annual Benefits and Costs
Solana Beach-Encinitas Coastal Storm Damage Reduction Feasibility Study
FY2013 Price Levels, 50-year Period of Analysis, 3.75% Discount Rate

	Segment 1 (Encinitas)	Segment 2 (Solana Beach)	Total
Investment Costs			
Total Project Construction Costs	$107,821,000	$62,764,000	$170,585,000
Interest During Construction	$101,000	$124,000	$225,000
Total Investment Cost	$107,922,000	$62,888,000	$170,810,000
NPV of Investment Cost	$54,070,000	$37,290,000	$91,360,000
Average Annual Costs			
Interest and Amortization of Initial Investment	$2,410,000	$1,662,000	$4,072,000
OMRR&R	$0	$0	$0
Total Average Annual Costs	$2,410,000	$1,662,000	$4,072,000
Average Annual Benefits	$3,692,000	$3,167,000	$6,850,000
Net Annual Benefits	$1,282,000	$1,504,000	$2,777,000
Benefit-Cost Ratio	1.53	1.91	1.68
Benefit-Cost Ratio (computed at 7%)*	1.54	1.64	1.59
*per Executive Order 12893			

[78] In addition to detailed, updated cost estimates for the NED Plans the benefits have been updated to FY 2013 price levels for this table.

7 UNCERTAINTY AND RESIDUAL RISK

7.1 Purpose & Major Sources

The *Planning Guidance Notebook* states, “Uncertainty and variability are inherent in water resource planning…Therefore, the consideration of risk and uncertainty is important in water resource planning.”[79] To accomplish this objective the Economic modeling included Monte Carlo simulation techniques to ensure the damages from episodic erosion events were defined by probability distributions rather than deterministic values. In addition the coastal storm damage that could be theoretically prevented was compared to the damage we expect to be prevented by construction of the NED Plans.

Major sources of economic uncertainty include variability in the cost of seawall construction, uncertainty about what share of parcels would be armored in time to prevent structure loss given the episodic nature of these bluff collapses, uncertainty about the financial resources private owners have to construct seawalls, variability in land and structure values, and uncertainty about how intensively study area beaches will be utilized in the future.

Risks from the tentatively selected plan include life-safety risk from collapsing bluff tops given the uncertainty around processes that cause and can halt episodic bluff collapse—the TSP has been formulated to reduce life-safety risk but does not purport to eliminate this completely. Risk also stems from the variability in the authorization, appropriation, and ultimate construction schedule for the TSP. The consequences of delay constructing the TSP include unanticipated damages from structure loss/collapse as well as injury or death from falling debris.

7.2 Preventable & Unpreventable Damages

Preventable bluff erosion damages result from episodic bluff erosion occurring under without project conditions after being adjusted to remove damages due to sloughing at the bluff top edge, which would not be prevented by any of the alternatives formulated. These *unpreventable* residual sloughing damages would still occur due to gradual erosion at the bluff edge. No alternatives were formulated to reduce sloughing erosion at the bluff top edge because that was determined to be outside the Federal interest of civil works projects. Therefore the NED Plan was not formulated to reduce or eliminate residual sloughing damage at the bluff edge; the NED Plan was formulated to reduce erosion at the base of the bluff only. Residual sloughing damages are primarily from land loss and would continue to occur under any project alternative. In Segment 1 the average annualized damage are $397,000 and in Segment 2 the damages are $143,000. These sloughing damages have been removed to arrive at the *Preventable bluff erosion damages* when analyzing project alternatives and selecting the NED Plan.[80]

7.3 Results

Preventable bluff erosion damages are also referred to as the *maximum potential Coastal Storm Damage Reduction (CSDR) benefit,* since they are the theoretical limit in benefits an alternative could achieve. Table 7.3-1 gives indicators of the residual risk and uncertainty for the NED

[79] The *Planning Guidance Notebook* ER-1105-2-100 section E-4

[80] These sloughing damages are not preventable from the perspective of the US Army Corps of Engineers because they are outside the Federal interest for civil works projects. However, other individuals or entities could construct features on the bluff edge to prevent/reduce these sloughing damages.

Plans. The maximum potential CSDR benefit under the low sea-level rise scenario are $2.76 million in Segment 1 and $2.80 million in Segment 2 with standard deviation $252,000 and $481,000, respectively. The maximum potential CSDR benefits under the high sea-level rise scenario are $3.17 million in Segment 1 and $3.51 million in Segment 2 with standard deviations of $375,000 and $489,000, respectively. Under the low sea-level rise scenario the NED Plan achieves $1.87 million in reduced bluff erosion damages for Segment 1 and $1.53 million for Segment 2, which averages 68% and 55% of the maximum potential CSDR benefits, respectively. Under the high sea-level rise scenario the NED Plan achieves $2.14 million in reduced in bluff erosion damages for Segment 1 and $2.42 million for Segment 2, which averages 68% and 69% of the maximum potential CSDR benefits, respectively. Importantly, these CSDR benefits are conservative since analysis of benefits and residual risk are based on spring beach profiles when sand density near the base of the bluff is typically lowest. In other words, we expect the sand density to be measurably higher during other seasons each year, which could afford more CSDR benefits and less residual risk than shown. Consequently, in practice the CSDR benefits may be higher than shown since summer and fall conditions typically promote increased sand density near the base of the bluff that has not been considered for this risk analysis. Similarly, actual residual damages may also be lower than shown in practice. [81]

The project alternatives were formulated to reduce erosion to the base/toe of the bluff exclusively. Preventable bluff erosion damages are the total without project damages excluding residual sloughing at the bluff top edge that would not be prevented by a Federal-interest project. *Prevented bluff erosion damages* are the NED Plan coastal storm damage reduction (CSDR) benefits. *Residual Preventable Damages* is the expected amount of damage that could occur with the NED Plan implemented. Again, residual damages are based on analysis of the spring shoreline profiles, which means expected residual damages may be biased upward due to lower sand density near the base of the bluff typical during this period. The *Residual Preventable Damage* as a share of the *Preventable Bluff Erosion Damages* is presented as the average across the study period and the minimum and maximum percentages attained within the nourishment interval.

Table 7.3-1 Residual Risk & Uncertainty for the NED Plans

	SEGMENT 1		SEGMENT 2	
	Low SLR	High SLR	Low SLR	High SLR
Plan Characteristics				
Duration of Nourishment Interval	5 yr	5 yr	13 yr	14 yr
Initial Added Beach Width	100 ft	100 ft	200 ft	300 ft
Preventable bluff erosion damages/max CSDR Benefits				
Expected Value	$2,759,000	$3,166,000	$2,807,000	$3,513,000
Standard Deviation	*252,000*	*374,000*	*481,000*	*491,000*

[81] See Coastal Engineering Appendix for an explanation about why spring profiles were used to estimate project alternative benefits.

Prevented bluff erosion				
damages/CSDR Benefits	$1,865,000	$2,141,000	$1,537,000	$2,424,000
Expected Value	*618,000*	*722,000*	*601,000*	*754,000*
Standard Deviation				
Residual Preventable Damages, $				
Expected Value	$895,00	$1,025,000	$1,270,000	$1,088,000
Standard Deviation	0	*684,000*	*574,000*	*714,000*
	597,000			
Residual Preventable Damages, %				
Expected Value, study period	32%	32%	45%	31%
(“Level of Residual Risk”)	19%/36%	19%/36%	35%/52%	17%/40%
Expected Value, min/max				

Residual Preventable Damages are not completely halted because the Coastal Engineering model indicates at least some wave attacks to the bluff toe would still occur with the NED Plans constructed. Alternatives offering lower residual preventable damages generally mean fewer episodic bluff collapses because of fewer wave attacks to the bluff toe. An alternative that results in zero residual damages is unlikely to exist in practice; therefore, an acceptable level of residual preventable damages must exist but is subjective and likely to vary considerably depending on the viewpoint (beach visitors, affected homeowners, local government officials, the USACE-HQ, and so on). Because of this subjectivity **Figure 7.3-1** and **Figure 7.3-2** were created to emphasize the relative level of risk alternatives offer. This has been done for all 180 beach fill alternatives analyzed. Results reveal that residual preventable damages decrease as the nourishment interval is shortened or as the sand volume is increased. .

As **Figure 7.3-1** and **Figure 7.3-2** show, alternatives were analyzed that reduce preventable damages below 20% to above 90% on average. The NED Plan for Segment 2 falls toward the center of this range (the NED Plan under the high sea-level rise scenario falls toward lowest portion of this range). The NED Plan for Segment 1 falls toward the lower portion of this range. Again, these estimates are based on spring beach profiles when sand density near the base of the bluff is typically lowest so residual damages shown here may be toward the higher end of reasonable estimates.[82] Nevertheless, the relative amount of residual damages each alternative provides can offer insight about the tradeoff between sand density (i.e., larger beach widths) and how alternatives could reduce preventable coastal storm damages, particularly under lower sand density conditions in the spring time.

[82] See the Coastal Engineering Appendix Section 6.6 for further elaboration.

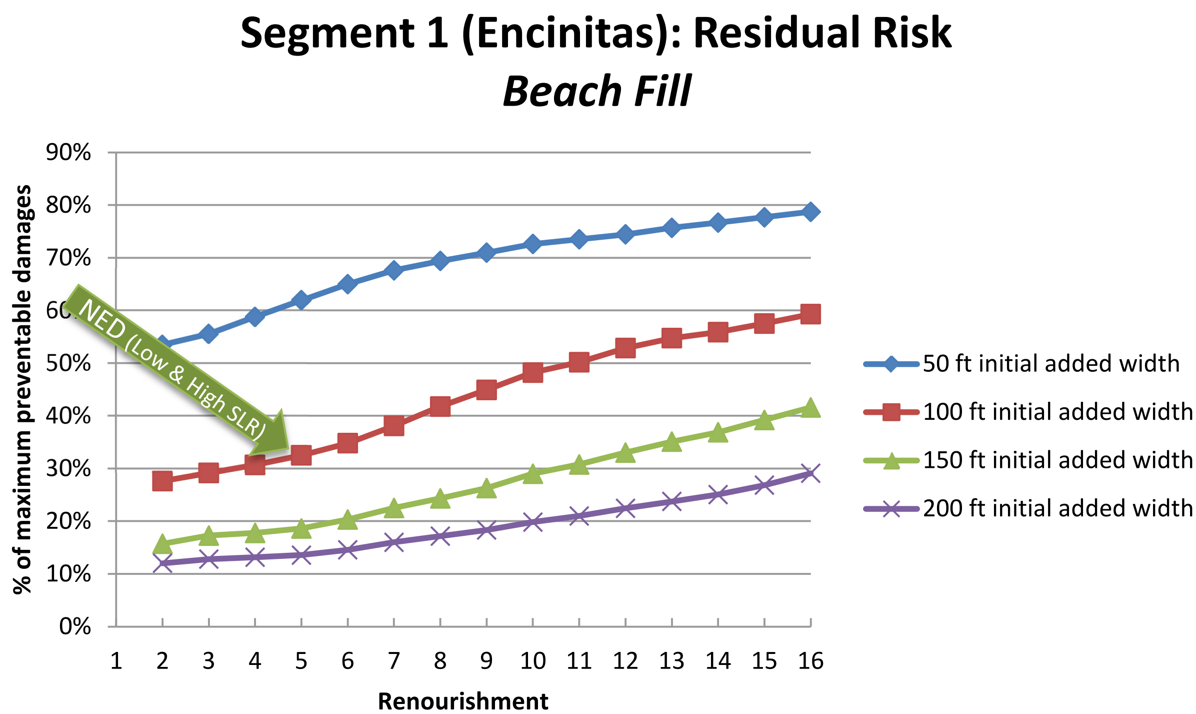


Figure 7.3-1 Residual Risk for Encinitas

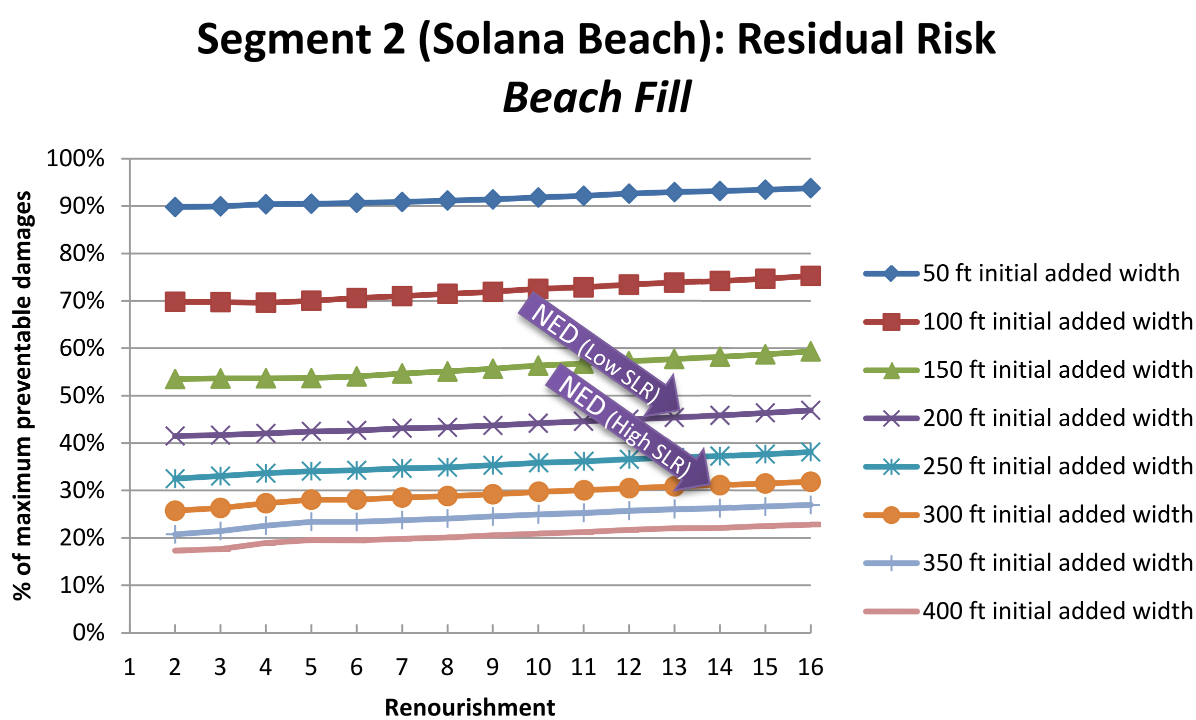


Figure 7.3-2 Residual Risk for Solana Beach

8 SCENARIO ANALYSES

8.1 Jointly-Synchronized Plan Analysis

8.1.1 Purpose

The purpose of the jointly-synchronized plan analysis is to augment plan selection criteria by determining the optimal set of project alternatives for Segment 1 or Segment 2 if the two segments are planned and constructed jointly to realize cost savings by sharing certain fixed costs through overlapping nourishment intervals. This analysis evaluates all nourishment intervals and added beach widths that can be applied in combination for Segment 1 and Segment 2 to determine the project alternative for Segment 1 and the project alternative for Segment 2 that yields the greatest combined net benefits when both projects can be executed jointly. This scenario relaxes a key assumption used to select the NED Plans—Segment 1 and 2 could not predictably synchronize nourishments to occur jointly due to uncertain future erosion rates and funding during the period of analysis. Instead this scenario relaxes those constraints and allows for synchronization to occur for every possible combination of beach width and nourishment cycle across both segments to determine the most economically beneficial plans that could be jointly constructed. This is an important scenario to analyze because if nourishment intervals overlap there would be substantial savings, primarily by sharing mobilization/demobilization costs.

8.1.2 Procedure

This analysis allows Segment 1 to vary across all possible combinations of added beach width and nourishment while Segment 2 is also allowed to vary across all possible combinations of initial added beach width and nourishment interval. Since both segments are evaluated for the pair of alternatives that generate the maximum combined net annual benefits, fixed construction costs have to be allocated to each segment. Each segment receives 50% of the combined construction equipment mobilization & demobilization costs plus 50% of all associated expenses (supervision & administration, interest during construction, contingency). The 50/50 split is a reasonable approximation of the actual cost allocation for the projects since much of the mobilization and demobilization costs stem from bringing the equipment long distances to the receiver site rather that shifting it a few miles between Encinitas to Solana Beach. Likewise, the duration the equipment would be used at each segment or the intensity of use (amount of dredged sand) has little impact to mobilization/demobilization costs.[83]

8.1.3 Results

Table 8.1-2 shows the combinations of nourishment intervals and initial added beach widths for both segments that yield the highest net annual benefits when we analyze the synchronized nourishment scenario. The ranking starts with the combination that yields the highest combined net benefits from both segments followed by the next nine highest combinations. Under the Synchronizing Scenario, results show the combined net benefits are greatest when the beach is initially extended 100 feet MSL and nourishments occur every 5 years in Segment 1 (the NED Plan) while Segment 2 is extended 200 feet every 10 years (250 feet under the high sea-level

[83] When each segment is viewed as a stand-alone project, the mob/demob cost excluding contingency and overhead for Segment 1 is $2,586,052 while the cost for Segment 2 is $2,379,818, which also supports the 50/50 cost allocation when nourishments are synched.

rise scenario). To achieve these results both segments would be constructed jointly starting in the base year and then jointly nourished every 10 years later as shown in **Table 8.1-1**.

Table 8.1-1 Synchronizing Nourishments to Maximize Net Benefits

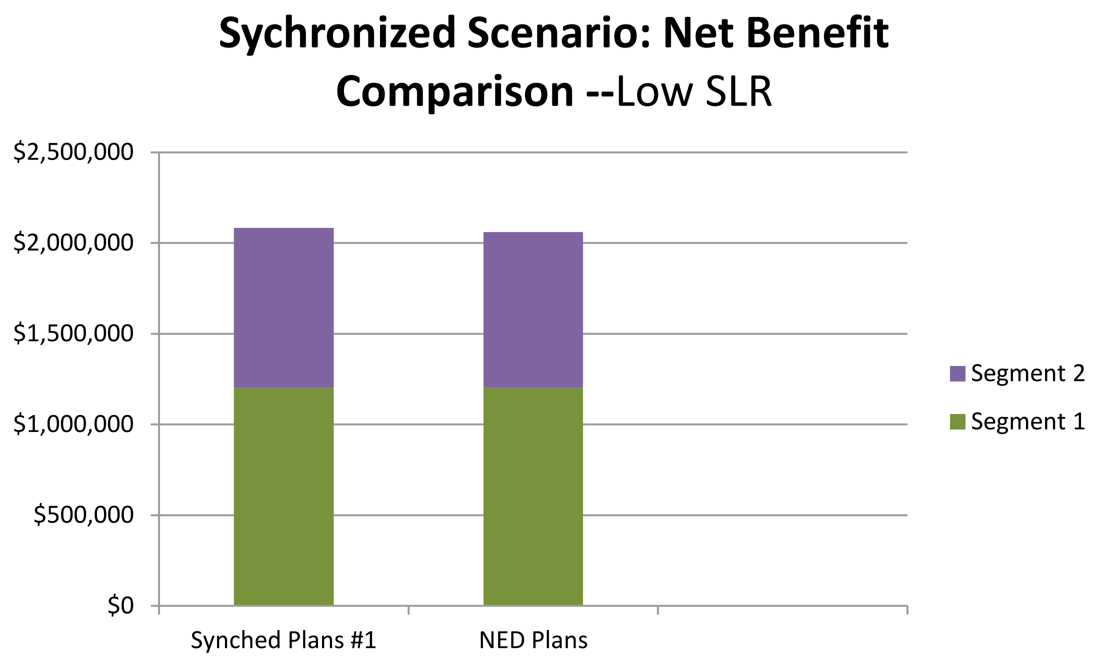
Low SLR		High SLR	
Segment 1	Segment 2	Segment 1	Segment 2
2014	2014	2014	2014
2019		2019	
2024	2024	2024	2024
2029		2029	
2034	2034	2034	2034
2039		2039	
2044	2044	2044	2044
2049		2049	
2054	2054	2054	2054

As noted previously, at this feasibility stage we are unable to determine if synchronizing would occur in practice. However, should nourishment cycles synchronize every 10 years, the commensurate savings from sharing mobilization/demobilization costs and related expenses would be $1.59 million for Segment 1 and $1.28 million for Segment 2 realized and the combined net annual benefits would be higher. Recall we formulated the NED Plans assuming construction at both segments cannot occur jointly except for the base year. In other words that cost savings was not factored in to select the NED Plans. However, when that savings is factored in to all overlapping nourishment cycles and net benefits compared, the NED Plans, which could never overlap during the 50-year study period, would produce the 10th highest net benefits (5th under high SLR) as shown in **Table 8.1-2**. This means that if synchronizing occurs in practice, then we expect constructing the NED Plans at both segments would produce moderately less combined net benefits than constructing the NED Plan at Segment 1 while extending the beach 200 feet at Segment 2 (250ft high SLR) and nourishing every 10 years. This would result in about $160k in increased net benefits compared to implementing the NED Plan at Segment 2. We have also demonstrated that identification of the NED Plan at Segment 1 is not affected by assuming synchronization can or cannot occur across all future nourishment cycles that overlap. In contrast, the NED Plan at Segment 2 would remain 200 feet of added beach width MSL but nourish every 10 years as opposed to every 13 years if synchronizing occurs.

Table 8.1-2 Synchronization Scenario Analysis: Plans by Highest Combined Net Annual Benefits

Low SLR	Segment 1 (Encinitas)			Segment 2 (Solana Beach)			
RANK	Nourishment Interval	Added Width	Net Benefits	Nourishment Interval	Added Width	Net Benefits	Total NED net benefits
1	5yr	100ft	$1,333,445	10yr	200ft	$882,858	$2,216,303
2	5yr	100ft	$1,277,522	15yr	200ft	$900,790	$2,178,312
3	5yr	100ft	$1,277,522	15yr	250ft	$895,278	$2,172,800
4	5yr	100ft	$1,333,445	10yr	250ft	$835,411	$2,168,856
5	6yr	100ft	$1,242,417	12yr	200ft	$868,593	$2,111,010
6	5yr	100ft	$1,277,522	15yr	300ft	$817,779	$2,095,301
7	5yr	100ft	$1,277,522	15yr	350ft	$817,064	$2,094,586
8	5yr	100ft	$1,333,445	10yr	300ft	$750,358	$2,083,803
9	6yr	100ft	$1,242,417	12yr	250ft	$820,293	$2,062,710
NED Plans 10	5yr	100ft	$1,201,073	13yr	200ft	$859,291	$2,060,365
High SLR	Segment 1 (Encinitas)			Segment 2 (Solana Beach)			
RANK	Nourishment Interval	Added Width	Net Benefits	Nourishment Interval	Added Width	Net Benefits	Total NED net benefits
1	5yr	100ft	$1,833,038	10yr	250ft	$1,209,783	$3,042,821
2	5yr	100ft	$1,777,115	15yr	250ft	$1,217,779	$2,994,894
3	5yr	100ft	$1,833,038	10yr	300ft	$1,126,067	$2,959,105
4	5yr	100ft	$1,833,038	10yr	200ft	$1,116,853	$2,949,891
NED Plans 5	5yr	100ft	$1,700,416	14yr	300ft	$1,196,398	$2,896,814
6	5yr	100ft	$1,777,115	15yr	300ft	$1,118,795	$2,895,910
7	5yr	100ft	$1,777,115	15yr	300ft	$1,104,536	$2,881,651
8	5yr	100ft	$1,777,115	15yr	400ft	$1,102,333	$2,879,448
9	5yr	100ft	$1,700,416	13yr	300ft	$1,169,807	$2,870,223
10	5yr	100ft	$1,777,115	15yr	200ft	$1,076,167	$2,853,282

Figure 8.1-1 shows the net annual benefits for two sets of alternatives: the Joint-synchronized plans with the highest net benefits and the NED Plans. This figure was created from the highlighted rows in **Table 8.2-1** and shows clearly that the net benefits from the #1 synchronized set of alternatives and the NED Plans would be similar if nourishments can be synchronized. In other words the difference in NED net benefits would be modest.



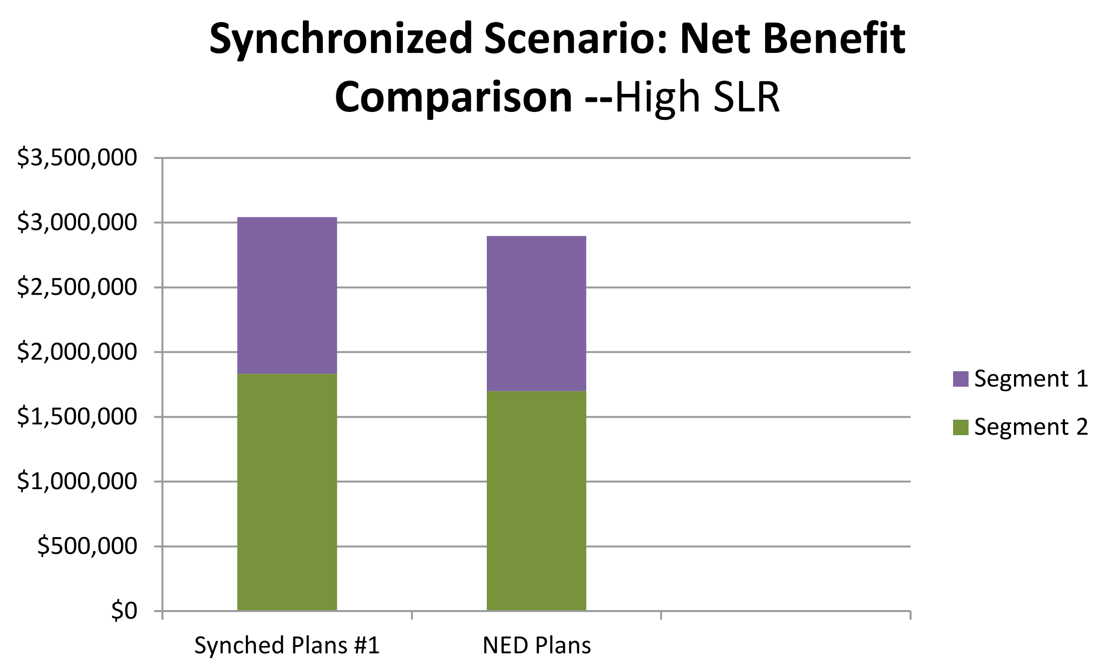


Figure 8.1-1 Scenario Analysis: Net Benefit Plan Comparison

8.2 <u>Unit Dredging Cost</u>

Since a large volume of sand would be placed during the 50-year study period, slight changes in unit dredging costs would impact project costs and could potentially impact plan selection. To determine the potential impact to plan selection a sensitivity analysis was performed on a reasonable range of “worst-case” cost estimates per cubic yard of dredged material.

Plans were formulated using dredging costs of $7.62 per cubic yard at Segment 1 and $7.15 per cubic yard at Segment 2 for dredging activity at the primary borrow site closest to the study area. Since that borrow site can be exhausted during the study period, a secondary borrow site was identified considerably farther from the study area. When a beach-fill alternative exhausted the primary borrow site, dredging costs were increased 50% to $11.43 and $10.75, respectively, to account for the added costs of dredging at the secondary borrow site identified by geotechnical experts. This 50% increase in unit dredging costs is expected to cover cost increases from dredging at the secondary site; however, because of uncertainty when establishing that cost increase a sensitivity analysis was performed to determine how plan selection could be impacted by increased dredging costs. The cost increases examined were hypothetical but cover the plausible range unit dredging costs could increase under various worst-case scenarios.

To perform the sensitivity analysis unit dredging costs at the secondary borrow site were increased by 75%. This caused unit costs in Segment 1 to increase from $7.62 at the primary borrow site to $13.33 at the secondary site. In Segment 2 the increase was from $7.15 at the primary site to $12.51 at the secondary site. Next unit costs were increased 100% such that the secondary borrow site increased unit dredging costs in Segment 1 to $15.24 and $14.30 in Segment 2.

The impact from increasing unit dredging costs on plan selection is shown in **Table 8.2-1** below. Plan selection is not impacted by this increase from 50% to 75% of fill cost. The NED Plan for Segment 1 is also unaffected when unit dredging costs at the secondary site increase 100%; however, the NED Plan changes to 200 feet of added beach width MSL nourished every 13 years at Segment 2 under the high sea-level rise scenario only. Under the low sea-level rise scenario there is no impact to plan selection at either segment. Overall, the impact to net annual benefits is modest; typically a 25% point increase in unit dredging costs at the secondary borrow site reduces annualized net benefits $25-75,000. In all cases the expected net annual benefits continue to be strongly positive.

Table 8.2-1 NED Plan Sensitivity to Unit Dredging Costs

Low SLR	Segment 1			Segment 2		
Dredging cost increase	***Baseline/ 50%***	***75%***	***100%***	***Baseline/ 50%***	***75%***	***100%***
Net Annual Benefits	1,201,000	1,175,000	1,146,000	860,000	860,000	860,000
NED Plan Altered?	--	NO	NO	--	NO	NO
NED Plan	100ft/5yr	100ft/5yr	100ft/5yr	200ft/13yr	200ft/13yr	200ft/13yr
High SLR	**Segment 1**			**Segment 2**		
Dredging cost increase	***Baseline/ 50%***	***75%***	***100%***	***Baseline/ 50%***	***75%***	***100%***
Net Annual Benefits	1,700,000	1,621,000	1,538,000	1,196,000	1,129,000	1,071,000
NED Plan Altered?	--	NO	NO	--	NO	YES
NED Plan	100ft/5yr	100ft/5yr	100ft/5yr	300ft/14yr	300ft/14yr	200ft/13yr

8.3 Armoring & Retreat Scenario Weighting

Recall that without project damages were determined by weighting two scenarios. First, the *Armoring Scenario* assumes all owners threatened by structure failure/collapse are able to construct seawalls in time. Second, the *Retreat Scenario* assumes these same owners are unable to construct seawalls in time and the first row of structures collapse given enough bluff erosion. Since with Project Benefits are determined by the reduction in without project damages, the *Armoring* and *Retreat Scenario* damages have to be combined to determine the amount of preventable without project damages (i.e. the with-project maximum CSDR benefits). Therefore, these scenarios are weighted by the probability of occurrence to determine the expected value.

Weighting was determined by combining the probability of unpreventable structure loss due to bluff collapse with the probability of financial, political, and personal factors inhibiting seawall construction prior to structure loss.[84] Since both probabilities have inherent uncertainty, a sensitivity analysis with weightings above and below the baseline was performed. The baseline weighting used for plan selection is shown in the table below along with sensitivity analyses done by adding and subtracting 10 percentage points to that baseline weighting.

Table 8.3-1 Retreat Scenario Weighting Sensitivity

	Baseline			+10% Sensitivity			-10% Sensitivity	
	Low SLR	High SLR		High SLR	High SLR		High SLR	High SLR
Segment 1	18%	20%		28%	30%		8%	10%
Segment 2	22%	29%		32%	39%		12%	19%

The baseline *Retreat Scenario* weighting is 18-20% for Segment 1 and 22-29% for Segment 2 depending upon the sea-level rise scenario. Conversely, the *Armoring Scenario* weighting is 80-82% for Segment 1 and 71-78% for Segment 2 since its weighting is one minus *Retreat Scenarios* weighting. *Retreat Scenario* involves greater damages than *Armoring Scenario* because structures can be lost. As a result increasing the *Retreat Scenario* weighting increases the without project damages, which in turn increases the maximum Coastal Storm Damage Reduction (CSDR) benefits any given project alternative can achieve. Decreasing the *Retreat Scenario* weighting has the opposite effect—lower CSDR benefits. When the *Retreat Scenario* weighting is increased by 10 percentage points (+10% Sensitivity) then Segment 1 weighting increases to 28-30% and Segment 2 increases to 32-39% with a corresponding decrease in *Armoring Scenario* weighting. This increased weighting on *Retreat Scenario* could be explained by higher than expected constraints on constructing a seawall in time to prevent structure collapse. In contrast if constraints to building a seawall in time were much less than expected, the *Retreat Scenario* should be weighted lower such as shown in the "-10% Sensitivity" that sharply reduces the impact from the *Retreat Scenario* on plan selection.

The results of this sensitivity analysis show that plan selection is not affected by sizeable changes to the weighting assigned to the *Retreat Scenario*. In other words the optimal beach width and nourishment interval for Segment 1 and Segment 2 are unaffected while the net annual benefits increase moderately when the retreat scenario weighting is increased 10-percentage points and decreases moderately when the weighting is decreased 10-percentage points.

[84] See *Weighting Armoring & Retreat Scenarios* earlier in this document for further explanation.

Table 8.3-2 NED Plan Sensitivity Retreat Scenario Weighting

Low SLR	Segment 1			Segment 2		
Retreat Weighting	***Baseline***	***+10%***	***-10%***	***Baseline***	***+10%***	***-10%***
Net Annual Benefits	1,201,000	1,220,000	1,184,000	860,000	947,000	764,000
NED Plan Altered?	--	NO	NO	--	NO	NO
NED Plan	100ft/5yr	100ft/5yr	100ft/5yr	200ft/13yr	200ft/13yr	200ft/13yr
High SLR	**Segment 1**			**Segment 2**		
Retreat Weighting	***Baseline***	***+10%***	***-10%***	***Baseline***	***+10%***	***-10%***
Net Annual Benefits	1,701,000	1,805,000	1,594,000	1,196,000	1,334,000	1,032,000
NED Plan Altered?	--	NO	NO	--	NO	NO
NED Plan	100ft/5yr	100ft/5yr	100ft/5yr	300ft/14yr	300ft/14yr	300ft/14yr

9 RED ANALYSIS

9.1 Regional Economic Development from Project Expenditures

9.1.1 Purpose

"The regional economic development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output and population."[85] The RED account displays information not analyzed in other accounts in the feasibility report that could have a "material bearing on the decision-making process."[86]

The RED account is born out of the difference in perspectives between the Federal government and local communities directly impacted by water resource planning. The Federal objective in water resource planning is contributing to national economic development and the Federal perspective is the nation as a whole. Local communities and regions directly impacted by water resource planning may consider impacts at the state, regional, or local level a more relevant measure. From the Federal perspective transferring employment opportunities and resources from one region of the nation to another to construct a water resource project does not in itself constitute national economic development and therefore regional economic impacts may not be fully captured in the national economic development (NED) account. However, from a regional or local perspective the transfer of employment opportunities and resources to construct a project in that region, as opposed to some other region of the United States, can be a significant benefit to the local economy in terms of more local employment, more local spending, and more local production. This is why the different perspectives between the Federal government and local communities impacted by water resource projects are addressed in different accounts. The Federal perspective is addressed principally in the NED account while the regional or local perspective is addressed principally in the RED account.

9.1.2 Process

To perform an economic analysis from the regional perspective (RED account), several different impacts from constructing the water resource project have to be analyzed. These impacts are termed direct, indirect, and induced effects.

i) *Direct effects* are "immediate effects associated with the change in total sales for a particular industry. In other words…the proportion of the expenditure in each industry that flows to material and service providers in that region."[87] Stated simply, these are the direct impacts to employment and income due to the demand for goods and services to complete construction (e.g. construction equipment and labor). The region is typically defined by political rather than economic or geographic boundaries. Political boundaries are broken down to state and county or metropolitan area for analysis.

ii) *Indirect Effects* are changes in inter-industry purchases in response to new demand from the directly affected industries. In other words the supply of materials and

[85] *Economic and Environmental Principles for Water and Related Land Resources Implementation Studies*, 1983
[86] Ibid
[87] *Regional Economic Development (RED) Procedures Handbook* 2011-RPT-01, March 2011

services to meet the needs of the companies or individuals directly engaged in constructing the project (e.g. concrete suppliers).

iii)

iv) *Induced effects* are "changes in spending patterns [from] increases in income to directly and indirectly affected industries."[88] Stated simply, this is the increased spending on local goods and services such as restaurants, grocery stores, hotels, and gas stations due to the direct and indirect effects of the project.

v)

The impact from spending to construct the project is shown in **Figure 13.1-1**. First the direct effects from hiring a construction firm to complete the project are experienced, then that firm purchases supplies and services from other firms to complete the project causing indirect effects.

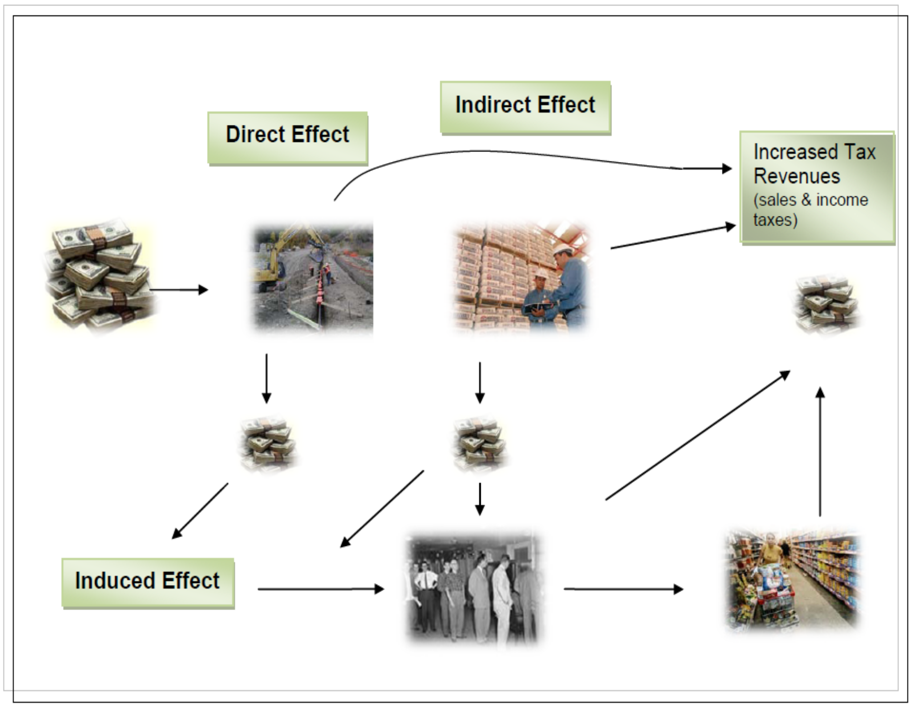


Figure 13.1-1 Process to Evaluate Regional Economic Development

Finally, both direct and indirect effects contribute to induced spending at local retailers, restaurants, convenience stores, etc. This leads local retailers, restaurants, convenience stores, and so on to purchase more goods and services and perhaps hire additional workers. At the same time all this cycling of dollars also leads to increased tax revenue. This cycle continues until the additional dollars are no longer in circulation in the regional economy due to leakages. Leakages occur when goods and services with value added outside of the region are purchased (e.g. clothing purchased that was manufactured in Asia or consulting services from a firm located and engaged in business activity primarily outside the region). The graphic below illustrates the concepts of direct, indirect, and induced effects.

The direct, indirect, and induced effects are estimated through multipliers, which can be thought of, figuratively, as money multiplying throughout the regional economy. A portion of the money

[88] Ibid

spent on construction equipment and labor (direct effect) gets re-spent on construction supplies (indirect effect) and a portion of the money from both is re-spent on local restaurants and gas stations (induced effect). Economists have used regression analysis on historical spending data to estimate how much spending and re-spending varies when there is an economic stimulus to the region through various construction projects. This produces the "multipliers" that are applied to the initial construction spending (i.e. cost of constructing the project) to estimate the direct, indirect, and induced effects of the project studied in this feasibility report.

Table 9.1-1 Construction Expenditure from (constant 2012 dollars)

Segment 1 (Encinitas) – NED Plan			
	Low SLR		High SLR
Initial 2014	$12,341,000	2014	$13,032,000
2019	$8,404,000	2019	$9,136,000
2024	$8,404,000	2024	$9,236,000
2029	$8,404,000	2029	$9,336,000
2034	$8,404,000	2034	$9,436,000
2039	$8,404,000	2039	$11,974,000
2044	$8,404,000	2044	$12,138,000
2049	$8,404,000	2049	$12,303,000
2054	$8,404,000	2054	$12,467,000
2059	$8,404,000	2059	$12,631,000
Total	$87,977,000		$111,689,000
NPV Total	**44,474,000**		**52,360,000**
Segment 2 (Solana Beach) – NED Plan			
	Low SLR		High SLR
Initial 2014	$33,003,000	2014	$45,329,000
2027	$9,554,000	2028	$14,496,000
2043	$9,554,000	2042	$20,991,000
2059	$9,483,000	2056	$18,950,000
Total	$61,594,000		$99,766,000
NPV Total	**42,264,000**		**64,336,000**

In addition to the regional benefits from direct, indirect, and induced spending on constructing the project there are also benefits from increased recreation demand from non-locals and tax benefits to the local and state economy from preserving property tax receipts since episodic erosion events causing property loss would be markedly reduced once the project is constructed. These are called forward linkages since they link the construction project to the regional "consumers" of the outputs from this coastal storm damage reduction project, which are decreased land loss resulting in the preservation of property tax receipts as well as increased recreational opportunities resulting in more tourist spending. This contrasts with backward linkages from the construction firm to its suppliers captured in the "money multipliers" described earlier and analyzed in this section.

9.1.3 Analysis

The RECONS model was used to estimate the direct, indirect, and induced effects of the NED Plans for Segment 1 and 2 based on construction cost estimates. This model generates regional construction multipliers based on the USACE business lines (navigation, flood mitigation, water storage & supply, etc). Each business line is subdivided into numerous work activities, which improves the accuracy of the estimates for regional and national job creation, and retention and other economic measures such as income, value added, and sales. For this analysis the business line is *navigation* and the work activity is *hopper dredging*. Next the USACE construction expenditures including local sponsor cost share were adjusted to remove certain costs not associated with direct construction expenditure.[89] Based on this adjustment **Table 13.1-1** shows the NED Plan in Segment 1 that is expected to result in $12.3 million in direct construction expenditures in the base year and $87.9 million over the entire study period under low sea-level rise conditions.[90] Direct expenditures at Solana Beach are expected to be $33.0 million initially and $78.0 million over the entire study period under low sea-level rise conditions. When discounted to the current period to account for the timing of those expenditures, this translates to $44.5 million and $42.3 million of construction expenditure for Encinitas and Solana Beach, respectively.

Since construction expenditures occur across a 50-year period and at different points throughout that study period depending on the Segment analyzed, discounted values were inputted in the RECONS model to account for the differences in the timing of expenditures. Consequently, results presented in section 13.1.4 estimate regional economic development in today's dollars. Another consideration is the difference in project expenditures between Segment 1 and 2. Given that Solana Beach would expend about $6.6 million on construction of reef and kelp transplanting while Encinitas would not be expected to have construction for environmental mitigation, the labor and equipment & repair local capture rates for Solana Beach had to be adjusted slightly higher than Encinitas. This is because the hopper dredges along with crew would originate outside of the region leading to limited local demand for labor. However, construction of environmental mitigation projects for Solana Beach would be expected to increase demand for local labor/expertise at a rate much higher than hopper dredging and consequently higher than overall labor demand from dredging only in Encinitas.

9.1.4 Results

<u>The NED Plans</u>

Results are presented for the region, state, and nation. The region consists of San Diego County shown in **Figure 10.1-2**, which includes the study area within Encinitas and Solana Beach. This means regional impacts that have been measured accrue within San Diego County but not specifically in the communities of Solana Beach and Encinitas. The state-level impacts shown in **Figure 9.1-3** are for California and the national impacts are for the contiguous United States. Since construction expenditures would occur over a 50-year period, discounting has been used to account for the differences in the timing of expenditures.

Direct impacts (effects) to employment and income due to the demand for goods and services to nourish the beach include fuels sales, equipment manufacturing and repair, transportation, retail/wholesale sales, and labor. These contribute to additional output, additional demand for

[89] Interest During Construction, which accounts for the opportunity cost of capital used during construction.

[90] Construction expenditures are held at current price levels, not inflated. Actual expenditures in nominal amounts would be higher.

jobs, and increased value-added to goods and services within San Diego County, the state of California, and the nation as shown in **Table 13.1-2**.[91]

Figure 9.1-2 Regional Level of Analysis (San Diego County)

Figure 9.1-3 State Level of Analysis (California)

[91] All values discounted to current/today's dollars

Table 9.1-2 Overall Regional Economic Impacts from NED Plans Expenditure

Segment 1 (Encinitas)				
		Regional	**State**	**National**
Total Spending (Present Value)		$44,474,000	$44,474,000	$44,474,000
Direct Impact	**Output**	$4,907,000	$14,951,000	$41,071,000
	Jobs[92]	94	116	955
	Labor Income	$2,151,000	$2,990,000	$21,016,000
	Value Added	$2,875,000	$4,175,000	$22,889,000
Total Impact	**Output**	$8,329,000	$25,835,000	$112,906,000
	Jobs	139	243	1,740
	Labor Income	$3,298,000	$6,254,000	$42,124,000
	Value Added	$4,926,000	$9,952,000	$59,306,000
Segment 2 (Solana Beach)				
		Regional	**State**	**National**
Total Spending (Present Value)		$42,264,000	$42,264,000	$42,264,000
Direct Impact	**Output**	$4,913,000	$15,664,000	$39,631,000
	Jobs	81	107	667
	Labor Income	$2,601,000	$3,825,000	$20,620,000
	Value Added	$3,379,000	$6,033,000	$23,889,000
Total Impact	**Output**	$8,392,000	$26,547,000	$101,610,000
	Jobs	117	204	1,216
	Labor Income	$3,779,000	$7,378,000	$40,596,000
	Value Added	$5,551,000	$12,321,000	$58,783,000

Based on these estimated impacts we expect about 175 full-time equivalent (FTE) jobs to be created from direct employment constructing the projects at both segments over the period of analysis. Roughly 81 additional FTE jobs should be created by indirect and induced effects that support or compliment that construction effort. More regional jobs are expected to be created per dollar spent on construction at Segment 2 because of mitigation measures that would require more localized expertise and labor. The regional capture rate, which is the region's direct output as a share of total spending, is around 12% and reflects the way hopper dredging is typically conducted—crews from outside the region travel with the hopper to the construction site. Since much of the labor and equipment comes from outside the region, we expect the capture rate to be lower as shown. However, from the perspective of the state of California the capture rate is over one-third suggesting that much more of the resources for construction would come from within the state as opposed to within San Diego County. Most of the remaining resources would come from other parts of the United States.

Overall, both projects should lead to $10.4 million in value-added goods and services to the region and nearly 256 additional job opportunities. Employment growth should be focused in those sectors specializing in maintenance and repair of construction equipment as well as food

[92] Full-time equivalent (FTE) jobs created during entire study period. Nominal construction expenditures were used to estimate FTEs rather than present value.

services, retail, and real estate/accommodations. The impact to the state would be of greater magnitude although less relative importance due to the large size of the California economy. Approximately $22 million in value-added goods and services and about 450 jobs would be created state-wide with similar business sectors impacted.

9.2 Regional Economic Development from Increased Recreation

9.2.1 Procedure & Methodology

The previous section focused on the temporary impact from project expenditures to the regional economy. These are called *backward linkages.* This recreation assessment focuses on the long-term impacts to the regional economy from the beach nourishment projects at Segment 1 and 2. These impacts are called *forward linkages* and result from increased spending in recreation and associated sectors of the regional economy. The direct, indirect, and induced effects for forward-linked impacts are identical to those examined for project expenditures (i.e., backward linkages) except the perspective has shifted from temporary construction impacts to longer-term recreation impacts.

i. *Direct effects* are changes in the industries associated directly with recreation and tourism spending, e.g., staying in a hotel.
ii. *Indirect effects are* changes resulting from the tourism industries made to other "backward-linked" industries in the region, e.g., hotel's purchases of linen supply and utilities.
iii. *Induced effects are* changes resulting from household spending from income earned as a result of visitor spending either directly or indirectly. This could be apartment rentals or retail spending by hotel employees.

Table 9.2-1 Recreation Survey Spending Data

Recreation Survey Data[93]	Encinitas		Solana Beach	
	Share	Amount	Share	Amount
Nonlocal visitors	56.2%	--	64.2%	--
Visits, day trip	75.8%	--	70.8%	--
Visits, overnight	24.2%	--	29.2%	--
Spending per day (all visitors)[94]	--	$84.37	--	$69.52

Since assessing the economic impact from recreation on the region takes a longer-term view, the economic impacts are more sensitive to initial estimates. These estimates include total visitor spending, spending by various categories (motel, restaurants, fuel, retail, etc.), increased demand and spending attributable to the beach nourishment project, and visitor spending in the local area versus spending outside the local area. Recreation surveys done for the cities of Encinitas and Solana Beach revealed the average spending related to trips to the beach and the share spent within the cities versus outside the cities.[95] While useful, the reports from these surveys only show spending in aggregate rather than spending by category, which is needed to

[93] Ibid
[94] Inflated to current price levels
[95] *Economic Analysis of Beach Spending and the Recreation Benefits of Beaches in the City of Solana Beach* and *Economic Analysis of Beach Spending and the Recreation Benefits of Beaches in the City of Encinitas*, both by Phillip King, Ph.D.

estimate impacts to employment, income, and regional output. Consequently, a generic spending pattern was selected for the modeling that was chosen in part to match the aggregate spending shown in these surveys. The economic impact from additional recreation/beach demand was estimated using the Recreation Economic Assessment System (REAS) developed jointly by the Engineer Research and Development Center within the US Army Corps of Engineers and the Department of Park, Recreation, and Tourism Resources at Michigan State University.

Several assumptions had to be made to estimate the economic impacts to the regional economy due to recreation. First we assumed that those living within Encinitas or Solana Beach would spend similar amounts of money locally with or without the project constructed. In other words locals would shift spending from recreation to another sector of the local economy and the net impact of this shift is zero or minimal to the regional economy. As a result recreation by locals was excluded from the analysis and all spending done by these local visitors was not included in the estimated impacts from recreation in either Encinitas or Solana Beach. According to the surveys commissioned by both cities in 2001, the share of beach visits from those living outside of Encinitas was 56% while the share of nonlocal visitors to Solana Beach was 64%. Since this is the most recent, comprehensive survey taken, these percentages were used to adjust the additional demand expected with the beach nourishment project constructed. For instance from the recreation analysis outlined earlier in this document we expect nearly 24,000 additional visits to Segment 1 (Encinitas) in 2015 because of the beach nourishment project. Yet of those visits only 56% are from those living outside of Encinitas, meaning only 14,000 additional visits are used for this economic assessment of recreation in 2015. This calculation was done for both cities across all 50 years of the study period to estimate the additional nonlocal visits.

We have assumed that additional demand for recreation at the beach is not materially different under high and low sea-level rise scenarios, which seems reasonable since sea-level rise should only affect recreation supply rather than demand. Another important assumption is that in the absence of recreating at the beach, nonlocal visitors would not engage in a substitute activity such as golf or shopping that also generates economic impacts. This is a necessary assumption given the data we have but does limit the accuracy of the estimates and likely means the economic impacts shown below are at the high-end of reasonable estimates.

We also have assumed that additional beach visits can occur within the study area or transfer to one of several nearby beaches within the region when the combination of beach erosion and crowding deter further visits to the study area beaches. This requires the additional assumption that these transfers have the same spending profile as visitors to the study area. If both assumptions hold then transfers should have the same economic impact to the region as those beach visitors who remain in the study area. However, this does not mean the cities of Solana Beach and Encinitas would not be negatively impacted by transfers to other beaches—obviously both communities would be. Therefore the economic impact to these communities from recreation with the beach nourishment projects constructed should be substantial even though modeling is not precise enough to estimate the specific regional impacts to just those two communities. As a consequence estimates are presented for the region as a whole, which is defined by the REAS model as a 30-mile radius from the study area.

The REAS model requires inputting spending profiles by category (hotel, camping, restaurants, fuel, groceries, etc.) but spending profiles at this level of detail were not available for either city. Surveys only revealed this amount in aggregate across all spending categories, so the generic spending pattern was selected in the REAS model and then each spending category was inflated by the same percent to reach $84 in sales per visit, which is the amount in current price levels from the recreation survey done for Encinitas. The same method was applied to Solana Beach to reach $70 per visit. Multipliers were selected from the Los Angeles region due to the absence of any multipliers in San Diego County.

To determine the total impacts from additional demand for recreation to the regional economy, we compared the demand for beach visits that would occur during the study period without the project constructed and the demand that would occur with the project constructed.[96] The difference is the additional demand attributable to the beach nourishment projects. Next this added demand to recreate was separated using recent survey data in to demand originating locally and non-locally.

Only additional nonlocal demand is used to assess the regional economic impacts once the projects are constructed at Segment 1 and 2. These additional nonlocal visits (demand) are recorded for all 50 years of the study period. Last, the marginal impacts shown in the tables below (Marginal Impacts of Spending and Visits) were applied to those additional visits to determine the regional impacts.

9.2.2 Results

<u>Marginal Impacts</u>

Based on recent survey data in Encinitas each beach visit generates $84 in sales on average. By modeling this in the Recreation Economic Assessment System (REAS) we can estimate how much of those $84 per visit remain or are captured within the region. This capture rate is direct sales divided by total visitor spending and accounts for how much visitor spending is captured by the local economy. For every dollar spent in Encinitas (Segment 1) approximately 90 cents is captured in the region, which means the local capture percentage is about 90%. Since sales are $84 per visit on average, $76 of this total spending is captured within the regional economy.[97] For this modeling the region is defined as a 30 mile radius and roughly approximates the area of San Diego County. This includes the San Diego metropolitan area and contributes to the high share of sales “captured” in the local region. The secondary effects (indirect and induced) from this spending generate an additional $57 in sales per visit within the region for a total impact of $134 in additional sales per visit.

The marginal impacts from these additional sales per visit is presented as changes to personal income, value added to goods & services, and jobs. Personal income is earnings from wages and investments. Value added is the difference between the sales prices of a good or service and its production cost, which is the total cost of components, materials, and services purchased from other firms. Jobs are given as full-time equivalents (FTE), which is the ratio of the total hours employed by the total work hours in one year, which is approximately 2080 hours. One FTE equals one person employed full-time for one year or two persons employed full-time for half a year each and so on. Based on the spending profiles outlined for Encinitas,

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[96] The estimates for beach demand came from the recreation analysis done under with and without project conditions. See *Recreation Analysis With/Without Project* sections earlier in this document for details. Offsite transfers are assumed to transfer to another beach within the region since there are nearby beaches.

[97] The reason 100% of sales are not captured by the regional economy is primarily due to leakages when goods not made in the local region are purchased by visitors. For those goods the retail margins are “captured” only.

one thousand additional visits should create about $27,000 in personal income from direct effects and an additional $19,000 in personal income for indirect & induced effects, which is a $46,000 increase in total personal income. Value added to good and services is expected to increase $37,000 from direct spending and $71,000 overall per one thousand visitors. About one FTE is created by the additional spending from one thousand visitors meaning there would be increased demand for approximately 2080 hours of labor every year of the study period.
Based on recent survey data in Solana Beach each beach visit generates $70 in sales on average. By modeling this in the Recreation Economic Assessment System (REAS) we can estimate how much of those $70 per visit remain or are captured within the region in the same manner that was done for Encinitas. For every dollar spent in Solana Beach (Segment 2) approximately 90 cents is captured in the region, which means the local capture percentage is about 90%. Since sales are $70 per visit on average, $63 of this total spending is captured within the regional economy.[98] For this modeling the region is defined as a 30 mile radius and roughly approximates the area of San Diego County. This includes the San Diego metropolitan area and contributes to the high share of sales “captured” in the local region. The secondary effects (indirect and induced) from this spending generate an additional $47 in sales per visit within the region for a total impact of $110 in additional sales per visit.

Table 9.2-2 Marginal Impacts to RED from Spending & Visits

Encinitas (Segment 1)			
		change per $1,000 of visitor spending	change per 1,000 visits
Direct	**Personal income**	$319	$26,834
	Value added	$443	$37,220
	Jobs	0.009	0.719
Total	**Personal income**	$547	$46,017
	Value added	$844	$70,905
	Jobs	0.013	1.1
Solana Beach (Segment 2)			
		change per $1,000 of visitor spending	change per 1,000 visits
Direct	**Personal income**	$324	$22,416
	Value added	$451	$31,169
	Jobs	0.009	0.6
Total	**Personal income**	$553	$38,263
	Value added	$853	$58,995
	Jobs	0.014	0.9

Based on the spending profiles outlined for Solana Beach and shown in **Table 13.2-3**, one thousand additional visits should create about $22,000 in personal income from direct effects and an additional $16,000 in personal income for indirect & induced effects, which is a $38,000

[98] The reason 100% of sales are not captured by the regional economy is primarily due to leakages when goods not made in the local region are purchased by visitors. For those goods only the retail margins are “captured.”

increase in total personal income. Value added to good and services is expected to increase $31,000 from direct spending and $59,000 overall per one thousand visitors. About one FTE is created by the additional spending from one thousand visitors meaning there would be increased demand for approximately 2080 hours of labor every year of the study period.

Table 9.2-3 Regional Economic Impacts of NED Plans from Increased Recreation

Encinitas (Segment 1)		Annual Impacts
Direct	**Personal income**	$2,340,000
	Value added	$3,250,000
	Jobs[99]	63
Total	**Personal income**	$4,020,000
	Value added	$6,190,000
	Jobs	96
Solana Beach (Segment 2)		**Annual Impacts**
Direct	**Personal income**	$3,300,000
	Value added	$4,580,000
	Jobs	88
Total	**Personal income**	$5,630,000
	Value added	$8,680,000
	Jobs	138

NED Plans

The NED Plan at Encinitas (Segment 1) would initially increase beach width by 100 feet MSL on average and then construct nourishments every 5 years to return the beach to that initial width. At Solana Beach (Segment 2) the beach would increase 200 feet MSL on average and be nourished every 13 years. Recreation analysis in section 0 suggested demand to recreate at the study area beaches would grow moderately following project construction. Initially this would result in 42,000 added non-local visits in the base year and increase to 250,000 additional visits within the next four years before leveling off at around 300,000 additional visits, which is about a 10% percent increase above the current number of visitors. Solana Beach is expected to benefit relatively more from the constructed project because it is expected to receive a larger share of these increased visits.

Overall the NED project in Encinitas (Segment 1) should create approximately 96 FTE jobs on an annual basis throughout the region due to the increased spending from beach visitors while the project in Solana Beach should contribute around 138 FTEs to the region as shown in **Table 13.2-3**. **Table 13.2-3** reflects the expected boost to the local economy annually from $3.2 to $4.5 million in direct value added (gross regional product) each year per segment. Personal incomes would grow slightly less at $2-3 million annually per segment.

These increases to income and value-added would accrue across San Diego county but direct impacts (tourism, food & beverage services, and related sectors) would be concentrated to

[99] Cumulative jobs created over the entire 50-year study period. Since we expect additional recreation demand primarily in the years immediately following initial construction in 2015, the majority of these jobs would be created during that same period.

some degree in the cities of Encinitas and Solana Beach. However, these values represent the high end of reasonable estimates because we had to assume that none of this spending by non-local beach visitors would have occurred in the region without the projects constructed at both segments. In reality some spending would have occurred in other sectors of the regional economy adding jobs and increasing personal incomes that should not be attributed to the beach nourishment projects. Nevertheless, the positive impact these projects would have on job creation and overall regional economic development due to increased beach visitations would be unambiguously positive.

10 OSE ANALYSIS

10.1 Purpose

Most water and land resource plans have beneficial and adverse effects on social well-being. These effects reflect a highly complex set of relationships and interactions between inputs and outputs of a plan and the social and cultural setting in which these are received and acted upon. These effects will be reported as appropriate in the system of accounts for each alternative plan. The OSE account is a means of displaying and integrating into water resource planning information on alternative plan effects from perspectives that are not reflected in the other three accounts.[100]

[New guidance] greatly increases the emphasis and potential application of the OSE account by stating all four accounts (NED, EQ, RED and OSE) will be considered in project analysis and decision making.[101]

The Other Social Effects (OSE) account analyzes the Recommended Plan effects on social aspects of the communities of Solana Beach and Encinitas. This is contrasted with the effects from no action or no plan. A number of indicators can be used to analyze Other Social Effects. For this study life-safety, social vulnerability & resiliency, emergency preparedness, displacement to population, and community cohesion & social connectedness were evaluated for impacts. After determining the extent of any impacts, life-safety, social vulnerability & resiliency, community cohesion were analyzed further due to the moderate to high probability the Recommended Plan and/or No Action Plan would cause moderate to significant impacts.

10.2 Dimensions of Interest

10.2.1 Life-Safety

A basic human need is for personal and group safety. Conditions that are seen as unsafe or unhealthy create personal stress and dissatisfaction among those affected. The level of perceived risk associated with conditions or alternatives is also a factor in determining satisfaction.[102]

Both communities have been subject to repeated bluff collapse resulting in property damage, large debris falling on the beach, and even loss of life. According to the Coastal Engineering analysis, if no action is taken bluff failures will continue with increased frequency. At the same time over 2.8 million beach visits to the study area are expected in 2011 and slightly more in the coming years. Therefore continued bluff collapse constitutes a significant life-safety issue and is analyzed further.

10.2.2 Social Vulnerability/Resiliency

Social vulnerability refers to the capacity for being damaged or negatively affected by hazards or impacts. Resiliency is the capability to cope with and recover from a traumatic event. Studies

[100] ER 1105-2-100
[101] EC 1105-2-409 Planning in a Collaborative Environment (EC 409)
[102] Handbook on Applying Other Social Effects Factors in Corps Planning 09-R-4

show that social institutions such as families and public and private organizations play an important role in mediating the effects of disasters.[103]

Under the no action plan those living along the bluff edge would continue to be negatively impacted by episodic bluff collapse. In addition all beach visitors would experience increased social vulnerability over time as beaches erode and episodic bluff collapses increase in frequency. Social vulnerability and resiliency are analyzed further.

10.2.3 Emergency Preparedness

The capacity and capability to mitigate the risk of interruption in the flow of essential goods and services needed for special requirements of local, regional, and national security.[104]

Coast Highway 101, which runs along the coast and through both communities, is a designated tsunami evacuation corridor. Inundation maps prepared by the University of Southern California Tsunami Research Center show little to no potential tsunami inundation in the project area due to both cities locations atop high bluffs.[105] Minor inundation covering roughly two city blocks could occur at Fletcher Cove and Moonlight beaches. Major inundation could occur at Batiquitos, San Elijo, and San Dieguito Lagoons that would disrupt travel and evacuations on Coast Highway 101. However, these lagoons would not be impacted by the NED Plans in Segment 1 and 2 and consequently a tsunami's propensity to inundate these lagoons and cause travel and evacuations disruptions on Coast Highway 101 would not be impacted with or without the Recommended Plans. Therefore, the effects on emergency preparedness are *not* analyzed further.

10.2.4 Displacement to Population

[Displacement is] the act or process of being expelled or forced to flee from home or homeland. Displacement effects include the displacement of people, business, and farms.[106]

The NED Plans offers protection that should allow few if any structures to fail during the study period due to the episodic bluff collapse described in the coastal engineering appendix. Should no action occur instead, we expect a majority of bluff-top parcel owners to armor in time to protect affected structures and prevent structure loss. However, some residences could be lost because of the episodic nature of bluff collapse in the study area as well as personal, financial, and regulatory constraints to armoring in time. This means the No Action Plans could compel displacement to a subset of residences situated on the bluff edge. Consequently, additional analysis has been performed on displacement to the population.

10.2.5 Community Cohesion & Social Connectedness

[Community cohesion & social connectedness are] the pattern of social networks within which individuals interact, which largely provides meaning and structure to life.[107]

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[103] Ibid
[104] Modified from ER-1105-2-100 section D-40
[105] *San Diego County Tsunami Inundation Maps* http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/SanDiego/Pages/SanDiego.aspx accessed 17-AUG-2011
[106] Merriam-Webster dictionary and ER-1105-2-100 section D-40
[107] Ibid.

The NED and No Action Plans would impact the area of beach available for recreation within the study area differently thereby altering the manner and frequency residents' interaction while recreating and also reshaping perceived benefits of living within Solana Beach and Encinitas. Changes to the community cohesion and social connectedness are analyzed further.

10.3 Analysis

10.3.1 Life-Safety: No Action Plan

Both communities have been subject to repeated bluff collapse resulting in property damage, large debris falling to the beach, and even loss of life. In the past decade numerous bluff failures have continued to occur and threaten public safety. Since the collapses are episodic, with little or no warning, city officials have tried to keep the public aware of the danger by displaying signs along the beach cautioning beach-goers to stay a safe distance from the base of the bluff at all times. After major bluff collapses that gather news media attention, city life guards often use the public attention to convey this same message: "Anybody that's walking anywhere on the North County beaches should be extremely aware of the danger and stay away from the cliffs."[108]

Both beaches are heavily utilized year-round—more than 2.8 million visits are expected in 2012.[109] Engineering analysis shows that most wave attacks to the toe of the bluff occur in the winter when sand volume at the beach is lowest. However, this is just a precursor to episodic bluff collapse, which can occur throughout the year and even during peak summer season when about 60% of all beach visits occur. To illustrate the danger to beach visitors and bluff-top residents, a list of major bluff failures is given in the following table. Note that these collapses cause significant safety issues because whenever recreation occurs near the base of the bluff, injury and death can and do occur.

Table 10.3-1 Major Bluff Failures since 2000

January 2000	A woman was killed in a bluff collapse while sitting on the beach in Leucadia (City of Encinitas).
January 2001	Four bluff-top homes in Leucadia (south of Beacon's Beach) were deemed unsafe by the City of Encinitas due to unstable and cracked bluffs. Large rocks were piled at the base of the bluffs to protect the cliffs from large surf and tides.
February 2001	A bluff collapse destroyed a portion of the trail at Beacon's beach off Neptune Avenue in Leucadia.
May 2001	In Solana Beach an adjoining bluff gave way as a neighbor was trying to reinforce it by driving steel pilings in to the bluff. A concrete slab from patio slid down toward the shore, taking with it a workman who had been standing on it. The bluff collapse also claimed part of an additional adjacent yard and rendered a portion of the house unsafe for occupancy. Owners of the three parcels obtained an emergency permit to build a 100-foot long, 35-foot high seawall.
July 2002	A man camping overnight in a small cave at South Carlsbad State Beach was killed when a portion of a bluff collapsed.

[108] Encinitas life guard captain quoted in North County Times http://www.nctimes.com/news/local/encinitas/article_fe7f01b6-2705-5071-8f59-6e09e0973cfb.html accessed 16-AUG-2011
[109] Based on recent attendance data provided by the cities of Encinitas and Solana Beach

July 2002	About 80 tons of sandstone, rocks, and boulders fell onto the beach as a 75-foot wide by 12-foot high section of bluff collapsed just south of Fletcher Cove Park, a major recreation area.
September 2002	Major bluff failure; Potential threat; Approx. 4 cu. yd. boulders, alluvium, and ice plant debris cascaded onto the beach
December 2002	Major bluff failure; Potential threat; 10 cu. yds of earthen debris and concrete; Posts, concrete footings, and other wooden retaining devices precarious; Continuation of already badly eroded area
February 2003	Major bluff failure; Potential threat; Approx. 3 cu yds, in and around existing sea cave plugs, large portion of bluff un-supported and in danger of collapse.
February 2003	Major bluff failure; 3rd Major failure 100 yards south of previously reported area; 3 cu. yd. of solid sandstone composition, debris and boulders.
November 2003	Major bluff failure; N. of cove, water flowing mid-bluff
March 2004	Major bluff failure; Upper and lower bluff failure over 2 cu. yds, dangling posts/rope
June 2004	Major, potential threat from overhang patio. Signs posted. Geosoils evaluating all.
July 2004	Major bluff failure; Directly S. of other failures, approx. 15' X 6' X 4'. Potential threat from overhang patio. Signs posted. On or about 6/30, contractor removed wall and concrete deck that had become undermined. On 7/6, “u-channel posts” and "Bluff Warning" signs were installed.
November 2004	Major bluff failure; Approx. 6' X 5' X 3', Initial failure was contained by protective shoring and fence system; subsequent bluff failure resulted in damage to shoring system.
November 2004	Major bluff failure; Potential threat; 2' X 8-10' portion of block wall separated from patio, large upper bluff failure, undermined a portion of concrete patio adjacent to rear of home. Overhanging portion to be removed and report to be updated.
November – December 2004	Major bluff failure; Approx. 22' X 5' X 3', bluff debris along with length of black pip, portion of fence dangling. Letter sent to owners 11/3.
November 2004	Major bluff failure; Upper bluff failure N. of Cove, area at top closed due to undermined fence along edge. Fence to be relocated and bench will be removed from outlook point, SW of Community center building.
April 2005	Major bluff failure. Although a large amount of material was deposited on the beach, it occurred from a localized area. Surrounding bluff does not appear in imminent danger of further failure.
June 2005	Major Upper bluff failure 2 cu yd or more witnessed by Encinitas lifeguard personnel.
August 2006	Major bluff failure; Potential threat; North of Seascape Sur access at reoccurring failure site;
February 2008	A landscaper was trapped and injured when a retaining wall atop beach bluffs in Encinitas collapsed.
May 2009	Major bluff failure; pre-existing failure site in Encinitas.
January 2010	Debris from private access staircase scattered across 1/2 mile of Beach - referred to Code Enforcement
March 2010	Major bluff failure, photos taken, caution tape placed. On 3/17/2010, the issue has been resolved to satisfaction of Engr. Dept.
April 2010	300-350 C yards detached from lower bluff, fell to beach.
August 2010	Lifeguards and firefighters rescued an injured man who was found on the beach at the bottom of a 30-foot cliff at the end of E Street. He suffered fractures to his legs. The victim probably rolled the first sloped 60 or 70 feet before the 30-foot vertical drop-off. Signs nearby warn visitors of the unstable cliffs.
December 2010	A bluff collapsed across two parcels damaging the existing seawall at the bluff base. An Encinitas lifeguard official subsequently warned, "Anybody that's walking anywhere on the North [San Diego] County beaches should be extremely aware of the danger and stay away from the cliffs."

January 2011	The southbound portion of San Elijo Avenue at Dublin Drive and Cornish Drive closed because of bluff collapses in mid-December leading to approximately 30 days of partial road closure.
January 2011	Major bluff failure (2 cubic yards or more). Lifeguards taped off area, photos taken.

As this list shows major bluff failures occur consistently and frequently throughout the study area. In response city officials continue to broadcast the dangers from unforeseen, episodic bluff failures to the public through signage and local media exposure. Those are the main tools local officials possess to discourage recreation near the base of bluffs and limit the chance of accidental injury or death since unstable bluffs can collapse without warning. This publicity tool probably has a positive impact on life-safety since news articles about major collapses tend to reveal local residents' concern and awareness that the bluffs are unstable and need to be avoided for this reason. However, local attention and exposure about the danger of bluff collapse only mitigates that danger rather than ensures the safety of beach visitors as three recent fatalities have shown.

Since the exposure is primarily through local media and government outlets, nonlocal visitors may be at increased risk to recreate too close to the base of these unstable bluffs. Nonlocal visits make up a sizeable share of all beach visits to the study area. The most recent and comprehensive survey of beach visitors in Encinitas revealed 35% or about 700,000 annually came from distances greater than 20 miles.[110] To highlight this danger several fatalities have occurred recently at or near the study area. Two tourists were killed when a beach bluff collapsed on them at Torrey Pines State Reserve, then in 2008 a Las Vegas resident was fatally struck in the head by rocks "the size of basketballs" when he sat down near a bluff to change shoes to play Frisbee.[111] One of the most tragic bluff collapses occurred in Encinitas in January 2000 when a woman was killed after an overhead bluff collapsed sending "tons of dirt and rocks down on her". According to the LA Times, "Horrified sunbathers tried desperately to dig through the moist red dirt that covered the woman while she was watching her husband surf near picturesque Moonlight Beach."[112] (Moonlight Beach is the most heavily visited beach in the study area. Counters placed by the city show that over 700,000 visits occur at this half-mile stretch of beach annually.) Another fatality occurred in July of 2002 at South Carlsbad beach when a portion of the bluff collapsed killing a man camping inside a cave. At the scene the chief lifeguard stated, "We constantly warn people to stay back [from the bluffs]."[113]

In addition to the large number of visitors to the study area, the area of beach available to recreate safely is expected to shrink over time if no action is taken. Data from 2009 showed that only three of nine reaches, about 1/3 of the length of all study area beaches, typically have dry beaches for recreation. The remaining six reaches or two-thirds of the study area beaches are chronically "wet" during the winter and spring because sand departs during winter storms and swells. Those six "wet" reaches currently host around 700,000 beach visits during the winter and spring season, typically have no dry beach area, and can leave only a narrow path that is a safe distance from bluffs and not saturated with ocean water for those beach goers to recreate. This limits the safe recreating area and may undermine beach visitors' ability to heed warnings

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[110] *Economic Analysis of Beach Spending and the Recreational Benefits of Beaches in the City of Encinitas* by Phillip King, PhD, 2001

[111] *Sign On San Diego* http://www.signonsandiego.com/uniontrib/20080222/news_1m22bluff.html accessed 16-AUG-2011 & LA Times http://articles.latimes.com/2008/aug/21/local/me-torreypines21 accessed 16-AUG-2011

[112] *LA Times* http://articles.latimes.com/2000/jan/16/news/mn-54646, accessed 16-AUG-2011

[113] North County Times http://www.nctimes.net/news/2002/20020718/55313.html, accessed 1-AUG-2011

by city officials to maintain a safe distance from bluffs. Figure 14.3-1, which is a photo taken from a public beach access point in Encinitas during a recent sunny winter day, illustrates this problem clearly. The trend is toward narrower beaches in the summer and particularly winter even under the low sea-level rise scenario as shown in **Table 14.3-2**. As sand continues to depart from these beaches during the study period these conditions are expected to worsen, namely, less area to safely recreate away from the bluffs and increasingly frequent episodic events earlier in the study period (before a majority of unprotected parcels have constructed seawalls).

Table 10.3-2 Winter Dry Beach Area with No Action Plan

Low SLR	2010	2015	2020	2030	2040	2050	2060	2064
REACH 3	-	12,375	7,414	-	-	-	-	-
REACH 4	34,966	110,599	104,216	91,450	78,684	65,918	53,152	48,045
REACH 5	-	33,657	23,405	2,900	-	-	-	-
…								
REACH 8	-	15,730	8,452	-	-	-	-	-
REACH 9	-	7,644	-	-	-	-	-	-
TOTAL	34,966	180,005	143,486	94,350	78,684	65,918	53,152	48,045
Segment 1	34,966	156,631	135,034	94,350	78,684	65,918	53,152	48,045
Segment 2	-	23,374	8,452	-	-	-	-	-

Figure 10.3-1 Wave Inundation at beach in Encinitas

10.3.2 Life-Safety: NED Plans

The NED Plans at Segment 1 and 2 involve placing sand near the base of the bluff to protect the bluff toe from erosion. This erosion is directly responsible for the episodic bluff collapses addressed by the NED Plans. By addressing this bluff collapse, the NED Plans offer two benefits for life-safety: markedly reduced and less frequent episodic bluff collapse that is triggered by erosion to the bluff toe; and widened and maintained beaches to increase the “safe” recreating area away from the base of the bluff. The reduction in episodic bluff collapse, also known as coastal storm damage protection, begins immediately after construction in the base year, 2015. This compares with the gradual, “piece-meal” protection from seawalls constructed on the existing unprotected parcels under the no action plan. The immediate reduction in bluff collapse from the NED Plans should result in less “close calls” where bluff collapses occur close in time and space to beach visitors without causing physical injury. It could also result in fewer or no injuries and deaths from direct exposure to falling debris. At the same time widened and maintained beaches provide larger dry beach areas extending outward from the base of the bluff. Since the base of the bluff is typically one of the highest points on the shoreline and therefore one of the last remaining dry beach areas when beach erosion occurs, the no action plan can create conditions that encourage recreation such as sunbathing, walking, and playing beach games close to the bluffs. The NED Plans would increase the dry beach areas substantially and maintain them as shown in **Table 14.3-3**, which should encourage recreation at a safer distance from the base of the bluff.

Table 10.3-3 Winter Dry Beach Area (Sqft) with NED Plans

Low SLR	2010	2015	2020	2030	2040	2050	2060	2064
REACH 3	-	198,000	198,000	198,000	198,000	198,000	198,000	108,000
REACH 4	45,000	272,000	272,000	272,000	272,000	272,000	272,000	185,000
REACH 5	-	410,000	410,000	410,000	410,000	410,000	410,000	228,000
…		-	-	-	-	-	-	-
REACH 8	-	529,000	473,000	487,000	529,000	497,000	487,000	529,000
REACH 9	-	602,000	537,000	554,000	602,000	566,000	554,000	602,000
TOTAL	45,000	2,011,000	1,890,000	1,921,000	2,011,000	1,943,000	1,921,000	1,652,000
Segment 1	45,000	880,000	880,000	880,000	880,000	880,000	880,000	521,000
Segment 2	-	1,131,000	1,010,000	1,041,000	1,131,000	1,063,000	1,041,000	1,131,000

In addition residual risk would be sharply lower if the NED Plans are constructed at both segments. Analysis on **Table 14.3-4** shows that coastal storm damages, which are the direct result of episodic bluff collapse, would be reduced 68% in Segment 1 and 55% in Segment 2 on average across the study period and would be reduced nearly 80% and 65% immediately after fill is placed, respectively. With the NED Plans constructed residual damages would average 32% and 45% with a commensurate reduction in episodic bluff collapses (32% and 31% under the high sea-level rise scenario).

The NED Plans would reduce the severity and frequency of episodic bluff collapse while simultaneously widening safe areas on the beach for the public to recreate. These two factors should noticeably reduce life-safety risks at these popular recreation areas compared to the No Action Plan, which would allow continued wave attack to further erode the shoreline and continue to compromise bluff stability. In contrast, constructing the NED Plans should lead to a significant improvement in life-safety to the public.

Table 10.3-4 Residual Risk for the NED Plans

	SEGMENT 1		SEGMENT 2	
	Low SLR	High SLR	Low SLR	High SLR
Plan Characteristics				
Duration of Nourishment Interval	5 yr	5 yr	13 yr	14 yr
Initial Added Beach Width	100 ft	100 ft	200 ft	300 ft
Residual Preventable Damages, %				
Expected Value, study period (“Level of Risk”)	32%	32%	45%	31%
Expected Value, min/max	19%/36%	19%/36%	35%/52%	17%/40%

10.3.3 Social Vulnerability: No Action Plan

Social vulnerability refers to the capacity for being damaged or negatively affected by hazards or impacts. The group with the greatest capacity for being negatively affected is beach visitors since they would be subject to the most immediate danger when episodic bluff collapse occurs under the no action plan. Bluff-top parcel owners and residents also have social vulnerability but we expect most of these affected parcels to get seawalls under the no action plan before any structures can be compromised and residents injured (but not before significant bluff top collapses have occurred spurring the seawall construction). Therefore this section focuses on social vulnerability to beach visitors.

Two hundred ninety structures rest along the bluff edge in the study area. Sixty-one percent or 177 structures (condominiums, duplexes, apartments, and single-family residences) are currently unprotected by seawalls. Until unprotected parcels become armored with seawalls, the episodic bluff collapses coastal engineering has modeled will continue to occur and worsen over time due to beach erosion.[114] Each collapse represents potential peril to beach visitors recreating near the base of bluffs. A fatal bluff collapse in 2000 demonstrates the danger to beach visitors and trauma suffered by bystanders. “A woman sitting on the beach was killed Saturday when part of a bluff suddenly collapsed and sent tons of dirt and rocks tumbling down on her, officials said. Horrified sunbathers tried desperately to dig through the moist red dirt that covered the woman while she was watching her husband surf near picturesque Moonlight Beach.”[115] Since bluff collapse would occur more frequently over time until seawalls are constructed on those 177 unprotect structures, social vulnerability for beach visitors is expected to initially increase/worsen over time under the no action plan. This is because we expect beach visitations to fall over time but the study area should continue to draw substantial visitors through the 2030s under the no action plan. At the same time bluff collapses should increase in frequency, which means the risk of injury or death to these visitors increases over time. In other words the social vulnerability to beach visitors should continue to increase until a large share of those 177 unprotected structures get seawalls halting most bluff collapses.

The increase in social vulnerability among beach visitors could manifest as increased “close calls” where bluff collapses occur close in time and space to beach visitors without causing

[114] See Coastal Engineering Appendix section 5-1 and 5-2
[115] LA Times http://articles.latimes.com/2000/jan/16/news/mn-54646, accessed 16-AUG-2011

physical injury or could manifest as injury or death from direct exposure to falling debris. In addition, beach visits could temporarily or permanently decline following news of major bluff collapses or injury and death occurring from bluff collapses. Local governments could decide to restrict access to sections of beach deemed too dangerous for recreation. All these responses to increased social vulnerability under the no action plan would tend to reduce social vulnerability over time to more acceptable levels while dramatically changing the manner and frequency the public interacts with the beach and ocean within Solana Beach and Encinitas.

10.3.4 Social Resiliency: No Action Plan

Social Resiliency is the capability to cope with and recover from a traumatic event. Both communities in the study area have high social resiliency by traditional socio-economic measures. The median household income is over $85,000 compared to $61,154 across the state of California, more than a 40% premium. Similarly, per capita income is 59% higher in Encinitas than the California average ($49,341 compared to $29,405). Vulnerable segments of the population such as children represent a smaller share of both cities population when compared to county and state data. Twenty-three percent of household have children in Solana Beach and 28% have children in Encinitas, but 31% of households have children in San Diego County and 33% in California. Minority populations (non-Caucasian) make up one quarter of residents. Sixty-three percent of Encinitas residences are owner-occupied and 60% of Solana Beach residences. In addition the average bluff-top structure value in Encinitas, which has primarily single-family residences along the bluff edge, is $327,474 before accounting for land value suggesting households have wealth as well as high income to cope with and recover from a traumatic event. In other words both communities have high resiliency in terms of financial capacity to deal with bluff collapses. However, financial capacity cannot mitigate for all trauma.

Under the No Action Plan, seawalls would be constructed gradually to protect most parcels that are currently unprotected. While the financial impact of armoring is severe and financially untenable for some, typically $668,000 for a 50-foot parcel, in general we have assumed bluff top parcel owners have atypical resiliency to these traumatic events because of the socioeconomic data for Solana Beach and Encinitas. Therefore the focus is on the capacity to cope with and recover from episodic bluff collapse and potential structure loss not affected by financial position. Stated more directly the concern and uncertainty from repeated bluff top collapse under the no action plan cannot be mitigated with financial resources. For instance a family member of an affected bluff-top parcel owner stated recently, "The property is in peril. We're just hoping for the best. We're optimistic that we can get some help."[116] Since all seawall construction must be approved by the California Coastal Commission, a state regulatory agency, unprotected parcel owners could be subject to uncertainty about whether seawall construction would be approved in time to secure their homes. Additional uncertainty occurs when neighboring parcels experience episodic collapses since adjoining parcels including those with seawall to protect against frontal wave attack, could become vulnerable to lateral wave attack from undermined neighboring bluffs that are not protected.

In addition beach visitors also have limited social resiliency to cope with "close calls," injuries, and even fatalities from episodic bluff collapse expected under the no action plan. Recreation along the coastline is a primary identity for both communities. This could manifest in a manner similar to that outlined under *Social Vulnerability*, namely beach visits could temporarily or permanently decline following news of major bluff collapses or injury and death occurring from

[116] *North Coast Times* http://www.nctimes.com/news/local/encinitas/article_fe7f01b6-2705-5071-8f59-6e09e0973cfb.html accessed 17-AUG-2011

bluff collapses, and local governments could decide to restrict access to sections of beach deemed too dangerous for recreation. Without a project in place such events could reoccur until the remaining unprotected parcels become armored or shifted to a more stable repose. In this regard both communities, regardless of financial strength, would suffer from limited capability to cope and recover from episodic collapses (i.e., limited resiliency).

10.3.5 Social Vulnerability & Resiliency: NED Plans

The NED Plans involve placing sand from offshore borrows on to Segment 1 (Encinitas) and Segment 2 (Solana Beach) and thereby protecting the bluff toe from erosion due to wave attacks. In turn episodic bluff collapse is reduced significantly from the base year, 2015. This contrasts with gradual, "piecemeal" protection afforded by individual parcel owners constructing seawalls one-by-one or in small groups over several decades. Therefore the NED Plans reduce social vulnerability by immediately reducing episodic bluff collapse that threatens beach visitors across all of Segment 1 and Segment 2.This immediate reduction in danger to beach visitors should manifest as increased recreation visits due to larger beaches while simultaneously lowering the overall risk of injury or death from bluff collapse compared to the no action plan. We would expect far fewer "close calls" and major bluff collapses that could have depressed recreation demand and fewer instances where local governments need to restrict beach access for safety concerns. The end result should be to preserve the manner the public interacts with the beaches and oceans while increasing the frequency of that interaction within Encinitas and Solana Beach due to decreased social vulnerability and decreased need to cope with the traumatic consequences of bluff collapse (social resiliency) among beach visitors and bluff-top residents.

10.3.6 Displacement to Population: No Action Plan

Displacement is the act or process of being expelled or forced to flee from home or homeland. Under the No Action Plan approximately 193 unprotected residential structures remain at risk of being compromised from episodic bluff collapse. Some of these residential structures include condominiums with multiple households resulting in closer to 300 households at risk of displacement. However, we expect that the majority of these residences would secure emergency seawall permits and construct seawalls in time to save the structures. In contrast, a subset of these residences may not construct seawalls in time due to the episodic, unexpected nature of bluff collapse as well as personal, financial, and regulatory constraints. This subset of residents in the study area could be forced to evacuate from their homes under the No Action Plan and relocate inside or outside their community depending on each displaced household's financial and personal circumstances after losing their residence. Presently, the median single family residence inclusive of land is valued at $730,600 in Solana Beach and $597,200 in Encinitas making displacement to more affordable locations outside of these communities more likely.[117]

10.3.7 Displacement to Population: NED Plans

Under the NED Plans narrowing areas of the beaches in Encinitas would be extended 100 feet MSL on average while beaches in Solana Beach would be extended 200 feet on average resulting in a significant reduction is bluff toe erosion that leads to episodic bluff collapse. Coastal storm damages that can be prevented by the NED Plans are expected to fall more than three-fifths across Segment 1 and Segment 2, the receiver sites for beach nourishment. While

[117] Zillow.com accessed May 22, 2012

coastal storm damage would be sharply reduced but not completely eliminated, those 193 residential structures at risk from episodic bluff collapse under the No Action Plan should be protected largely from being undermined. In turn few if any residents would be displaced leading to a strong improvement to this dimension of interest.

10.3.8 Community Cohesion & Social Connectedness: No Action Plan and NED Plan

Beaches have value to communities. Surveys done in 2001 by Dr. Phillip King estimated the economic value of the beaches at Encinitas and Solana Beach at $22 and $17 per beach visit, respectively. Currently that is over $60 million dollars in economic value annually and this value comes from the benefits these beaches provide.[118] This section of the OSE Account focuses on what these benefits are and how some of these benefits directly and indirectly impact community cohesion and social connectedness when the beach recedes (No Action Plan) and when the beach is maintained (NED Plans).

Dr. Phillip King performed a more comprehensive survey on the economic value of beaches for Carlsbad, which is the beach community immediately north of Encinitas. Since this beach community is immediately north of the USACE study area and of similar demographics, in general the results and conclusions should be applicable to the USACE study area.[119] Those results and conclusions revealed that just over half of respondents cited physical activities that can be performed at the beach as the primary reason for visiting. These activities included swimming, playing in the sand, and surfing. Nearly all remaining respondents cited "hanging-out on the beach" as the primary reason for visiting the beach, which suggests these visitors benefit from the unique environment and social opportunities of the beach. This survey showed that 98% of respondents come to the beach to engage in activities that can only be enjoyed while at a beach. In addition beach visitors benefit from the unique recreation opportunities at the beach whether through active enjoyment (swimming, playing in the sand, and surfing) or passive enjoyment ("hanging out on the beach"). We believe this is also true within the USACE study area, which borders to the south.

These types of unique recreation opportunities at the beach attract visitors from outside the local beach community. Seventy-three percent of beach visitors live outside of the city of Carlsbad, where the survey was taken.[120] For those visitors the beach is a significant reason to plan a trip or vacation as shown in the survey. Seventy-five percent of respondents cited visiting the beach as an important reason for their trip or vacation and that results in important business and social relationships for affected beach community. While drawn to the beach, many beach visitors also engage in activities in the nearby communities. Spending in restaurants averages nearly $50 per day for a family of four. Those attending the beach also spend money on beer and spirits, and goods from stores. In other words beach visitors are actively engaging in business within the community in social settings such as restaurants and bars. Many also remain in the community overnight. Both businesses and friends and family are affected by the

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[118] Values are derived from the travel cost method described in *Economic Analysis of Beach Spending and the Recreational Benefits of Beaches in the City of Solana Beach/Encinitas Economic Analysis of Beach Spending and the Recreational Benefits of Beaches in the City of Solana Beach/Encinitas* by Dr. Phillip King 2001. $22 per visit times 2.7 million beach visits annually in Encinitas; $17 per visit times 130,000 visits annually in Solana Beach.

[119] See *The Economic and Fiscal Impact of Carlsbad's Beach: a Survey and Estimate of Attendance*, by Dr. Phillip King 2005 for additional details.

[120] For comparison less comprehensive surveys by Dr. Phillip King done in Solana Beach and Encinitas revealed 64% and 57%, respectively, of visitors to those beaches came from outside the immediate community.

draw the beach has to visitors. Over one-third of all beach visitors (local and nonlocal) stay in hotels or campgrounds and nearly one-third stay with friends and family, and thereby engage in important business and social interactions with members of these beach communities.

In contrast when beaches disappear as under the no action plan beach attendance drops and the same business and social relationships that benefit from beach visitors become negatively impacted. The Carlsbad study also asked how a smaller beach would impact attendance. By shrinking the beach in half, a phenomenon that will occur in most of the study area beaches within two decades if no action is taken, attendance at Carlsbad beaches would drop 28%. Projecting a similar drop in attendance in the neighboring study area could result in over 700,000 less beach visits to the study area.[121] A significant portion of this projected loss in attendance could be averted by implementing the NED Plans because this would maintain beach area across two large portions of the study area. Surveys conducted for Encinitas and Solana Beach revealed that each nonlocal visit that does not occur would result in a loss of spending of $70 and $84 on average per visit. Since nearly 60% of the drop in beach visits would be due to fewer nonlocal visits to the study area beaches, the result could be $30 million less spending in Solana Beach and Encinitas annually. Again, at least a portion of this could be retained by the communities if the Recommended Plans are implemented to prevent further beach erosion.

The fiscal consequences of significantly less spending on local restaurants, hotels, and bars in Encinitas and Solana Beach are not known but could include some business closures, fewer services, or shorter periods of operation. Less beach attendance could also mean fewer overnight stays at hotels and the residences of local friends and family members under the no action plan compared to the Recommended Plan. One third of beach visitors fall in to the latter category. Less visits by this group amounts to lost opportunities for friends and family to recreate together and enjoy the unique environment these beaches and beach communities can offer.

In conclusion under the no action plan the beaches would substantively erode away by the 2030s curtailing beach visits to Solana Beach and Encinitas while the NED Plans grow and then maintains these beaches leading to moderate increases in beach visits. The Recommended Plans ensures that these beaches continue to provide unique recreation and social opportunities that draw people to beach communities. Many beach visitors extend their trips overnight by staying with friends and family, camping, or staying at a hotel. When not at the beach many enjoy social activities in local restaurants and bars. Therefore the Recommended Plans benefit the individuals who use these beaches and the beach communities that host these visitors to a significantly greater extent that the No Action Plan.

[121] 2.8 million annual visits in 2010 times 28% equals 784,000 less visits annually

10.4 Dimensions of Interest Summary

Table 10.4-1 Other Social Effects Dimensions of Interest Summary

	No Action Plan	National Economic Development Plan
Life-Safety	Strongly Adverse	Strongly Beneficial
Social Vulnerability & Resiliency	Strongly to Moderately Adverse	Moderately Beneficial
Emergency Preparedness	No Impact	No Impact
Displacement to Population	Moderately Adverse	Moderately Beneficial
Community Cohesion & Social Connectedness	Moderately Adverse	Moderately Beneficial