EVALUATION OF EROSION MITIGATION ALTERNATIVES

for Southern Monterey Bay

Prepared for
Monterey Bay Sanctuary Foundation
and
The Southern Monterey Bay Coastal
Erosion Working Group

May 30, 2012

ESA PWA

Photo Brad Damitz

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SOUTHERN MONTEREY BAY

Prepared for

Monterey Bay Sanctuary Foundation
and the
Southern Monterey Bay Coastal Erosion Working Group

Prepared by

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ACRONYMS

AMBAG	Association of Monterey Bay Area Governments
B/C	Benefit Cost Ratio
BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
BT	Benefits Transfer
CCC	California Coastal Commission
CDP	Coastal Development Permit
CRSMP	Coastal Regional Sediment Management Plan
CSBAT	Coastal Sediment Benefit Analysis Tool
CSMW	Coastal Sediment Management Working Group
DEFRA	Department of Environment, Food and Rural Affairs
ENR	Engineering News Record
FS	Factor of Safety
LCP	Local Coastal Program
MBNMS	Monterey Bay National Marine Sanctuary
MBSF	Monterey Bay Sanctuary Foundation
MCWD	Marina Coast Water District
MHW	Mean High Water
MLLW	Mean Lower Low Water
MRWPCA	Monterey Regional Water Pollution Control Agency
NAVD	North American Vertical Datum of 1988
NIBS	National Institute of Building Sciences
NPS	Naval Postgraduate School
ReCAP	Regional Cumulative Assessment Project
ROI	Return on Investment
RUM	Random Utility Model
SCOUP	Sand Compatibility and Opportunistic Use Program
SLR	Sea Level Rise
SMB	Southern Monterey Bay
SMBCEW	Southern Monterey Bay Coastal Erosion Workgroup
TDC	Transfer of Development Credits
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WTP	Willingness to Pay

1. INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

The goal of this *Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay* (Alternatives Study) is to provide an assessment of various erosion mitigation measures to support development of a regional strategy to address coastal hazards in southern Monterey Bay.

The purpose of the project is to provide a technical evaluation of various erosion mitigation measures, conduct a cost benefit analysis of some of the more promising measures and to make recommendations on Subregional approaches for effectively addressing coastal erosion in Southern Monterey Bay (SMB). Each of these measures was identified by the Southern Monterey Bay Coastal Erosion Workgroup (SMBCEW; See 1.2.1). In this study, each of the erosion mitigation measures were evaluated using a variety of criteria and compared with more traditional types of shore protection via a cost benefit analysis. A series of project alternatives were then developed. Each *Alternative* was comprised of one or more *mitigation measures* for each critical erosion Subregion that will avoid erosion hazards, protect upland development, and maintain beach health. This analysis therefore supports development of one or more shore management strategies for southern Monterey Bay, potentially as part of a Regional Shoreline Management Plan. The terminology is summarized in Section 1.1.3 Definitions.

While focused on southern Monterey Bay, this report is expected to clarify the benefits, costs, and effectiveness of a range of erosion mitigation management measures for California's shores over multiple time horizons. Specifically, this report assesses the effectiveness of each measure at protecting upland property and beach widths, and compares the costs and benefits of each measure with coastal armoring, the status quo strategy for mitigating erosion impacts. This report is also expected to begin to inform adaptation to increased coastal hazards and vulnerability resulting from accelerated sea level rise.

1.1.1 Objectives

The objectives of this Alternatives Study are to make recommendations on shore erosion mitigation measures to be pursued in the SMB that will:

- maintain ecological and recreational functions
- mitigate impacts to the physical, ecological and recreational functions
- be compatible across multiple jurisdictions and Subregions
- adaptable to future climate changes
- support the overall goal of producing a Shoreline Management Plan for SMB

1.1.2 Evaluation of Erosion Mitigation Measures

Through the work of SMBCEW, an initial laundry list of erosion mitigation measures was brainstormed in 2006 (Appendix 8.1). For a variety of feasibility reasons, ranging from cost, to ineffectiveness to inappropriateness of the technique in the geomorphic setting, this initial list of 55 was reduced to a list of 22 measures.

These 22 measures form the focus for this report:

1. Managed Retreat (Relocation / Removal)
2. Transfer of development credit
3. Fee Simple Acquisition
4. Rolling easements
5. Conservation Easements
6. Present use tax incentive
7. Structural Adaptation
8. Habitat Adaptation
9. Setbacks for Bluff top Development
10. Setbacks + Elevation for Beach Level Development
11. Cessation of Sand Mining from the Beach
12. SCOUP/ Opportunistic Sand
13. Beach Dewatering – Active
14. Beach Dewatering **-** Passive – PEMs
15. Beach Dewatering – Active – Desalinization wells
16. Nourishment (evaluated in CRSMP)
17. Seawalls
18. Revetments
19. Groins
20. Emergent Breakwaters
21. Artificial Reefs/ Submergent Breakwaters/Low crested structures
22. Perched Beaches

1.1.3 Definitions

Measures are individual mitigation measures; a combination of them will form Subregional **alternatives**, a combination of alternatives across the SMB region form the coastal hazard mitigation / adaptation **strategy,** which will feed into the development of a Shoreline Management **Plan for SMB.** Erosion mitigation measures are also called “tools” for convenience in this report. The terminologies for these and for other key parameters used in this report are defined as follows:

- *Measure*: A method of mitigating erosion damages to the man-made and/or natural environment;
- *Alternative*: One or more measures selected for a Subregion;
- *Strategy*: A regional plan comprised of alternatives selected for each Subregion;
- *Region*: Also known as the littoral cell, from the Monterey peninsula to Moss Landing
- *Subregion*: A section of shore used in this and related reports based on physical conditions; and,
- *Reaches:* A length of shoreline with similar development characteristics and erosion rates used in the Cost Benefit Analysis
- *Critical Erosion Areas*: Locations identified in the Coastal Regional Sediment Management Plan where erosion is expected to have adverse erosion effects within the planning time frame; and,

- *Planning Time Frame and Horizons*: The overall time frame is 100 years , divided into the following intervals, or “Horizons”:
  - 0-5 years
  - 6-25 years
  - 26-50 years
  - 51-100 years

1.2 BACKGROUND

The need for this alternatives study was recognized and pursued by the SMBCEW and supported by the Monterey Bay National Marine Sanctuary (MBNMS). This technical evaluation of mitigation measures and alternatives for addressing coastal erosion in the Southern Monterey Bay region is the second of two individual, yet complementary, components of a larger integrated approach for sediment management and addressing coastal erosion in the SMB region. The other component is the *Coastal Regional Sediment Management Plan for the Southern Monterey Bay* (CRSMP), which was completed in 2008 (PWA et al., 2008). Support for these studies was provided by the California Coastal Sediment Management Workgroup (CSMW), and by the MBNMS. Both components have been carried out under the direction of MBNMS and the Association of Monterey Bay Area Governments (AMBAG), a California joint powers agency representing the counties of Monterey, San Benito, and Santa Cruz, and the cities within, in close collaboration with the SMBCEW, local municipalities, and other local stakeholders.

To ensure consistency throughout this SMB collaborative regional shoreline management process, information and scientific findings from the CRMSP were utilized for this analysis of erosion mitigation alternatives. The CRSMP provided the scientific basis for information on erosion rates, coastal processes, and geomorphology. In particular, historic erosion rates were used, and the rates were not increased to account for accelerated sea level rise.

Results of armoring or attempting to hold the shore in place through engineering structures create a host of problems, many of which are incompatible with maintaining a natural beach system that supports the local tourism economy and coastal ecosystem. Generally, on a natural shore, as the shore erodes, beach width is maintained. However, when structures are built on an eroding shore, passive erosion occurs in which the beach in front of the structure becomes drowned over time as the adjacent shore continues to erode. This results in the structure projecting like a peninsula out into the ocean, which blocks lateral (alongshore) access.

The southern Monterey Bay shore is on average the most erosive sandy shore in California (Hapke et al., 2006). Despite the high erosion rates, beach widths have not narrowed over time along most of the littoral cell (Reid, 2004). Although only a very small proportion of the shore is armored at this time, there are several examples of passive erosion occurring: the rip-rap seawall fronting Stillwell Hall in Fort Ord (since removed) and the rip-rap at the end of Tioga Avenue in Sand City. In addition, the shore access is presently blocked at high tide at the Monterey Beach Resort and the Ocean Harbor House condominiums seawalls (both are located in Monterey) during the winter when the beach is seasonally reduced. This situation is expected to become worse due to continued erosion, and increased erosion as sea levels rise, and the seawalls will project into the ocean, blocking access along the beach. This anticipated loss of the beach in southern Monterey Bay is a key driver of this study to find better alternatives than traditional engineering structures.

Threats to coastal development have increased the pressure to protect coastal upland with various types of coastal armoring such as seawalls and revetments to reduce erosion. The MBNMS has been addressing the issues of coastal erosion and armoring in the context of updating the Sanctuary's Management Plan, as well as in reviewing and authorizing permit applications that involve disturbance of the seabed. As part of its revised management plan, the MBNMS developed Coastal *Armoring Action Plan* addressing coastal erosion and armoring issues. The goal of this action plan is to reduce expansion of hard coastal armoring in the coastal areas near the MBNMS through proactive regional planning, project tracking, and comprehensive permit analysis and compliance. The Coastal Armoring Action Plan recommends developing a more proactive and comprehensive regional approach that minimizes the negative impacts of coastal armoring on a sanctuary-wide basis (MBNMS, 2008).

1.2.1 Southern Monterey Bay Coastal Erosion Workgroup

Consistent with the *Coastal Armoring Action Plan*, the SMBCEW was initiated in 2005 by the MBNMS, in collaboration with the City of Monterey and other state and local partners, and with the support of Congressman Sam Farr. The workgroup was formed to facilitate the development of a regional approach to address coastal erosion within the Southern Monterey Bay region between Moss Landing and Wharf II in Monterey. The 20-member workgroup is made up of scientists, federal and state agencies, local governmental representatives, conservation interests and other local experts. The goals of the SMBCEW are to: compile and analyze existing information on erosion rates and geomorphology in the region, as well as identify corresponding critical erosion areas, including threats to private and public structures within the Southern Monterey Bay (SMB) region; identify and assess the complete range of options available for responding to erosion in the region; and, based upon the above analyses, to develop a proactive and comprehensive regional shore preservation, restoration, and management plan with selected site-specific and broader area-wide recommendations for responding to coastal erosion that minimize environmental and socioeconomic impacts to the maximum extent feasible—this current Alternatives Study will be used in the development of this comprehensive plan.

1.2.2 Coastal Regional Sediment Management Plan

The Coastal Regional Sediment Management Plan (CRSMP) for the Southern Monterey Bay region is a related study that was completed and adopted by the AMBAG Board of Directors in 2008 (PWA et al., 2008). The CRSMP and this Alternatives Study are intended to be complementary decision support and planning tools, each assessing a distinct set of options for mitigation of coastal erosion and sea level rise impacts in the SMB. The CRSMP compiled the best existing information on coastal processes, erosion rates, and geomorphology, identified sources of sediment that could potentially be used in beach nourishment projects to reduce erosion hazards, and evaluated some of the regulatory and permitting framework involved in managing sediment within Southern Monterey Bay (SMB). The CRSMP also made recommendations on sediment management approaches to be pursued for the SMB region including cessation of sand mining from the beach, continuation of natural dune erosion in the less developed reaches, and a sand nourishment project in the southern portion of the littoral cell to provide additional storm protection. The key recommendations from the CRSMP are shown in Figure 1. The recommendations also identified the need for a study which used the CRSMP as a baseline to build a regionally comprehensive erosion abatement approach, a portion of which forms the basis for this report. The CRSMP for the SMB was the first Coastal Regional Sediment Management Plan completed in California.

The plan covers the *Southern Monterey Bay Littoral Cell*, which extends from Moss Landing to Point Pinos in Monterey. The CRSMP was completed by Philip Williams and Associates in November 2008 in collaboration with AMBAG. Technical input was provided by a stakeholder group, which included the SMBCEW, consisting of local agencies and municipalities and other stakeholders and led by the Monterey Bay National Marine Sanctuary. Input and review for the CRSMP was provided during numerous meetings including meetings of the AMBAG Board of Directors, the SMBCEW, and dedicated public outreach meetings throughout the course of the study. The CRSMP was formally accepted by the AMBAG Board of Directors in November 2008.

The information on geomorphology and coastal processes in the CRSMP provides the baseline inventory for the evaluation conducted for this study assessing the feasibility and suitability of the potential erosion mitigation measures identified by the SMBCEW. For more detail on the physical setting and processes in SMB, please refer to the CRSMP (http://www.dbw.ca.gov/csmw/pdf/SMontereyBay_CRSMP_3Nov2008.pdf).

The CRSMP also identified sources of sediment that could be used in nourishment projects to reduce erosion hazards, and evaluated the traditional cost benefits of various scales of nourishment projects and included the potential recreational benefits. The CRSMP has a sediment management focus and analyzes and includes recommendations for beach nourishment projects for parts of the SMB shore—therefore the scope of this Alternatives Study does not include further analysis of beach nourishment and other sediment management approaches other than as a comparison to the other erosion mitigation measures.

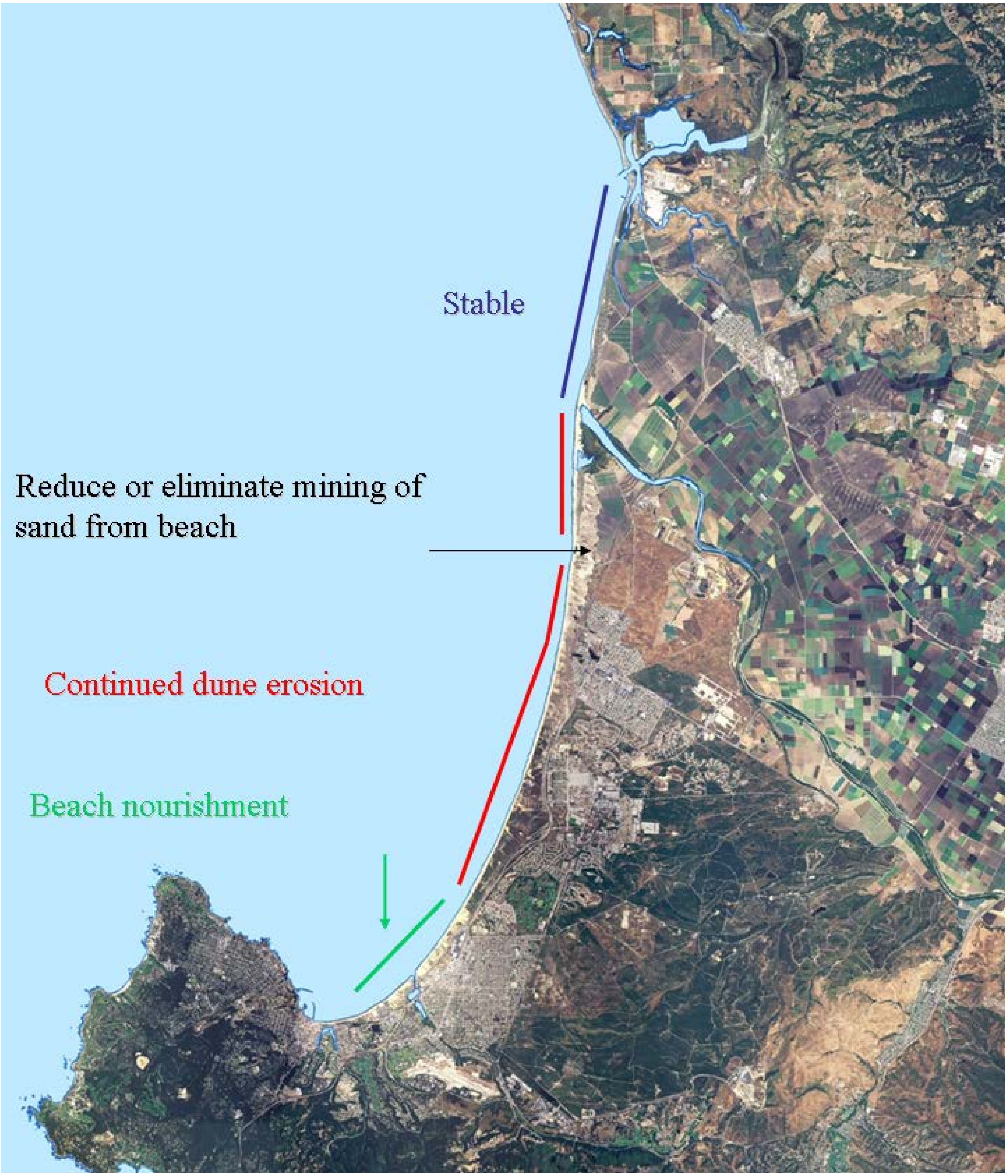

Figure 1 Summary of Recommendations from Coastal Regional Sediment Management Plan

The CRSMP subdivided the SMB shoreline into eight (8) Subregions of varying lengths and identified eight (8) Critical Erosion Areas within these Subregions. These Subregions were established based on similarities in coastal erosion rates, development patterns, and land use/ownership.

The eight (8) Subregions are as follows:

1. Subregion 1 – Wharf II to Del Monte Townhomes[1];
2. Subregion 2 – Del Monte Townhomes to Monterey Seaside Boundary
3. Subregion 3 – Monterey Seaside Boundary to Tioga Ave
4. Subregion 4 – Tioga Ave to Fort Ord
5. Subregion 5 – Ford Ord to Reservation Road
6. Subregion 6 – Reservation Road to Marine Dunes Resort
7. Subregion 7 – Marina Dunes Resort to Salinas River Mouth
8. Subregion 8 – Salinas River Mouth to Moss Landing

Critical Erosion Areas are defined in the CRSMP as development under threat from continued erosion using historic erosion rates over the next 50 years with a high-risk factor and potentially severe consequences. There are eight (8) Critical Erosion Areas in five (5) Subregions from South to North:

1. Del Monte Townhouses (Subregion 1)
2. Ocean Harbor House (Subregion 2)
3. Monterey Beach Resort (Subregion 2)
4. Monterey Interceptor (Subregions 1, 2 and 3)
5. Seaside Pump Station (Subregion 3)
6. Tioga Ave – Sand City (Subregions 3 and 4)
7. Marina Coast Water District Facilities (Subregion 6)
8. Sanctuary Beach Resort (Subregion 6)

The Subregions and Critical Erosion Areas are depicted in Figure 2.

[1] The Del Monte Townhomes are also known by their former name of La Playa Townhomes.

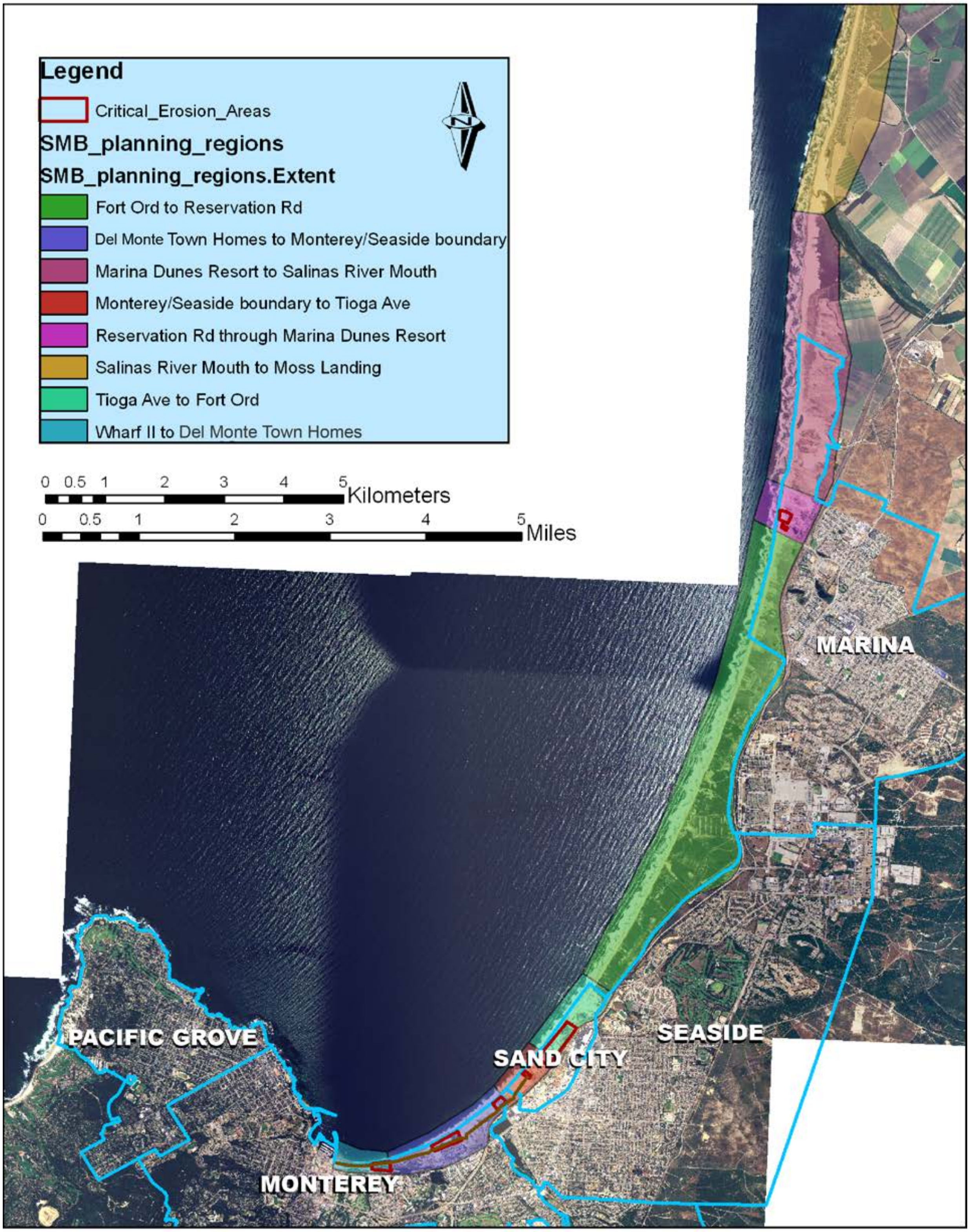

Figure 2 Southern Monterey Bay Subregions and Critical Erosion Areas

2. RECOMMENDATIONS – REGION, SUBREGION, AND CRITICAL EROSION AREAS

This section presents recommendations made by ESA PWA based on the interpretation of the results of the technical analyses conducted for this study. A separate assessment was completed for each measure using criteria including effectiveness, environmental impacts and a benefit cost analysis.

The recommendations from this Alternatives Study are organized into three sections:

- *Section 2.1 - Regional Recommendation*
  This section revisits the CRSMP recommendations and identifies alternative strategies to be considered within a regional shoreline management plan for the entire SMB region;
- *Section 2.2 - Subregion Management Recommendations*
  This section identifies the measures that are appropriate for each Subregion
- *Section 2.3 - Additional Recommended Studies*
  This section identifies research and development topics to improve upon the analyses accomplished in this report and to support future work toward a regional shoreline management plan.

Most of these erosion mitigation measures will require additional feasibility studies, regulatory and permitting coordination, and collaborative planning, prior to being implemented. For example, planning for large scale nourishment or Rolling Easements may take a decade or more to implement so the recommendation may be identified in a future time horizon, but efforts to implement them should begin immediately. The recommendations therefore are listed over their effective time horizon. These combinations of recommendations for each Subregion support one another, for example ceasing sand mining and implementing opportunistic sand nourishment while planning for a larger one.

2.1 REGIONAL RECOMMENDATIONS

2.1.1 Evaluation of Recommendations from the CRSMP:

Cessation of sand mining from the beach - this recommendation initially identified in the CRSMP remains the most significant erosion mitigation measure that should be the highest priority for all jurisdictions in the southern Monterey Bay region. Further analysis done for this report shows that implementing this measure would reduce erosion rates by at least 60% across the entire region (see *Section 4.2.1* Cessation of Sand Mining from the Beach). *The overall savings to the communities in the region by ceasing sand mining from the beach is estimated to have a present value equal to $124.5 million in 2010 dollars.* The cost of cessation is unknown and could vary greatly based on whether the mine was purchased at fair market value, or operations are modified, or beach mining stops due to other potential processes such as regulatory or legal action.

Continuation of dune erosion to supply beach sediments– this recommendation identified in the CRSMP remains an important component to maintaining the natural sediment supply to these beaches. Analyses completed in this study show that Rolling Easements, are likely to be the least costly options for continuing sediment supply sediment supply from erosion for the SMB Littoral Cell. Other implementation mechanisms for this strategy could occur on a parcel-by-parcel basis using a "no future armoring" condition, or through *Local Coastal Program* (LCP) updates, or regulatory or ordinance language by a local municipality or government agency with regulatory and permitting authority (e.g. Coastal Commission, local cities, or potentially a new Joint Powers Authority (JPA) focused on addressing coastal erosion). Specific implementation mechanisms for this recommendation would depend on levels of existing and potential coastal development and jurisdictional considerations. Action would likely not be required for undeveloped coastal areas.

Beach Nourishment – The CRSMP included a recommendation to consider developing a large beach nourishment project for the Southern Bight of the SMB (approximately 3 to 4 miles of coastline in Monterey, Seaside and Sand City) within Subregions 1 to 4 where development is most concentrated and the majority of the critical erosion areas are located. The CRSMP recommendations identified two distinct nourishment projects—large scale placements (two million cubic yards) and small scale placements of opportunistic sediments (e.g. 75,000 cubic yards from Monterey Harbor)—and found favorable benefit cost values for both projects, using the Coastal Sediment Benefits Analysis Tool (CSBAT).

Develop an opportunistic sand placement program

Consistent with the initial recommendation in the CRSMP, this program should be developed and applied as opportunistic sediment becomes available. This should not be considered an effective long-term erosion mitigation strategy due to the limited volumes of sediment. We assume that the volumes of available opportunistic sand are small, but there may be future opportunities to obtain larger volumes of sand, which would be incorporated into a larger nourishment alternative.

While analyses conducted herein show that small nourishments only have an incremental benefit to long term erosion mitigation, the low cost and applicability to specific sites show that it still provides some erosion mitigation benefits in the Southern Bight (Subregions 1-4) where erosion rates are less than -1.5 ft/year (45 cm/yr).

A more exhaustive analysis of the two CRSMP identified nourishment projects completed for this Alternatives Study expanded upon the CSBAT methodology by including potential structural damages, ecological and recreational benefits (see Section 3.5). The revised results generally indicate lower but still positive Benefit Cost (BC) ratios. The largest BC ratios were seen in the Southern Bight (Subregions 1-4) with lower BC ratios outside (Subregions 5-7). Higher costs are the result of the need to re-nourish more frequently outside the southern bight (Subregions 5-7) where erosion rates are higher. The benefit-to-cost ratios resulting from our analysis are considered high estimates due to two factors that require further investigation:

- The benefit to the beach ecosystem may be initially negative due to adverse effects to existing organisms, and frequent re-nourishment may not have a net benefit.
- Accelerated sea level rise may increase the required frequency of renourishment, thereby increasing costs and increasing the potential for adverse ecological effects.

In addition, the regulatory feasibility of nourishment projects in the Monterey Bay National Marine Sanctuary remains uncertain and it is likely that implementation of any large nourishment project would present challenges. Also, as pointed out in the CRSMP, the feasibility of attaining funding for beach nourishment while sand mining is occurring is dubious.

2.1.2 Additional Regional Recommendations

The benefit/cost analysis indicates that the land use planning measures not previously considered in the CRSMP are substantially more beneficial than any of the structural erosion mitigation measures. Therefore, regional coastal management should consider the land use planning measures in addition to the sediment management measures identified initially in the CRSMP. This finding largely depends on a regional approach that includes consideration of public trust resources associated with recreation and ecosystem services as opposed to the current practice of parcel level decision making which is largely responsible for the proliferation of shoreline armoring in SMB.

In SMB, the CRSMP and this Alternatives Study indicate the most promising approaches would be cessation of sand mining, Rolling Easements, and beach nourishment (for a full explanation and analysis of the various alternatives analyzed refer to *Section 4* of this report). However all of these measures have uncertain feasibility. A mechanism for cessation of the Marina commercial sand mining operation has not been identified. It is not known whether property owners will participate in a program of Rolling Easements or state agencies would require such a program. Large scale nourishment appears to be most effective in the southern bight where erosion rates are less and development exists; however ecological impacts would likely be highest in this reach as well, potentially affecting the benefits and costs of nourishment. Frequent re-nourishment due to accelerated erosion resulting from sea level rise or sand mining would further reduce viability of nourishment. Development of a regional shoreline management plan would therefore require further public process, planning and coordination.

We recommend that the following actions be included within the regional shoreline management process:

Monterey Regional Water Pollution Control Facilities
Continue planning and implementation to relocate the regional sewage infrastructure.

Monitoring of Coastal Changes
Establish a series of coastal transects that are monitored periodically over time. Appendix 2 is a recommended Monitoring Plan to track coastal changes. This monitoring plan should be implemented to assess long term changes and can be augmented for specific projects. This monitoring should focus on key issues such as effects of erosion management measures and research that will support a more accurate benefit cost analysis and adaptive management strategy

Institutional Funding Framework – As described in the CRSMP (PWA et al., 2008), regional management requires further development of an institutional framework and implementation mechanism including in particular a governance structure and funding. During the course of this study, several interesting concepts were identified in discussions with leading experts, for example, the concept of a “sand bank” that would fund plan implementation via a coordinated “revolving fund” created from a range of sources such as permit fees (e.g. Coastal Commission permit sand mitigation fees), federal grants, or other sources (personal communications with Jim Titus, Meg Caldwell, and David Wilmot).

Regional Review of Setback Policies – Currently, local setback policies are the most commonly applied erosion mitigation measure but they differ in their application throughout the region. It should be noted that analyses show that this strategy is not effective in the long term and has the highest risk of regulatory takings lawsuits. It may make more sense to have a regional systematic setback policy however local issues may require additional considerations. Additionally, if revetments or armoring is eventually permitted, then setbacks only serve to delay the impacts.

It is recommended, at a minimum, that a “standard” setback for the region is established to facilitate coordinated regional planning. The Del Monte LCP standard, a 100 year average annual erosion rate calculation is the recommended minimum setback. A more appropriate setback would entail a minimum forecast period of 100 years and include consideration of accelerated sea level rise and other hazards such as tsunami run-up. Variations to this standard could be tiered based on the type and size of proposed development. The fact that communities have adopted less restrictive setbacks indicates that this recommendation may be difficult to implement and may include consideration of other factors such as local tax revenue, property values, and consensus about coastal hazards and environmental effects. Some variances may be warranted on some parcels since strict application of setbacks may preclude redevelopment in some cases and trigger takings claims (see Section 5).

Implement Pilot Projects – Several of the mitigation measures assessed in this study (e.g. passive dewatering) have less scientific certainty, and others such as the use of geotextiles and opportunistic beach nourishment, have unknown ecological impacts. It is recommended that current scientific literature is reviewed to reassess its applicability. It is also recommended that small-scale “pilot” experiments be conducted using some of the alternatives having less potential for environmental impacts and are more affordable. These pilot projects would be conducted using close monitoring of physical, ecological and recreational affects.

Public Education and Real Estate Disclosures – Given the high costs estimated to manage the hazards resulting from coastal erosion, we recommend public outreach and real estate disclosure to educate property owners on risks of coastal hazards. Public participation in development of the regional shore management plan would accomplish this to some degree. However, more systematic actions may be needed to reach a broader section of the public. For example, mapping of the coastal hazard zone (to include erosion, flooding, tsunamis) and required disclosure as part of real estate transactions would help ensure that the public was informed. The geographic scope of the zone could be expanded to include inland parcels based on a future sea level rise hazard assessment.

2.2 SUBREGION MANAGEMENT RECOMMENDATIONS

The recommendations for each Subregion are summarized in Table 1.This table only highlights the recommendations by Time Horizon and Subregion found in Section 2. It does not discuss rationales for recommendations, or further delineate measures that are not likely to work, or may work but seem to be cost prohibitive. The detailed analyses used to identify these recommendations are found in the Erosion Mitigation Measures described in Section 4.2.

Table 1 Summary of Subregion Management Recommendations

Erosion Mitigation Measures	Time Horizon	Subregion 1	2	3	4	5	6	7	8
Rolling Easements	Immediate 0-5	■	■	■	■	■	■	■	■
	Short - 6-25	■	■	■	■	■	■	■	■
	Medium - 26-50	■	■	■	■	■	■	■	■
	Long - 51-100	■	■	■	■	■	■	■	■
Managed Retreat	Immediate 0-5	■	■	■	■	■	■	■	■
	Short - 6-25	■	■	■	■	■	■	■	■
	Medium - 26-50	■	■	■	■	■	■	■	■
	Long - 51-100	■	■	■	■	■	■	■	■
Transfer Development Credit	Immediate 0-5				■			■	
	Short - 6-25				■			■	
	Medium - 26-50				■			■	
	Long - 51-100				■			■	
Conservation Easements	Immediate 0-5	■	■	■	■		■	■	
	Short - 6-25	■	■	■	■		■	■	
	Medium - 26-50	■	■	■	■		■	■	
	Long - 51-100	■	■	■	■		■	■	
Fee Simple Acquisition	Immediate 0-5	■	■	■	■		■	■	
	Short - 6-25	■	■	■	■		■	■	
	Medium - 26-50	■	■	■	■		■	■	
	Long - 51-100	■	■	■	■		■	■	
Structural Adaptation	Immediate 0-5								■
	Short - 6-25	■	■	■	■	■			■
	Medium - 26-50	■	■	■	■	■			■
	Long - 51-100	■	■	■	■	■			■
Setbacks	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50								
	Long - 51-100								
Sand Mining Cessation	Immediate 0-5	■	■	■	■	■	■	■	■
	Short - 6-25	■	■	■	■	■	■	■	■
	Medium - 26-50	■	■	■	■	■	■	■	■
	Long - 51-100	■	■	■	■	■	■	■	■
SCOUP	Immediate 0-5	■	■	■	■				
	Short - 6-25	■	■	■	■				
	Medium - 26-50	■	■	■	■				
	Long - 51-100	■	■	■	■				
Beach Dewatering	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50								
	Long - 51-100								
Beach Nourishment	Immediate 0-5								
	Short - 6-25	■	■	■	■				
	Medium - 26-50	■	■	■	■				
	Long - 51-100	■	■	■	■				
Revetments	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50								
	Long - 51-100								
Seawalls	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50								
	Long - 51-100								
Perched Beaches	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50								
	Long - 51-100								
Groins	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50	■	■						
	Long - 51-100	■	■						
Breakwaters	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50								
	Long - 51-100								
Artificial Reefs	Immediate 0-5								
	Short - 6-25								
	Medium - 26-50								
	Long - 51-100								

Subregions and Summary Statistics

Assessor's parcel-level data provided by AMBAG were reviewed for the entire study region. The following statistics were derived within the area between Moss Landing and Wharf II, and within 300 feet of the shore:

- 380 oceanfront parcels are on record within a total area of about 150 km^2 (1100 acres)
- 80 parcels (21%) are publicly owned making up 66% of the land area
- 300 parcels (79%) are privately owned making up 34% of the land area
- 288 of 380 parcels have 0 or NO assessed value (improved or land value)

2.2.1 Subregion 1 – Wharf II to Del Monte Townhouses

This entirety of Subregion 1 is located in the City of Monterey, and includes the area located between Wharf II and the Del Monte Townhomes[2] (Figure 3)[3].

Erosion rates in this Subregion are less than those in the other Subregions, ranging from near 0 ft/yr (0 cm/yr) to 0.5 ft/yr (11cm/yr), with the lower rates near Wharf II increasing moving up-coast towards the Del Monte Townhouses. A wall was placed along Wharf II to arrest sand from filling in the Harbor; this has resulted in Wharf II acting as a breakwater accreting sand adjacent to the Wharf and building up a wide beach.

Wide beaches, low, active, migrating dunes, and minimal wave energy in comparison with the other Subregions, characterize this portion of the shore. Correspondingly, threats to existing structures are not as imminent as those found in other Subregions. Another unique aspect of Subregion 1 is the existence of fine-grained sand probably due to the addition of fine sediments in the runoff from the hills that collects near the drainage culvert at the wharf. The sand composition however becomes coarser moving to the north of the wharf.

Because of its proximity to popular Monterey tourist attractions, and availability of parking, this stretch is one of the most heavily used for beach oriented recreational activities, including walking on the beach, sunbathing, kayaking, fishing, beachcombing, SCUBA diving, and swimming. Monterey Abalone Company operates an abalone farm under Wharf II, which could potentially be impacted by turbidity changes.

[2] The name of this property has changed and has been called La Playa Townhomes and Parklands Monterey

[3] Detail not shown: The section of beach from Wharf II to Camino El Estero is part of Monterey with the remainder being part of Monterey State Beach. Although it is owned by State Parks, the Monterey State Beach portion is under the jurisdiction of the City of Monterey through a Memorandum of Understanding.

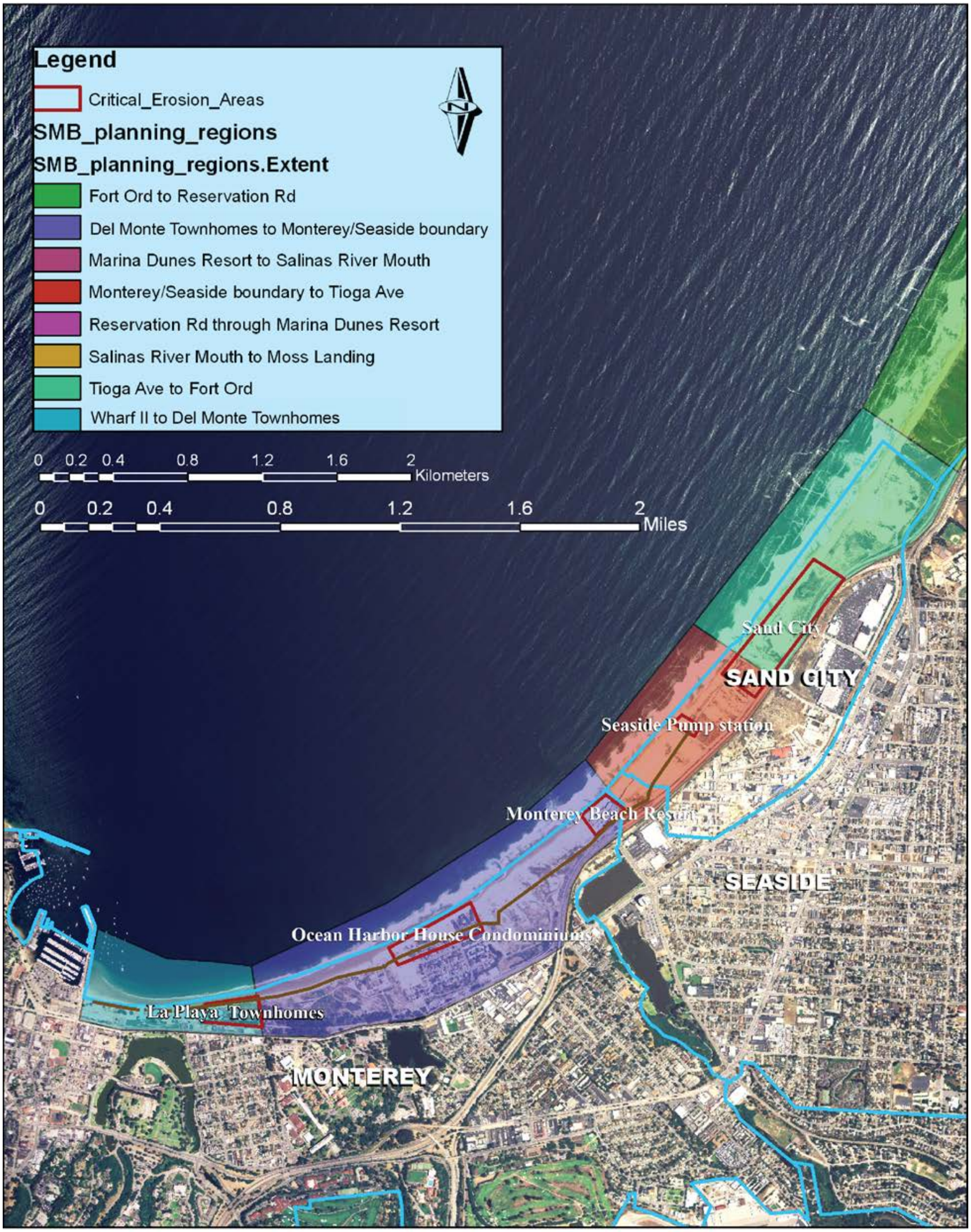

Figure 3 Subregions 1 – 4

Existing Coastal Protection Structures and Practices:

The only existing armoring in this Subregion is a small amount of riprap at the fence line of the Del Monte Townhouses. The City of Monterey practices beach scraping in this location to build up a berm in front of the Catellus property in order to prevent wave run-up from reaching Del Monte Boulevard. The entire stretch of coast from Wharf II to the Ocean Harbor House condos is raked by the City to remove debris such as driftwood and seaweed.

Critical Erosion Sites Included:

Portions of the Monterey Interceptor; Catellus East Property; Del Monte Townhomes; Lake El Estero Storm Drain Outfall

Assessors Summary:

This area is about 3080 feet long, with 98 parcels. The total value of near oceanfront property (from the Assessors data) is $29,568,253, with average values of $301,716 per parcel and $9,608 per foot of shore. This translates to $31,522,310/km

2.2.1.1 Subregion 1 - Recommended Actions

Immediate term

- Implement land use planning measures (1. Rolling Easements; 2. Conservation Easements; 3. Fee Simple Acquisition of threatened structures with a hybrid lease back option for structures that are still suitable for habitation until they cease to be safe; 4. Fee Simple Acquisition)
- Cessation of Sand Mining from the beach
- Implementation of an opportunistic sand placement program (including potential use of sand from dredging of Monterey Harbor) to address critical erosion areas
- Other recommendations from observations not analyzed in the report:
  - Use of temporary structures (e.g. geotextile sand bags[4] , K-rails) as an interim storm protection measure
  - Controlling storm water run-off at the Del Monte Townhouses to reduce sand saturation and reduce hotspot erosion
  - Reduce or eliminate beach grooming and the removal of beach wrack which in addition to supporting and comprising part of the sandy beach ecosystem also improves natural sand accumulation and retention processes

Short term

- Structural adaptation (underpinning and elevation) of threatened structures
- Relocation of portions of the Monterey Interceptor
- Beach nourishment (large). It should also be noted that there are significant regulatory hurdles to implementing this in the Monterey Bay National Marine Sanctuary. Also, note that for this Subregion, ecological impacts are likely to be the highest given the eel grass beds, offshore rocky reefs, and sandy beach ecosystem. It is NOT recommended that this option be considered without first ceasing sand mining from the beach.

[4] Geotextile Sand Bags (also known as scour pillows) refer to plastic or other fabric bags filled with sand or gravel and used to form a barrier to erosion appropriate for minor erosion, low environmental loads and short durations. Other measures may also be useful but all should be subject to careful consideration before installation.

Medium term

- Groins as a sand retention structure show positive net benefits over 100 years in this Subregion and is worth further investigation in a feasibility study.

Long term

- Structural Adaptation or Relocation of transportation infrastructure
- Managed Retreat

2.2.2 Subregion 2 – Del Monte Townhomes to Monterey Seaside Boundary

This Subregion begins just beyond the Del Monte Townhomes property and continues to the Monterey-Seaside Boundary, slightly past the Monterey Beach Resort. The section of beach from the Ocean Harbor House condos to the Monterey Beach Resort is part of Monterey State Beach under the jurisdiction of State Parks and the land between the Del Monte Townhomes and just before the properties on Beach Way are under the jurisdiction of the Naval Postgraduate School (NPS).

Erosion rates in most of this Subregion are relatively low compared to other Subregions ranging from 11 to as high as 60-80 cm/year. The rates increase moving up-coast from the Del Monte Townhomes and are highest in this Subregion at the Monterey Beach Resort. The beach is wider here than further up the coast; however, it is narrower than in Subregion 1. Subregion 2 includes the highest concentration of both threatened sites and existing armoring in the southern Monterey Bay Region.

Subregion 2 is heavily used for recreational activities including walking on the beach, sunbathing, surfing, fishing, volleyball and beachcombing. This entire stretch is also part of Monterey State Beach under the jurisdiction of California State Parks. The dunes to the north of the Ocean Harbor House are known to support nesting snowy plover. Lateral access can be impeded in several areas of Subregion 2 during winter storms including at the Ocean Harbor House, Del Monte Lake outfall, the Monterey Beach Resort, and at the point where recreation trail is closest to the beach along Sand Dunes Drive approaching the Monterey Beach Resort.

Subregion 2 includes a portion of the Monterey Interceptor—between the Monterey Pump Station (located near the former City of Monterey treatment plant) and Tide Avenue—that was designated as high-risk in the assessment of threat to MRWPCA facilities completed in 2004. Other sections of the Monterey Interceptor in this Subregion were designated as moderate risk. This stretch also includes a section of Highway 1, near the Monterey Beach Resort, that is in closer proximity to the coast than in other Subregions.

This Subregion includes a former petroleum tank site located between the Ocean Harbor House condos and the Monterey Beach Resort; asphalt and remnants from old roads remain at this site. Another potential consideration is a plume of gasoline-contaminated groundwater located at the point where the recreation trail is in closest proximity to Del Monte Avenue, just beyond the Del Monte Beach subdivision. This plume is currently being observed, through funding by Chevron, to track its activity by a monitoring well in the vicinity.

There is a historical landfill in this Subregion, between Beach Way and the Monterey pump station, containing debris from the historic Del Monte Hotel fire. This landfill is currently being uncovered by storm waves.

The portion of Monterey State Beach from the Ocean Harbor House condos to the Monterey Beach Resort is potential snowy plover habitat.

Existing Coastal Protection Structures and Practices:
Armoring exists at the Del Monte Lake storm drain outfall, Ocean Harbor House condos, and Monterey Beach Resort.

Critical Erosion Sites Included:
Parts of Monterey Interceptor; Naval Postgraduate School Research Building; Old Monterey Treatment Plant; Del Monte Lake Storm Drain Outfall; Del Monte Beach Subdivision; Ocean Harbor House; parts of Sand Dunes Drive; Monterey Beach Resort; Roberts Lake/Laguna Grande Outfall; Part of Highway 1. There is also a warehouse located on the dunes at the Naval Postgraduate School property, however that building is sacrificial and will be removed if threatened by erosion. The recreation trail (bike path) is another sacrificial structure, that if threatened should be removed and relocated rather than protected.

Assessors Summary:
This area is about 7300 feet long, with 241 parcels. The total value of near oceanfront property (from the Assessors data) is $107,814,546 with average values of $477,363 per parcel and $14,769 per foot of shore. This translates to $48,454,724/km

2.2.2.1 Subregion 2 - Recommended Actions

Immediate term

- Implement a land use planning measures (1. Rolling Easements; 2. Conservation Easements 3.Fee Simple Acquisition of threatened structures with a hybrid lease back option for structures that are still suitable for habitation until they cease to be safe.; 4. Fee Simple Acquisition)
- Cessation of Sand Mining
- Implementation of an opportunistic beach nourishment program including use of clean sediment from dredging of Monterey Harbor to address critical erosion areas
- Other measures not evaluated in this report
    - Use of temporary structures (e.g. geotextile sand bags , K-rails) as an interim storm protection measure

Short term

- Structural adaptation underpinning and elevation of threatened structures
- Beach nourishment (large). It should also be noted that there are significant regulatory hurdles to implementing this in the Monterey Bay National Marine Sanctuary. It is NOT recommended that this option be considered without first ceasing sand mining from the beach.

Medium term

- Groins as a sand retention structure show positive net benefits over 100 years in this Subregion and is worth further investigation in a feasibility study.

Long term

- Managed Retreat
- Structural Adaptation or Relocation of transportation infrastructure

2.2.3 Subregion 3 – Monterey-Seaside Boundary to Tioga Ave

Subregion 3 begins at the border of Seaside and continues to Tioga Avenue in Sand City. It includes all of Seaside's beachfront property and parts of Sand City.

Erosion rates in this Subregion continue to increase from Subregions 1 and Subregion 2, and are highest near Tioga Avenue. Lateral access along the beach can be cut off during storm episodes and high tides at the terminus of Tioga Avenue.

Subregion 3 is used for recreational activities including walking on the beach, sunbathing, fishing, volleyball and beachcombing, although not as frequently as Subregion 1 and Subregion 2.

There is very little development in Subregion 3 and what does exist is infrastructure rather than commercial or residential development. This Subregion would benefit from cleanup of sites and potential retrofit or improvement of certain structures. While there is more area available for coastal retreat than the previous 2 Subregions, this Subregion has limited space with Highway 1 in proximity to the shore; therefore focus on keeping wide beaches might be appropriate.

Several threatened sites exist in Subregion 3, including a section of the Monterey Interceptor—between the Seaside Pump Station and the Monterey Beach Resort—that was designated as high-risk in the PWA threat assessment study conducted in 2004. The Seaside Pump Station, located only 75 feet from the shoreline, was also determined to be a high risk (PWA, 2004). PWA estimated that the facility may be threatened within 20 years and could be compromised by short-term episodic events even sooner. The estimated cost to replace this pump station is $55 million dollars (Appendix 3).

Existing Coastal Protection Structures and Practices:
Seawall at Monterey Beach Resort

Critical Erosion Sites Included:
Parts of Monterey Interceptor; parts of Sand Dunes Drive; Seaside Pump Station; Part of Highway 1; Bay Street storm drain outfall; Sand City at end of Tioga Avenue; Monterey Beach Resort.

Assessors Summary:
This area is about 3360 feet long, with 225 parcels. The total value of near oceanfront property (from the Assessors data) is $595,096 with average values of $2,644 per parcel and $177 per foot of shore. This translates to $580,709/km.

2.2.3.1 *Subregion 3 - Recommended Actions*

Immediate term

- Implement land use planning measures (1. Rolling easements; 2. Conservation Easements 3. Fee Simple Acquisition of threatened structures with a hybrid lease back option for structures that are still suitable for habitation until they cease to be safe.; 4. Fee Simple Acquisition)
- Cessation of Sand Mining
- Implementation of an opportunistic sand placement program
- Other measures not analyzed in this report
  - Use of temporary structures (e.g. geotextile sand bags) as an interim protection measure

Short term and Medium term

- Structural adaptation of threatened structures
- Beach nourishment (large volume of 2 million c.y.) recognizing that this is only an intermediate and not long term solution. It should also be noted that there are significant regulatory hurdles to implementing this in the Monterey Bay National Marine Sanctuary. It is NOT recommended that this option be considered without first ceasing sand mining from the beach.

Long term

- Managed Retreat
- Structural Adaptation or Relocation of transportation infrastructure

2.2.4 Subregion 4 – Tioga Ave to Fort Ord

This Subregion begins just northeast of Tioga Ave. in Sand City and continues to the boundary of Sand City and Fort Ord. Erosion rates in this Subregion are higher than Subregions1-3, with the highest rates near Tioga Avenue.

The land in this Subregion falls within the boundaries of Sand City and also includes a section of Monterey Regional Parks District (MRPD) parkland known as Landfill Dune Preserve. This preserve is located on the site of a previously located landfill for the Monterey Peninsula cities, which closed in 1955. The site then served as a go-cart racetrack which remained open until 1969. The land was acquired by MRPD in 1995 and underwent partial remediation during the next two years with the assistance of the California Integrated Waste Management Board. The landfill material was unearthed and sorted and the recoverable or recyclable materials were removed with the remaining debris being re-buried and covered with sand. Although the debris was buried beyond a projected 50-year erosion setback, sea level rise was not taken into consideration. The coastal dunes were subsequently restored with native vegetation and an extension of the Monterey Bay Coastal trail was constructed.

Subregion 4, although not heavily used for recreational activities compared to the previous Subregions, is used for walking on the beach, sunbathing, fishing, beachcombing, and surfing. This may change in the future as the transition in ownership from the military to California State Parks has opened this area up for recreational use.

This Subregion includes very little existing development. However, there are two proposed developments within its boundaries. Sand City, MRPD and California State Parks have a Memorandum of Agreement that establishes these two areas where development would be allowed seaward of Highway 1 in Sand City. The first site is the combined 7-acre Sterling property and the adjoining 23-acre McDonald property to the north. This project is under review by the Sand City. The other property is the 39-acres Ghandour project, located on an old sand mine between the large sand dune visible from Highway 1 and the north end of Sand City, adjacent to Fort Ord. The development proposal has been contested and the project review is continuing at the time of this report.

A portion of the Monterey Interceptor is also located within this Subregion; however it was determined by PWA not to be at high risk, as part of their assessment for MRWPCA (PWA, 2004). This area was identified in the CRSMP as one critical to maintain sediment supply through continued erosion of the dunes.

Existing Coastal Protection Structures and Practices:
There is limited coastal protection in this Subregion; however there is some "de facto" armoring caused by the dumping of concrete and construction rubble near the end of Tioga Ave. However, accelerated sea level rise was not considered in this 2004 analysis.

Critical Erosion Sites Included:
Parts of Monterey Interceptor (although not high-risk); debris and concrete on the dunes adjacent to Tioga Avenue

Assessors Summary:
This area is about 4835 feet long, with 9 parcels. The total value of near oceanfront property (from the Assessors data) is $10,355,798 with an average value of $1,150,644 per parcel and $2,141 per foot of shore. This translates to $7,024,278/km. It is our understanding that assessed values do not necessarily reflect developed fair market values and hence may not be accurate.

2.2.4.1 Subregion 4 - Recommended Actions

Immediate term

- Implement land use planning measures (1. Rolling Easements; 2. Conservation Easements 3. Fee Simple Acquisition of threatened structures with a hybrid lease back option for structures that are still suitable for habitation until they cease to be safe.; 4. Fee Simple Acquisition)
- Cessation of Sand Mining
- Implementation of an opportunistic sand placement program
- Assess potential for a Transfer of Development Credits program to remove development potential from erosion hazard zones and provide a densification of development within Sand City, perhaps through urban redevelopment
- Other measures not analyzed in the report
    - Application of any sand mitigation fees to Sand Bank

Short term and Medium term

- Structural adaptation of proposed structures (e.g. modular construction)
- Transfer of Development Credits of developable parcels
- Beach nourishment (large) recognizing that this is only an intermediate and not long term solution. It should also be noted that there are significant regulatory hurdles to implementing this in the Monterey Bay National Marine Sanctuary. It is NOT recommended that this option be considered without first ceasing sand mining from the beach.

Long term

- Managed Retreat
- Structural Adaptation or Relocation of transportation infrastructure (We assume that infrastructure function will be maintained however it is possible that changes in transportation needs would allow rerouting and demolition and not require reconstruction).

2.2.5 Subregion 5 – Ford Ord to Reservation Road

Subregion 5 encompasses Fort Ord Dunes State Park and parts of Marina State Beach. Steep narrow beaches with coarse sand, and high dunes characterize this Subregion. (Figure 4) Erosion rates in this Subregion are higher than the previous Subregions. This Subregion includes very little existing development along the shore; however the park does include more than 100 abandoned military buildings. The dunes in this Subregion vary in elevation between sea level and 140 feet above mean sea level, and are heavily vegetated with iceplant.

Subregion 5 includes very little existing development, and current state park plans call for removal of what does exist as it becomes threatened by coastal erosion. Although the erosion rates are significantly higher than many of the other areas within the Southern Monterey Bay region, with wide dunes and Highway 1 relatively far from the shoreline, this Subregion does not face the more imminent threats that the other Subregion s must address. Accordingly, avoidance based responses such as managed retreat might be appropriate.

Figure 4 Subregion 5

Fort Ord Dunes State Park was opened in 2009 and includes four miles of shore along Monterey Bay. The property includes the remnants of fifteen small arms firing ranges, the former Fort Ord ammunition storage area that includes twelve bunkers, and other military era structures that are not in use, including a wastewater treatment plant. Fort Ord Dunes also includes an internal road system and utility lines. Several of the ammunition supply bunkers on the site will be used by State Parks for storage; however the structures will be removed as they become threatened by coastal erosion. State Parks uses a 700-foot setback zone in anticipation of the 100-year erosion line.

Subregion 5 is not as heavily used for recreational activities compared with the previous Subregions owing to limited access to the beaches guarded by high dunes. However, it has the potential for increased use due to its new State Park status, and is used to some degree for walking on the beach, sunbathing, fishing, beachcombing, and some surfing. The Fort Ord Dune State Park is accessed through Fort Ord. The main access point to Marina State Beach is at the west end of Reservation Road.

Three storm water outfalls that were previously causing severe erosion problems in this Subregion were removed from the beach by Fort Ord Reuse Authority in 2003. The outfalls were truncated and are now discharging to retention basins in the dunes. A fourth outfall structure that remains under the army's ownership has also been stabilized and will ultimately be phased out.

Several monitoring wells west of Highway 1 in Fort Ord also exist in Subregion 5 to monitor the progress of a waste plume that originated near 12 Street and is migrating seaward. These wells are part of a remediation program that also includes injection wells into which water from the plume, that has been treated, is pumped. Both the Monitoring wells and injection wells are currently in use, and are owned and operated by the Army Corps. of Engineers. At least one of the monitoring wells is seriously compromised by erosion, including one located at the top end of the bluff located due west of the abandoned wastewater treatment plant. The injection wells are located on the east side of the highway and are not threatened (Gray, 2006).

Critical Erosion Sites Included:
Monitoring wells at Fort Ord; Fort Ord Stormwater Outfalls

Assessors Summary:
This area is about 26,925 feet long, with 28 parcels. The total value of near oceanfront property (from the Assessors data) is $596,221 with average values of $21,293 per parcel and $22 per foot of shore. This translates to $72,168/km.

2.2.5.1 Subregion 5 - Recommended Actions

Immediate, Short, Medium and Long term

- Cessation of Sand Mining
- Rolling Easements implemented as conditions of approval for new or re- development
- Managed Retreat/Relocation/Demolition of any threatened structures
- Structural adaptation of any proposed structures (e.g. modular construction)

2.2.6 Subregion 6 – Reservation Road to Sanctuary Beach Resort

This Subregion is entirely encompassed within Marina State Beach. (Figure 5) There is a lack of existing development in Subregion 6. This area is probably highly impacted by the CEMEX sand mining operation up-coast. Therefore cessation of the mining operation would most likely have a positive effect on erosion and structure threats in this area. There is significant area available for coastal retreat in this area with substantial dunes and distance separating Highway 1 from the ocean, therefore managed retreat is probably a likely option in this Subregion.

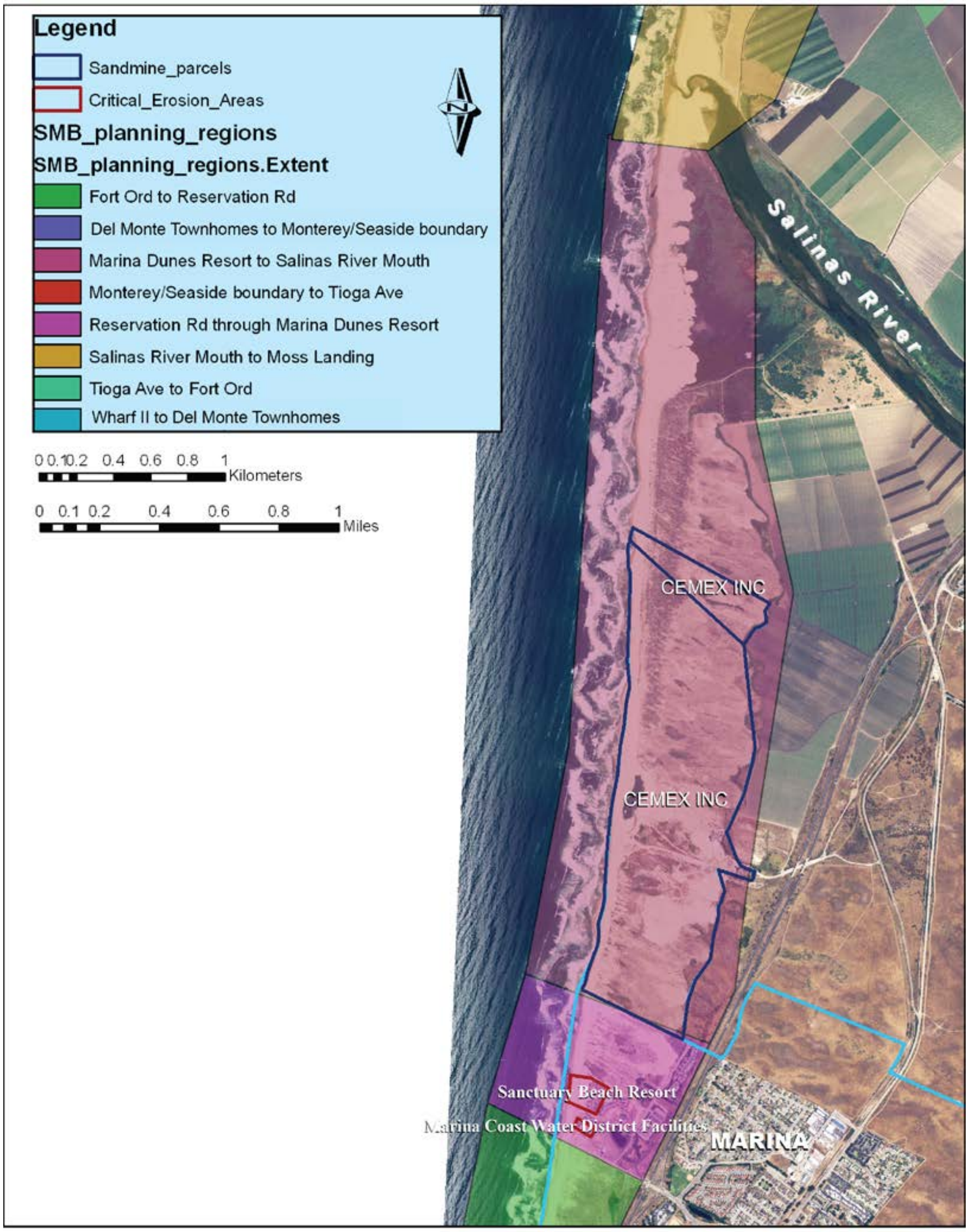

Figure 5 Subregion 6 and 7

The main access point to Marina State Beach is at the west end of Reservation Road. This access point includes a parking lot, restroom, and a boardwalk that leads through the Marina Dunes Natural Preserve. Also at the end of Reservation Road are the Marina Coast Water District (MCWD) facilities. The parking lot is one of the few points along the Monterey Bay shore where ocean viewing can be conducted from parked cars. MCWD has plans to remove and/or relocate the facilities.

The beach is known for hang-gliding, surfing, and surf fishing. The beach is a popular site for picnics.

Critical Erosion Sites Included:
Marina Coast Water District Facilities at end of Reservation Road; Reservation Road Parking lot, and Sanctuary Beach Resort

Assessors Summary:
This area is about 2,703 feet long, with 7 parcels. The total value of near oceanfront property (from the Assessors data) is $26,728,303 with average values of $3,818,329 per parcel and $9,887 per foot of shore. This translates to $32,437,664/km.

2.2.6.1 Subregion 6 - Recommended Actions

Immediate, Short, Medium and Long term

- Implement land use planning measures (1. Rolling Easements; 2. Conservation Easements 3. Fee Simple Acquisition of threatened structures with a hybrid lease back option for structures that are still suitable for habitation until they cease to be safe.; 4. Fee Simple Acquisition)
- Cessation of Sand Mining
- Managed Retreat/Relocation of any threatened structures
- Structural adaptation of any proposed structures(e.g. modular construction)

2.2.7 Subregion 7 – Sanctuary Beach Resort to Salinas River Mouth

Subregion 7 begins just north of the Sanctuary Beach Resort and continues until reaching the Salinas River Mouth. (Figure 5) This area includes wide dunes with very limited coastal development. Erosion rates in this Subregion are the some of the highest in Southern Monterey Bay and have increased significantly in the last twenty years presumably as the result of the significantly increased sand mining at the CEMEX site over this period of time (see Section 4.2.1).

The CEMEX sand mining operation is located on a 400-acre property along the Marina coast about a half-mile up coast from Reservation Road within this Subregion. This site has been actively mined since 1906, and does not have (nor is required to have) permits from the County of Monterey, City of Marina, California Coastal Commission, or the State of California. A reclamation plan was developed for the site, as required by the California Surface Mining and Reclamation Act of 1975. This plan was finalized in the early 1990's, and the reclamation program has been under the supervision of City of Marina since then. However, jurisdiction is currently being transferred to the State of California. Of the 400-acres on the property, 104 acres are disturbed by current mining operations. In the 1991 Reclamation Plan EIR, the previous owner estimated that mining operations at the site would continue for 50 years. After the site is sufficiently mined, the parcel will be available for other coastal dependent or visitor-serving uses as allowed by the Marina Coastal Zone Land Use Plan.

Currently there are no proposals for future developments on the west side of Highway 1 in Marina; however there are two vacant parcels on the east side of the highway. There is the potential for 78.35-acres of the CEMEX property to be developed in the future; but this will not likely occur until after 2020. Potential future uses include a coastal resort hotel or RV park. While existing zoning regulations would set a maximum limit of 1,200 units for resort development of the site, with average unit size of 700sq. ft., the limited availability of information about the specific characteristics of the site render it virtually impossible to know whether any (and if so, what type of) development of the site is feasible under existing laws.

Critical Erosion Sites Included:
CEMEX sand mining operation.

Assessors Summary:
This area is about 15,144 feet long, with 12 parcels. The total value of near oceanfront property (from the Assessors data) is $18,125,312 with average values of $1,510,442 per parcel and $1,197 per foot of shore. This translates to $3,927,165/km.

2.2.7.1 Subregion 7 - Recommended Actions

Immediate, Short, Medium, Long term

- Rolling Easements
- Conservation Easements particularly on the 5 acre CEMEX property
- Cessation of Sand Mining
- Managed Retreat/Relocation of any threatened structures
- Transfer of development credits
- Other measures not analyzed in the report
    - Application of any sand mitigation fees to Sand Bank
- Fee Simple Acquisition of Sand Mine

2.2.8 Subregion 8 – Salinas River Mouth to Moss Landing

Subregion 8 extends from the Salinas River Mouth north to the south jetty of Moss Landing Harbor (Figure 6). This Subregion was identified in the CRSMP as a stable to an accretional Subregion (i.e. not eroding). This Subregion is characterized by a dune backed shore with a backdune wetland complex created by the remnants of the Salinas River when it used to flow unconstrained and meet the ocean north of Moss Landing.

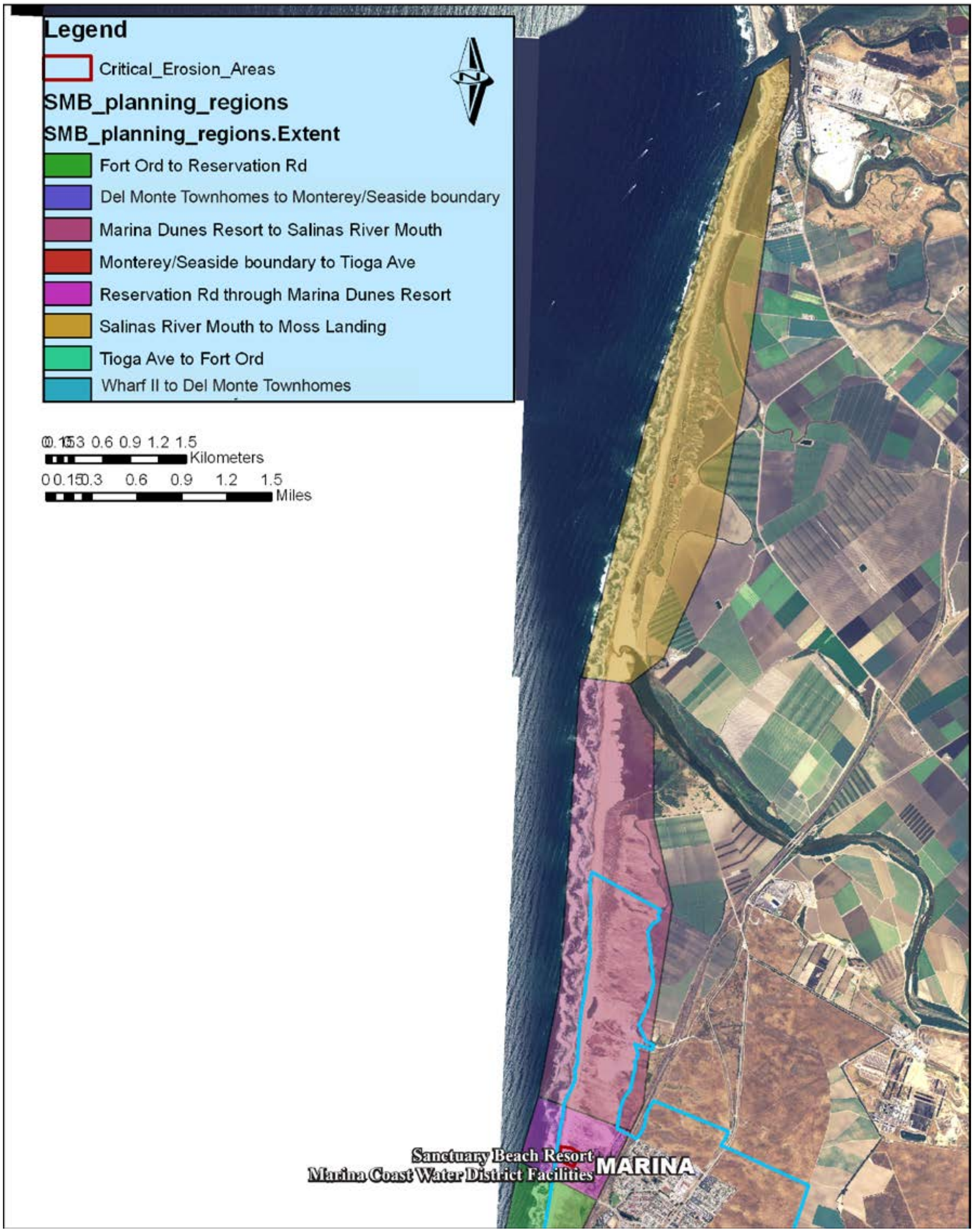

Figure 6 Subregion 8

<u>*Critical Erosion Sites Included:*</u>

No sites were identified although the Monterey Bay Aquarium Research Institute (MBARI) is located very near the active beach and could become threatened over time, especially as sea level rises and erosion accelerates.

2.2.8.1 Subregion 8 - Recommended Actions

Immediate term

- Implement land use planning measures (1. Rolling Easements; 2. Conservation Easements 3. Fee Simple Acquisition of threatened structures with a hybrid lease back option for structures that are still suitable for habitation until they cease to be safe.; 4. Fee Simple Acquisition)
- Conservation Easement acquisition on developable parcels
- Cessation of Sand Mining
- Managed Retreat/Relocation of any threatened structures

Short term to Long term

- Structural adaptation of any proposed structures including mobile construction

2.3 ADDITIONAL RECOMMENDED STUDIES

2.3.1 Conduct Planning Scale Sea Level Rise Coastal Hazard and Vulnerability Study

Evaluate future erosion hazard zones at a planning level considering sea level rise and climate change. Integrate both the erosion and flood hazards to predict medium to long term impacts. Improve existing erosion hazard zone calculations using specific data sets on erosion rates, and seasonal variability in beach morphology. Provide initial assessment of uncertainty by aggregating multiple scenarios to identify relative risk of various areas. Include tsunami risk mapping. Identify vulnerable infrastructure in revised hazard zones.

2.3.2 Improve Real Estate Database

Fact check and update current Assessors database with updated property values, ownership (public vs. private), structural improvements and zoning to improve planning level vulnerability assessment and provide more robust level planning data.

2.3.3 Improve Cost/Benefit Analysis

Incorporate results from the SLR studies, the improved real estate database and monitoring data (Sections 2.3.1, 2.3.2, and Appendix 2) into the present study cost benefit modeling and improve assessment of recreational benefits, and ecological costs and benefits into the future.

2.3.4 Evaluate Potential Interim Storm Protection Measures

It is recommended that a study be conducted to evaluate some potential interim storm protection measures (e.g. geotextile sand bags (Figure 7), etc.). Other potential options to evaluate could be the use of sacrificial timber bulkheads as an interim storm event protection (>5+years).

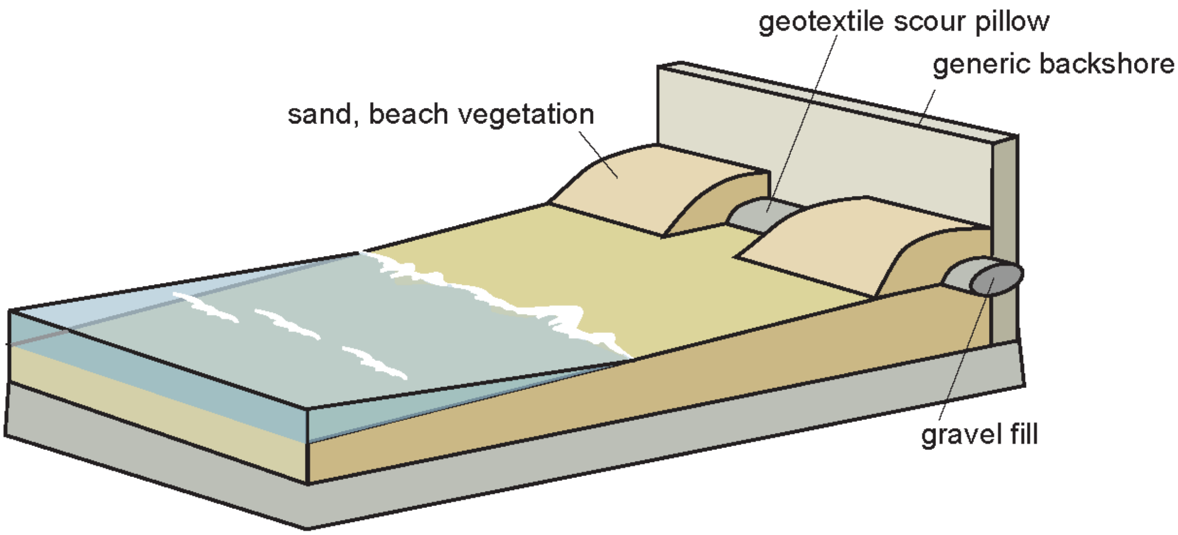

Figure 7 Conceptual temporary erosion mitigation device e.g. geotextile sand bag (also known as "geotextile scour pillow")

2.3.5 Recreational User Study

Conduct baseline research and data collection on recreational uses in southern Monterey Bay including: subtidal, intertidal, dry sand, and dune to undeveloped lands. This could include a combination of online and site surveys, as well as video camera analytics to systematically document the number of recreational users.

2.3.6 Ecological Evaluation

Conduct comprehensive baseline surveys of the biota of beach and dune habitats of SMB.

Develop and conduct biotic monitoring programs that can be used to evaluate ecological responses to and impacts of different erosion control strategies as they are implemented in SMB (see Appendix 2 for more information on monitoring)

2.3.7 Cessation of Sand Mining from the Beach

This is a regional shore management issue that requires further attention (see Section 2.1 Regional Recommendations). We recommend additional legal research into the costs and means of implementing this recommendation. A first step may include a formal discussion with the sand miners to evaluate their interests and possible cooperative actions such as clarification of linkages between mining and erosion, alternative sand sources, and a cost – benefit analysis of the alternatives to present operations including cessation that come out of that formal discussion. Other means to implement this which have been identified include:

- Regulatory injunction
- 3rd party lawsuit
- Fee Simple Acquisition

3. METHODOLOGY

3.1 STANDARD SCALES AND ASSUMPTIONS

To assess the erosion mitigation measures and evaluate their effectiveness over various time scales, some standardizing assumptions about the appropriate planning horizons, spatial scales, climate change, and coastal management decisions, were made to facilitate the analysis. In addition, the evaluation criteria were refined following discussions with the SMBCEW.

3.1.1 Time Frames and Horizons

For this project, we attempt to assess the effectiveness of each mitigation measure over a variety of time frames. This enables results and mitigation measures to be identified for the planning horizon of interest. but with consideration of long term effects that will begin to identify appropriate adaptation strategies and options to enhance community resiliency to climate changes in the future:

- Immediate 0-5 years
- Short 6-25 years
- Medium 26-50 years
- Long 51-100 years

3.1.2 Spatial

The overall spatial scale is the regional littoral cell scale. However, recommendations will be made at a Subregional spatial scale to address critical erosion areas and identify appropriate strategies by time horizon. The Subregional alternatives must be considered together to ensure consistency and compatibility over the littoral (regional) scale. Cost estimating is done on a $/km value to be applicable at a greater than parcel scale level.

3.1.3 Climate Change

The use of historical erosion rates implicitly ignores the effects of climate change and acceleration of sea level rise which are expected to increase erosion rates. For the purposes of this study, we recommend future work adopt the sea level rise scenarios from the California Climate Adaptation Strategy of 16 inches by 2050 and 55 inches by 2100 (CNRA, 2009). Sea level rise will likely increase erosion rates (PWA, 2009). The higher erosion rates will exacerbate previously identified critical erosion areas, making these sites more vulnerable to erosion and flooding impacts sooner, and potentially exposing new areas to flooding and erosion.

Recent climate change research indicates changes in wave climate, precipitation and sediment transport are possible but the changes are less certain than sea level rise (Allan and Komar 2006, Adams et al., 2008, Ruggiero, 2010). In this study, we implicitly assume that there will be no changes to either the long term sediment budget or wave climate by extrapolating historical erosion rates. Sea level rise is not addressed. In discussions with the SMBCEW it was decided that since a source of funding could not be identified to address sea level rise in a timely manner for this study, it would best be considered in a subsequent study along with adjustments for expected future sand mining rates.

3.2 EVALUATION CRITERIA

To standardize the evaluation of each alternative so that they can be compared systematically, we applied several standardized criteria. Most of the criteria are based on previous efforts by the SMBCEW, with several new criteria added to provide a more thorough assessment of impacts, costs, and effectiveness. Criteria are categorized as Technical and Impacts, as follows:

Technical

- Effectiveness – reducing threat to upland
- Effectiveness – maintaining beach width
- Resiliency – adaptable to future conditions
- Certainty of success – scientific certainty that measure will function as intended

Impacts

- Environmental
- Recreation
- Safety/Access
- Aesthetics
- Cumulative – if all oceanfront parcels received treatment

3.3 EROSION MITIGATION MEASURES

The erosion mitigation measures have been divided into the following categories of tools: Land Use Planning, Non-Structural, Structural and Other. In general, the measures can be categorized as measures which avoid the risk to coastal hazards, measures that improve or enhance sand supply, and measures that hold the line in a fixed location. Managed Retreat in its broader context can include all alternatives, including hard armoring that is temporary, beach nourishment, development setbacks, etc. Here, Managed Retreat is treated as a local erosion hazard mitigation alternative that could be labeled Relocation.

Following consultations with the SMBCEW, the laundry list of alternative erosion mitigation measures was reevaluated based on new information and subsequent work completed during the RSM process. This led to the addition of several alternatives back to the list. In addition, Low Crested Structures were added to the list, as these represent new management approaches being tested in the European Union.

The following alternatives were evaluated for this project:

Land Use Planning Measures

- Managed Retreat (Relocation / Removal)
- Transfer of development credit
- Fee Simple Acquisition

- Rolling Easements
- Conservation Easements
- Present use tax incentive
- Structural Adaptation
- Habitat Adaptation
- Setbacks for Bluff-top Development
- Setbacks + Elevation for Beach Level Development

Non structural Measures

- Sand Mining cessation
- Opportunistic Sand Placement / Nourishment
- Beach Dewatering
  - Active
  - Passive
- Nourishment (evaluated in CRSMP and comparative benchmark for the Cost/Benefit Analysis)
  - Beach Nourishment
  - Nearshore Placement
  - Beach Placement
  - Dredge Sand from Deep or Offshore Deposits
  - Dune Nourishment (adding both sand and vegetation)
  - Potentially add ecological impacts/benefits of nourishment

Structural Measures

- Seawalls/Revetments
- Groins (including geotextiles)
- Emergent Breakwaters
- Artificial Reefs / Submergent Breakwaters / Low Crested Structures
- Perched Beaches
- Low Crested Structures

Measures that reduce factors which exacerbate erosion

- Native Plants
- Sand Fencing / Dune Guard Fencing
- Controlling Surface Run-off
- Controlling Groundwater
- Berms / Beach Scraping

3.3.1 Land Use Planning Measures

The approaches in this category primarily focus on allowing the natural coastal processes to operate unimpeded. These issues include Managed Retreat (relocation / removal), Rolling Easements, Conservation Easements, Transfer of Development Credits, Present Use Taxes, Fee Simple Acquisition, Structural Adaptation, or Setbacks.

In general, these mitigation measures have higher initial costs, long implementation timelines and high benefits. Some have limited application due to shortage of undeveloped parcels, and some simply put the problem off to a later date or the next generation.

3.3.2 Non Structural Measures

The alternatives in this category tend to be focused either on enhancing sediment supply and accretion processes, or reducing sediment losses. These alternatives include: cessation of sand mining, large scale sand placement, implementation of an opportunistic sand use program, and beach dewatering.

Implementing mechanisms for these types of alternatives will likely require the involvement of a regional planning entity (AMBAG coordinated with various jurisdictions and their respective departments – planning, public works, flood control, etc. Some of the tools here though are more site-specific and so will follow a more traditional local permitting process). In general, these measures replace eroded sand frequently and repeatedly. Cessation of sand mining is a special case that could be characterized as a Land Use Planning Measure as well as a Regional Strategy.

3.3.3 Structural Measures

Approaches that fall into this category involve the design and construction of structures to protect the coastline. These alternatives include: seawalls, revetments, groins, breakwaters, perched beaches, low crested structures and artificial reefs. While the stated objective of the SMBCEW is to avoid coastal armoring structures, because of the potential impacts to the beach and coastal recreation and habitats, several of the other structural engineering alternatives may also protect the beach and so are discussed in more detail.

Implementing these strategies will likely follow a relatively traditional permitting process involving the local permitting agencies, California Coastal Commission, California State Lands Commission, and for those located below Mean High Water (MHW) the Monterey Bay National Marine Sanctuary and the U.S. Army Corps of Engineers (USACE).

3.4 TAKINGS CLAIM ANALYSIS

Some of the hurdles to implementing some of the land use planning tools stem from the perception by local jurisdictions that a private property takings claim and resulting lawsuit could occur as a result of implementing certain measures. Based on conversations with SMBCEW, and local planning staff it was recognized that a brief analysis of regulatory takings was an important component of this study. As part of the analysis, five hypothetical case studies in the SMB region were selected representing a range of likely types of potential takings claims. These case studies and legal insights provide an initial discussion of considerations as they may arise during implementation of the land use planning mechanisms. This discussion is not to be used in lieu of legal counsel.

This approach to this work is outlined below:

- Review of takings, public trust, and key cases
- Assessment of the following Planning Tools:
  - Managed retreat
  - Setbacks
  - Rolling Easements
  - Conservation Easement
  - Transfer of Development Credits
- Assessment of five case studies based on different conditions:
  - Multiple unit pre-Coastal Act
  - Post Coastal Act – no seawalls condition of Coastal Development Permit
  - Undeveloped
- Assessment of each measure for comparison

3.5 COST BENEFIT ANALYSIS

Following the initial evaluation of erosion mitigation measures, SMBCEW requested a more robust cost benefit analysis of erosion management measures. In response, a quantified cost benefit analysis methodology was developed based on a simplified conceptual model of beach width and associated benefits, and the costs of beach and upland erosion. The cost benefit analysis included:

- A beach width index that changed over time and in response to each measure
- An initial assessment of ecosystem services in dollars linked to beach width
- An initial assessment of recreational benefits in dollars

Discussions with the SMBCEW helped to narrow the range of measures analyzed in detail under this cost benefit analysis and additional funds were provided by the MBNMS to support the improvements. The SMBCEW selected the following alternatives for more detailed cost benefit analysis:

- Managed Retreat (relocation / removal)
- Transfer of Development Credit
- Rolling Easements
- Conservation Easements
- Fee Simple Acquisition
- Structural Adaptation
- Setbacks (combined)
- Sand Mining
- Beach Nourishment (large scale nourishment in RSM)
- Revetments and Seawalls (as a benchmark)
- Groins
- Breakwaters
- Artificial Reefs

The SMBCEW decided to drop the following alternatives from the detailed cost benefit analysis:

- Dewatering Active (due to lack of scientific certainty and cost information)
- Dewatering Passive (due to lack of scientific certainty and cost information)
- Present Use Tax (due to lack of ability to mitigate erosion)
- Habitat Adaptation (due to lack of ability to mitigate erosion)
- Beach Dewatering – Desalination (due to lack of scientific certainty and cost information)
- Perched Beaches (due to lack of scientific certainty and cost information)
- Opportunistic beach nourishment (small nourishment in RSM due to lack of ability to mitigate erosion across an entire Subregion)

3.5.1 Cost-Benefit Analysis Methodology

The goal of the cost-benefit analysis was to set up a more holistic accounting scheme that includes ecosystem services (ecological, recreational, and storm damage reduction benefits) of the natural shore in addition to the costs and benefits traditionally considered (construction costs and benefits to private property and infrastructure services). The analysis extends over time, and considers site-specific characteristics of each Subregion, in order to inform planning decisions based on local conditions but also to facilitate a regional aggregation. The physical aspect of the methodology is illustrated conceptually in Figure 8 and the site specific characteristics are shown in Figure 9. We attempted to evaluate a quantitative cost benefit for specific erosion mitigation measures over the planning horizons.

We have developed a framework to account for the Costs and Benefits of the erosion mitigation measures over the various planning horizons 5, 25, 50, and 100 years. Our approach tracks various beach zone widths over time in response to the physical changes caused by coastal erosion that would occur under each mitigation measure. The underlying assumption is that the beach zone widths relate to ecosystem services, recreation and storm damage reduction benefits. Thus for each time step, the method tracks changes in beach widths and the resulting effect on recreational, ecological, and property damages. These beach zone width zones used in the analysis are shown in Figure 8, which illustrates the impacts of a revetment on the beach system over time. For each zone and time horizon we attempt to account for changes in values as a result of changes in widths resulting from erosion and construction. To account for the range of physical beach and coastal processes conditions in SMB we have relied on physical widths from 3 representative profiles along Del Monte Ave, Sand City, and Marina (Figures 10, 11, and 12). During this accounting process we attempted to identify projected changes in the physical widths through time as a result of each erosion mitigation measure.

The first step was to designate and define various widths or zones across a nearshore profile. Beginning offshore of Mean Lower Low Water (MLLW) is the surf zone recreational area or subtidal habitat area. Between MLLW and Mean High Water (MHW) is the intertidal recreation and habitat zone. Above MHW to the toe of the dune is the dry sand beach recreation and habitat zone. From the base of the dune to the inland extent of development is considered upland undeveloped or habitat zone. The final zone is from the ocean side line of development inland and is referred to as the developed width (Figure 8). It should be noted that these zone designations are generalized and do not entirely account for the complexity of the sandy beach ecosystem.

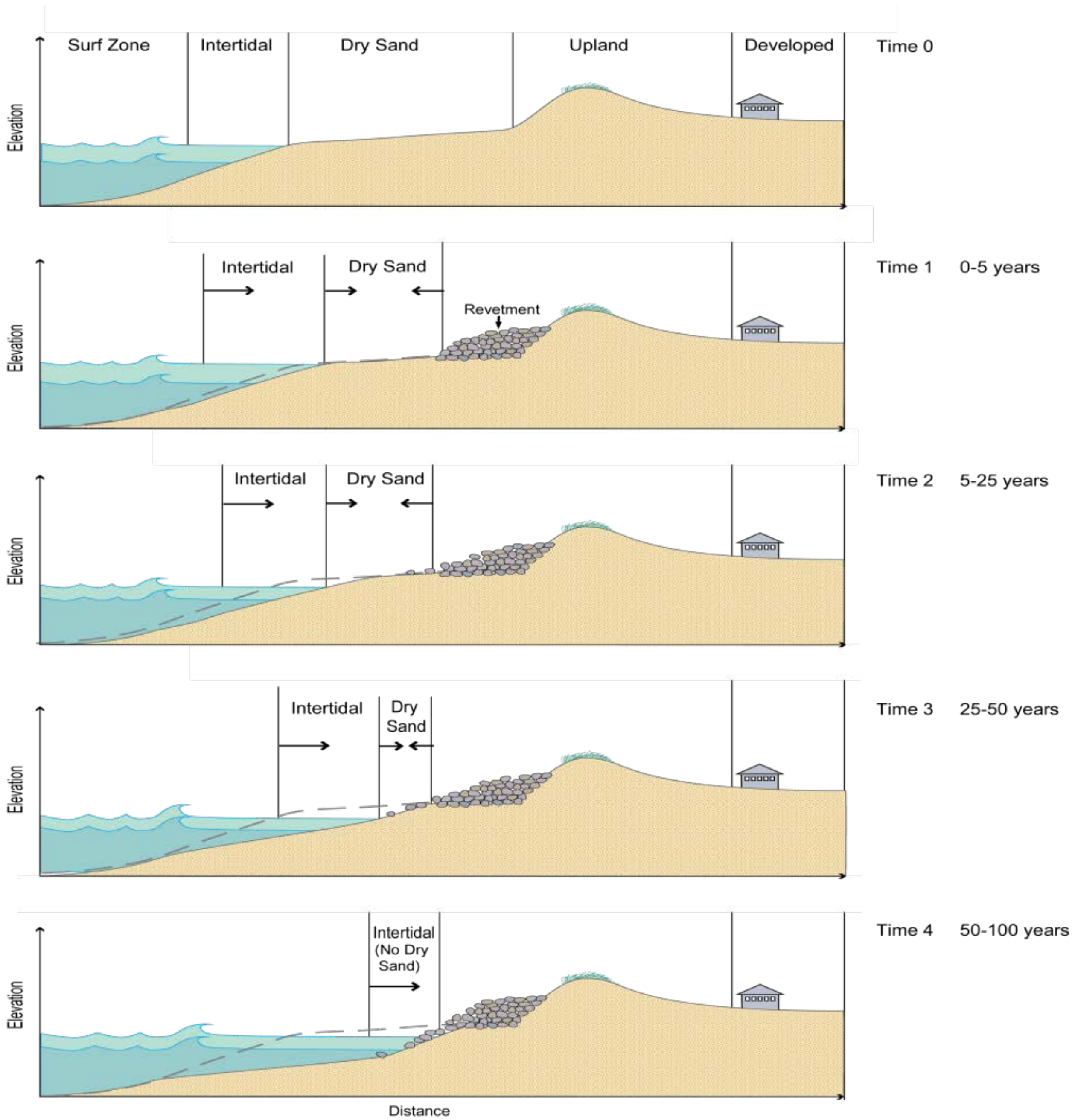

Figure 8 **Conceptual Model of Accounting for changes to physical, ecological and recreational environments through time using the example of a revetment (baseline condition)**

3.5.2 <u>Cost-Benefit Analysis Assumptions</u>

Assumptions were made for some parameters that were required for the analysis but were uncertain or unknown. In many cases, less than optimal data exists to conduct a complete and robust cost/benefit analysis. The authors of this report have conducted due diligence to understand the physical, ecological, and recreational information necessary to apply such a model, however, there remain outstanding gaps in our knowledge and metrics of human and ecological use of Southern Monterey Bay. To complete the assessment several assumptions were made by the authors, as agreed by the SMBCEW, based on professional judgment, observations and experiences in Southern Monterey Bay and other places in California. These assumptions include the following:

- Analyses assume that physical changes in dry sand beach widths are related to changes in ecological function
- Analyses assume that physical changes in dry sand beach width are related to changes in recreational value
- *Managed Retreat and Structural Adaptation* measures assume that erosion processes would continue unimpeded
- *Setbacks* assume that erosion would continue until upland undeveloped within 20' of development then revetment is placed
- *Opportunistic Sand Placement (SCOUP)* – the smaller nourishment described in the CRSMP ~75,000 cubic yards would add three feet of beach width every 5 years (for the Del Monte subcell)
- *Revetments and Seawalls* – Includes placement losses which reduce beach width at time of construction. Includes active erosion effects which accelerate beach loss when beach width narrows and wave run-up frequently reaches structure.
- *Beach Nourishment* – the large nourishment alternative described in the CRSMP (~2 million cubic yards on beaches in Monterey, Seaside and Sand City) would widen the beach by 100 feet every 25 years. *Groins, Artificial Reefs, Breakwaters* –Coastal engineering structures would be used in conjunction with the large beach nourishment alternative as a sand retention structure. The retention structures would essentially slow the rate of sand transport away from the nourishment area, thereby slowing the rate of beach width reduction. This effect is modeled as a reduction in width loss, using the concept of sand diffusion. Offshore emergent breakwaters are considered the most effective because wave sheltering and diffraction reduces sand transport directly. Artificial reefs or submerged breakwaters are considered less effective than emergent breakwaters because the wave sheltering is reduced by the lower crest height, which allows wave overtopping. Groins are considered the least effective because wave climate would not be reduced and rip current formation would cause offshore transport, bypassing and edge effects.
- All *Managed Retreat* and *Structural Adaptation* measures assume that erosion processes continue unimpeded and therefore have no ecological impacts
- With the *Transfer of Development Credit* measure, we assume that the value of the "receiver" site and its use is similar to the shore parcel that development credit is transferred from *Rolling Easements* assumes that there would be no public cost to acquire the easement and that the natural erosion process would continue unimpeded.
- *Conservation Easements* assumes that there would be some public cost to acquire the easement. This cost is selected to be 50% of fair market value. This cost is only applied to private property (e.g. not State Parks).
- *Fee Simple Acquisition* assumes that there a public purchase to acquire the property at fair market value
- *Structural Adaptation - Setbacks + Elevation for Beach Level Development* this also assumes that erosion processes would continue unimpeded. Cost estimates range from $200-$500 per square

foot with the smaller cost associated with smaller dwellings in the larger cost associated with large infrastructure such as Highway 1

- *Setbacks for Dune-top Development* assume that erosion would continue until upland undeveloped reaches within 15' of development then a revetment is placed. Placement loss would occur and ecological damages follow a linear decline corresponding to dry sand beach loss.
- *Cease Sand Mining* assumes that erosion rates are reduced by 60% (See Section 4.2.1; Figure 25). Cost varies from Fee Simple Acquisition at fair market value to a regulatory injunction at no public cost.

3.6 COST ESTIMATING

This section describes the construction cost estimating used for the cost benefit analysis (Sections 3.6.1 and 3.6.2). The estimated costs resulting from damages to the coastal sewer system are described in Section 3.6.3 and Appendix 3. Additional Information about the estimates is provided in Section 3.6.4.

3.6.1 Initial Estimates

PWA investigated the costs of structural measures to mitigate erosion in southern Monterey Bay. Construction costs were estimated per kilometer of shore as agreed upon with the SMBCEW. The Sand City Erosion Study[5] provided estimates for confinement structures to enhance beach nourishment (breakwaters and groins), as well as seawalls and revetments. These costs were escalated using construction cost index data published by the Engineering News Record. The Coastal Regional Sediment Management Plan[6] for the study area provides a conceptual description of large-scale beach nourishment consisting of about two million cubic yards deposited over a 3 to 4 mile section (southern most, Monterey through Sand City). This report also includes a description of a smaller nourishment volume characterized as "opportunistic" beneficial reuse of sand excavated for other purposes. A 75,000 cubic yard volume from the Monterey Marina Dredging project was used, but other inland sources of similar scale are also represented by this SCOUP measure. PWA also contacted design firms to inquire about the costs of revetments, seawalls and artificial reefs, and reviewed available construction costs from recent projects. These other firms consulted included Haro Kucinich, Power Engineering, and ASR, Ltd.

The above data were reviewed and a range of costs were obtained. From the range, it was concluded that the range of costs was largely affected by location (exposure and erosion rate) and likely structure life. For the purposes of this study, a single representative value for each measure was desired. Values were selected using judgment assuming a 25 year structure life with no maintenance. After 25 years each structure was rebuilt at the previous cost of construction, using 2010 dollars (See Table 2). The following costs were selected:

[5] Battalio & Everts, 1990, Moffatt & Nichol Engineers, Sand City Erosion Study.

[6] PWA, 2008, Coastal regional Sediment Management Plan for southern Monterey Bay.

Table 2 Generalized Construction Cost Estimates

Item	Cost ($/ foot or $/sf)	Cost ($M/ km)
Rock revetment	$4,500	$15
Seawall	$5,900	$20
Groins (with sand placement)	$8,000	$26
Reefs (with sand placement)	$12,000	$39
Breakwaters (with sand placement)	$12,000	$39
Sand Placement Large (about 2,000,000 cy)	-	$3.3
Sand Placement Opportunistic (about 75,000 cy)	-	$0.4
Structure Underpinning	$200 / sf	-
Bridge / trestle to elevate roadway	$500 / sf	-

A review of the estimated costs including a comparison with the prior Sand City Shore Erosion Study, led PWA to present the following opinions to the SMBCEW:

1. The estimates are concept level and very approximate. These should be considered more applicable in terms of relative costs per kilometer and not used for budgeting.
2. The beach nourishment costs may be under estimated.
3. Seawalls have become relatively less expensive over last few decades
4. It is difficult to estimate breakwaters and reefs although experts in reef design and construction were consulted (ASR, Ltd)
5. Actual costs are site and time specific, and depend on design criteria.

3.6.2 Revisions Based on August 5, 2010 SMBCEW Meeting:

PWA and team presented the first draft estimates and benefit / cost analyses to the SMBCEW for their consideration and comment. Estimates were revised based on our interpretation of the discussion and comments received. Revisions consist of a range rather than a single estimate. If the original estimate was considered high, a lower value was estimated and vice versa. The following Table 3 summarizes the results.

Table 3 Revised Generalized Construction Cost Estimates

Item	Cost ($M/km) Low	High	Description of Changes
Rock Revetment	$15	$18	Estimated high range by increasing low estimate by 50%.
Seawall	$20	$33	Estimated high range using Ocean Harbor House costs of about $8M for 800 lineal feet of seawall[1] which is $10,000 / lf.
Groins (with sand placement)	$17	$26	Established low estimate as 67% of high estimate (so high estimate is about 50% higher than low estimate).
Reefs (with sand placement)	$26	$39	Established low estimate as 67% of high estimate (so high estimate is about 50% higher than low estimate).
Breakwaters (with sand placement)	$26	$39	Established low estimate as 67% of high estimate (so high estimate is about 50% higher than low estimate).
Sand Placement Large (about 2,000,000 cy)	$3.3	$5.0	Estimated high range by increasing low estimate by 50%.
Sand Placement Opportunistic (about 75,000 cy)	$0.4	$0.8	Estimated high range using trucking instead of marina hydraulic dredging. Used $32/cubic yard, including mobilization and environmental costs. This compares to about $27/cy discussed in 2005 for Ocean Harbor House sand mitigation fee[2].

[1] SMBCEW verbal comments at August 5 2010 meeting. Approximate value.
[2] California Coastal Commission staff report "Revised Findings for Coastal Development Permit" OHH-Th13a-1-2005, January 13 2005 hearing date for Ocean Harbor House shore protection and sand mitigation fee, etc.

Given that the level of funding for the project prevents detailed cost estimates, a range of values will be used to convey the sensitivity of the benefit cost evaluation to construction costs for structural measures. We defined the high cost as 50% higher than the low cost, which means that the low cost is about 67% of the high cost. Based on the comments from the SMBCEW, we assigned the original estimates as either low or high.

The SMBCEW indicated that the seawall costs seemed low, and recommended that the Ocean Harbor House seawall costs be considered as a recent relevant example: The Ocean Harbor House seawall costs were much higher. The City of Monterey indicated that they thought the hybrid alternatives (groins, reefs, breakwaters with sand) would cost less in the southern portion of the Bay because of the lower wave climate and erosion rates: This observation was generally supported. Several coastal engineers expressed doubts that the beach nourishment alternatives would remain functional for 25 years, and therefore the cost might be low: The shore modeling accomplished for this study and the prior regional sediment management plan indicates a widened beach life of closer to 20 years. Also, maintaining a net wider beach (minimum width) to mitigate storm damages may be a design objective. Therefore, the original beach nourishment estimate was assigned the "low" value and a higher estimate increased by 50% was established. Similarly, the opportunistic sand placement was based on Monterey Harbor dredging and was considered to cost less than typical trucking options. An increased estimate based on land-based sand supply and a cost of about $32 per cubic yard provided a high value that was roughly twice the low value.

3.6.3 Sanitary Sewer Transmission Damage Costs

The Monterey Peninsula Water Pollution Control Agency (MRWPCA) provided estimated replacement and failure costs for their sanitary sewer facilities along the shore. Additional information about the estimates is provided in Appendix 3: MRWPCA Costs. PWA used prior studies to identify when each component of the MRWPCA facilities would be impacted, triggering a cost[7,8]. The selected threshold was a minimum protective summer / fall beach width of 65 feet, in order to provide an adequate buffer for winter conditions and severe erosion due to storms. A single width was selected for simplicity although different widths could be selected for each facility based on damage mode and location.

3.6.4 Additional Information about Cost Estimates

The information provided herein was developed to provide a standard basis for comparison between different shore erosion mitigation measures for the benefit of coastal zone management discussions. The information provided herein is neither intended nor authorized for any other use and should not be used for any purpose without prior written approval by PWA.

For planning purposes we have provided order of magnitude estimates to allow comparison of alternative erosion mitigation measures. These estimates are intended to provide an approximation of shore erosion, benefits and costs appropriate for the conceptual level alternatives comparison.

These estimates do not explicitly include consideration of all possible costs, such as design, environmental review, permitting, construction administration, monitoring, property purchase and other costs. In particular, significant costs can be expected for sand mitigation fees for coastal armoring projects. Please note that in providing opinions of probably costs, ESA PWA has no control over the actual costs at the time of construction. The actual cost of construction may be impacted by the availability of construction equipment and crews and fluctuation of supply prices at the time the work is bid. ESA PWA makes no warranty, expressed or implied, as to the accuracy of such opinions as compared to bids or actual costs.

These estimates do not consider all possible benefits and costs including indirect, consequential, aesthetic, and community health and well-being. Estimation of benefits is less certain than construction costs. Higher confidence is afforded recreational economics, while ecological values are inherently uncertain. PWA makes no warranty, expressed or implied, as to the accuracy of opinions of erosion rates. In particular, the erosion rates are not consistent with existing guidance on sea level rise which would tend to increase the rates of erosion.

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[7] Op cit.

[8] PWA, 2004; Southern Monterey Bay Coastal Erosion Study, Memorandum to Robert Jaques, PE, PWA, Ref. # 1729, Nov. 24, 2004.

3.7 PHYSICAL CHANGES TO NEARSHORE WIDTHS

The second part of the cost/benefit analysis was to estimate future changes to the widths of the beaches and uplands of southern Monterey Bay for each of the prioritized erosion mitigation measures. To conduct the cost-benefit analysis we subdivided the littoral cell into three shoreline reaches based on similarity in erosion rates and jurisdictional boundaries (Figure 9). We assigned initial widths to each of the nearshore zones based on historic beach profile envelopes (Figures 10-12). The same erosion rates for SMB beaches that were identified in the CRSMP were used for this analysis.

For the Del Monte reach, we assumed the erosion rate was about -1.5 feet per year, with initial dry sand beach widths of 118 feet, and an upland total on average of 200 feet divided into undeveloped upland on average about 100 feet, and developed upland about 100 feet. The typical shore profile used to represent this reach is shown in Figure 10.

For the Sand City reach, we assumed the erosion rate was about -3.0 feet per year, with initial dry sand beach widths of 110 feet, and an upland total on average of 200 feet divided into undeveloped upland on average about 90 feet, and developed upland about 110 feet. The typical shore profile used to represent this reach is shown in Figure 11.

For the Marina reach, we assumed the erosion rate was about -4.5 feet per year, with initial dry sand beach widths of 127 feet, and an upland total on average of 275 feet divided into undeveloped upland on average about 75 feet, and developed upland about 200 feet. The typical shore profile used to represent this reach is shown in Figure 12.

The beach profiles shown in Figures 10 – 12 are cross-sections of the shore, and are considered representative of each reach. These beach profiles are based on field data collected over the last several decades under the direction of Dr. Ed Thornton.

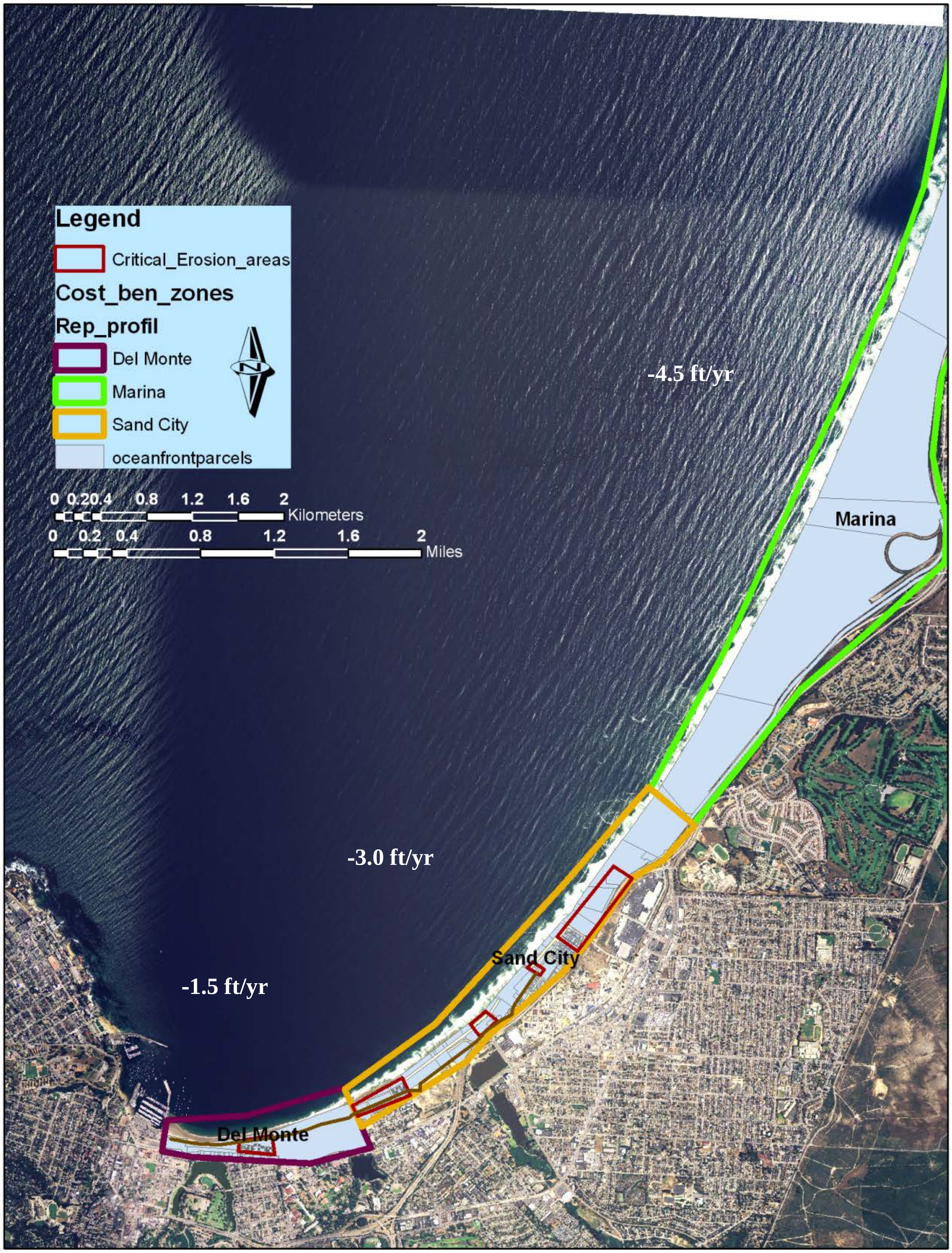

Figure 9 Cost Benefit Reaches of Analysis

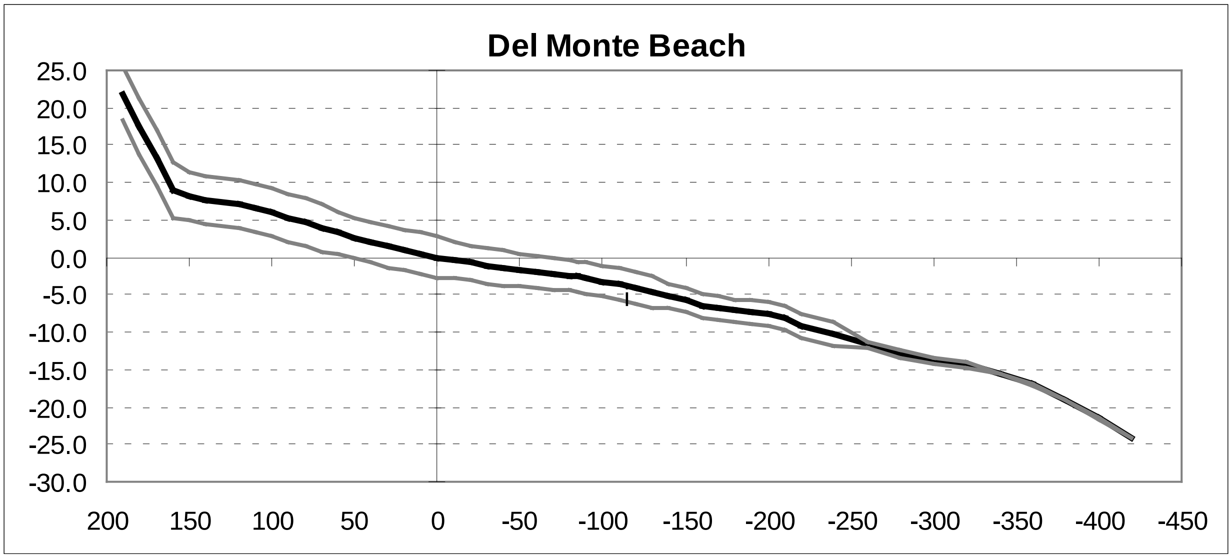

Figure 10 **Del Monte Beach historic beach profile envelope (source Ed Thornton, unpublished data)**

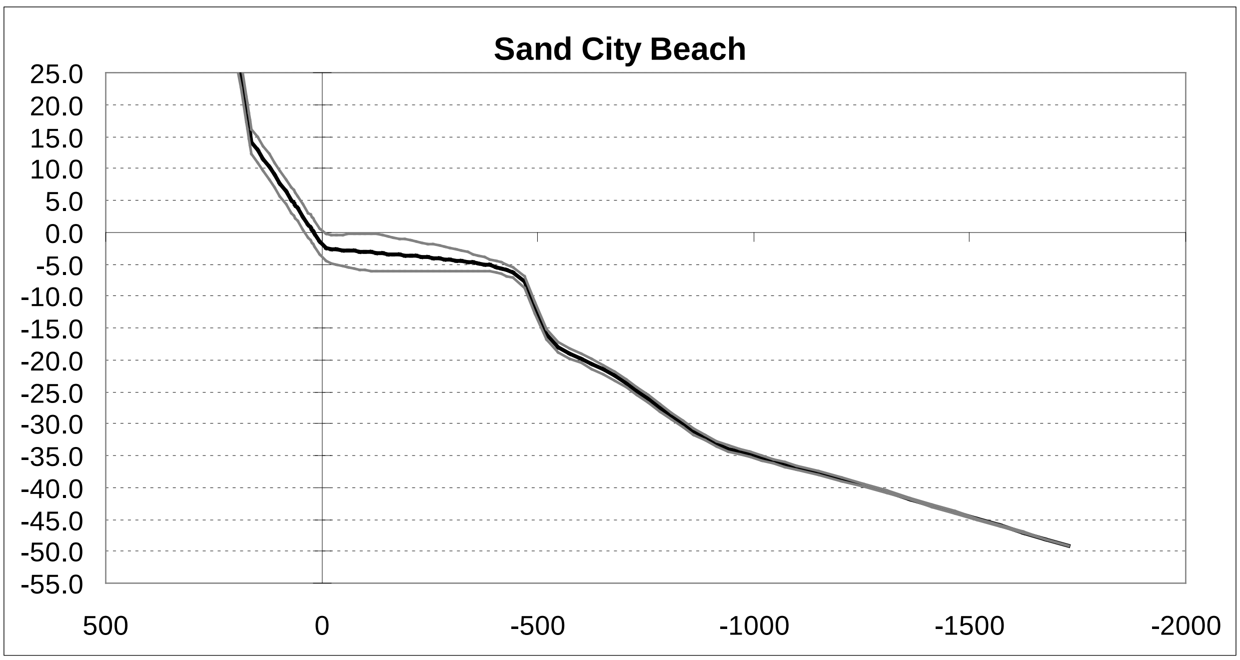

Figure 11 **Sand City historic beach profile envelope (source Ed Thornton, unpublished data)**

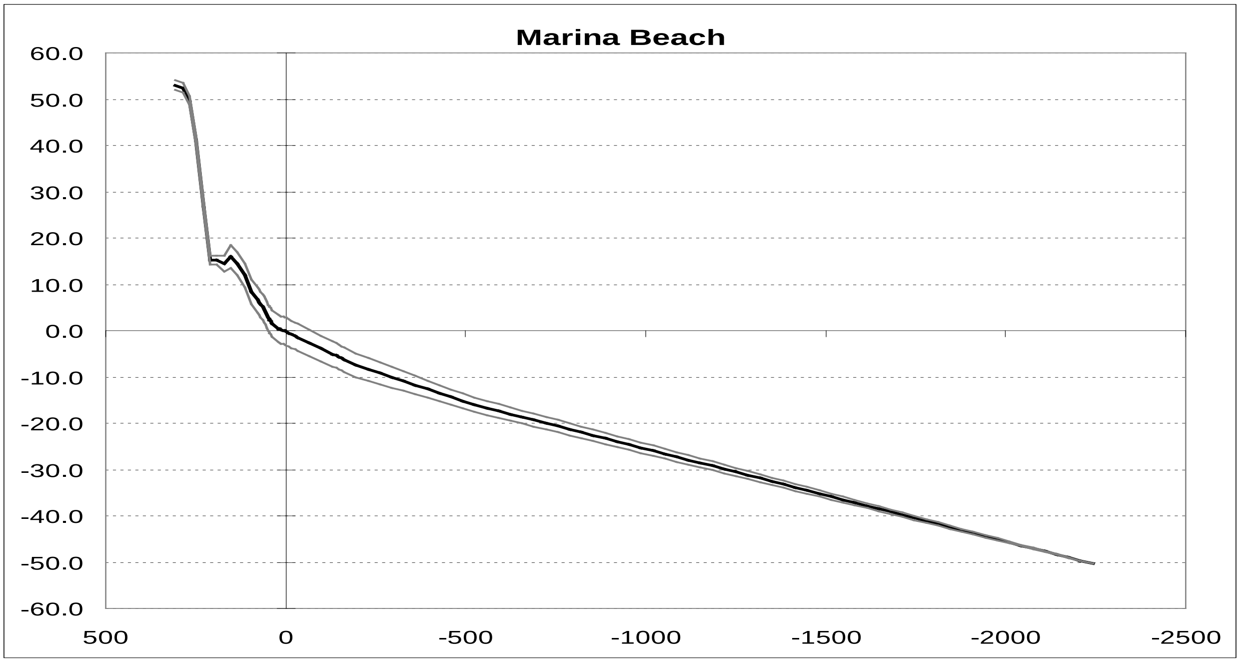

Figure 12 Marina historic beach profile envelope (source Ed Thornton, unpublished data)

3.8 SANDY SHORE ECOSYSTEM SERVICES

Ecosystem services are the benefits to humankind that arise from an intact and healthily functioning ecosystem. Obvious examples of various ecosystem services include production of oxygen, food production, water purification, protection from storms, or nutrient recycling. Unfortunately, it is difficult to put a “price tag” on these services and there is limited information about these benefits for sandy beaches or how to properly measure them. However due to the clear importance of the benefits that a healthy beach system can provide, it makes no sense to completely ignore ecosystem benefits in the assessment, as is often the case. In this cost/benefit analysis we attempt to incorporate an initial assessment of the ecological values of the sandy shores in SMB. This section discusses ecological function of sandy shores, focused on beaches. Section 3.9, The Economic Value of Beaches and the Coastal Zone, addresses the economic valuation of the ecosystem services.

For simplicity, we have focused primarily on beaches and dunes as the proxy for sandy shore ecological function. This is a significant simplification that is likely to lead to under-estimation of services, under-representation of impacts, and hence adds method uncertainty and bias to the analysis. However, this analysis is relatively less biased than prior analyses, and is a first step toward multi-objective shore management. A more complete description of the shore ecology of southern Monterey Bay is provided in the Coastal Regional Sediment Management Plan (PWA et al., 2008), including subtidal and terrestrial habitats.

Sandy beach and dune ecosystems exist at the narrow dynamic boundary of land and sea. Composed of unconsolidated sand from watersheds and coastal bluffs that is constantly shaped by wind, waves and tides, they are strongly influenced by marine and terrestrial processes. Although often under-appreciated, the irreplaceable biodiversity, and unique ecological functions and resources supported by sandy beach ecosystems are important to consider in coastal management along with their high socio-economic values (Brown & McLachlan 2002, Schlacher et al. 2007). Intrinsic ecological values and functions of beach and dune ecosystems in SMB include: unique vegetation, rich invertebrate communities that are prey for shorebirds, fish and marine mammals, absorption of wave energy, the filtration of large volumes of seawater, nutrient recycling, and critical habitat (nesting and foraging) for declining and endangered wildlife, such as shorebirds and pinnipeds, and for a variety of threatened dune plants (McLachlan & Brown 2006, PWA 2008).

The structure and function of open coast beach ecosystems appear to be closely linked to press and pulse (trend and storm event) environmental drivers and human activities operating on a range of spatial scales (McLachlan & Brown, 2006, Defeo et al., 2009). Along with environmental drivers associated with climate change, evolution in beach and strand geomorphology, sediment dynamics, coastal and watershed perturbations, recreational activity, beach grooming, beach scraping, armoring, nourishment and beach front development have all been shown to affect these coastal ecosystems, the wildlife that depends on them, and the ecosystem function and services they provide.

The ecology of beaches of southern Monterey Bay has been addressed in prior reports such as project-level environmental impact reports. However, beach ecology in this region is not well studied and very little direct information is presently available for use in analysis and consideration of ecological responses to the alternatives presented in this report. Although there is some information on the distribution of limited features of a few threatened species, such as the locations of nests of western snowy plovers, the knowledge sufficient to evaluate impacts of different alternatives is lacking for almost all other groups and taxa, including a number of threatened species of plants and animals. For example, there have been no comprehensive surveys of beach and dune invertebrate communities in southern Monterey Bay. A general overview of California beach ecosystems is presented to provide some context for discussion.

Beach ecosystems provide habitat and resources for a diversity of species, ranging from invertebrates to birds, fish and marine mammals. Interstitial organisms (bacteria, protozoan and meiofauna) inhabit the spaces between sand grains. Larger intertidal invertebrates burrow actively in the sand and include representatives of many phyla, but are usually dominated by crustaceans, molluscs and polychaete worms. These taxa include suspension- and deposit feeders, detritivores, scavengers, and predators which can reach high abundance and biomass, particularly on many intermediate beach types, such as those in southern Monterey Bay. Most beach invertebrate species occur in no other coastal habitats, their unique adaptations for life in these dynamic ecosystems include: high mobility, rapid burrowing ability, rhythmic behaviour, specialized orientation mechanisms and behavioural plasticity (McLachlan & Brown, 2006).

Ecological zonation on exposed sandy beaches is extremely dynamic due to the highly unstable nature of the sandy substrate and the mobility of the intertidal animals and the resources on which these animals depend (McLachlan & Jaramillo, 1995, McLachlan & Brown, 2006). In general, three different intertidal zones inhabited by distinct groups of mobile animals are present on exposed sandy beaches, such as those in SMB (McLachlan & Jaramillo, 1995). These intertidal zones generally correspond to the

- relatively dry sand/substrate of the coastal strand and supralittoral zone at and above the drift line,
- the damp sand of the mid-intertidal and below the water table outcrop, and
- the wet or saturated sand of the lower intertidal and swash zone (Figure 13).

It is important to understand that these zones and the animals associated with them constantly move up and down the shore in response to tides and changing beach conditions. To maintain preferred environmental conditions (e.g. sand moisture, etc.), feeding opportunities and to avoid avian and fish predators and wave impacts, many beach invertebrates of the lower to mid shore migrate in the active swash across most of the intertidal zone with every high and low tide while upper shore invertebrates move over the exposed sand surface to access food resources and follow the high tide driftline up and down the beach. In winter conditions, adequate room to migrate up the shore to avoid storm waves and surges may be a key to the survival of both lower and upper shore invertebrates. Beach erosion and societal responses to erosion that induce changes in the relative proportions and condition of these zones can result in strong ecological responses that propagate up the food web (Dugan & Hubbard, 2006, Dugan et al., 2008).

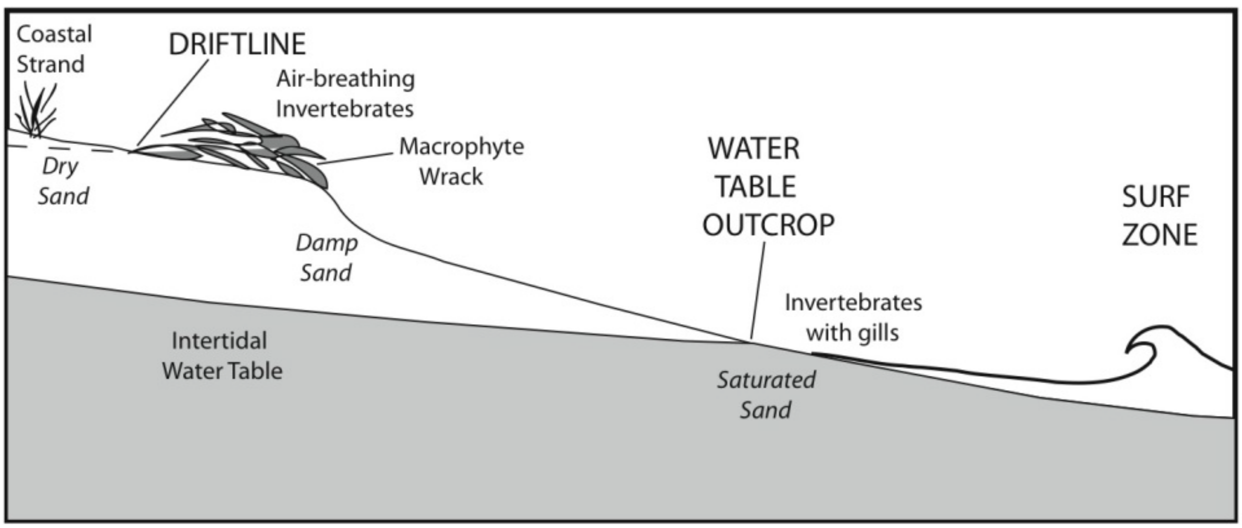

Figure 13 Generalized beach profile illustrating some of the major features of a sandy beach ecosystem

Open coast beaches are characterized by a lack of attached plants and the shifting sands support relatively low *in situ* intertidal primary production. The diverse invertebrates inhabiting California beach ecosystems depend almost entirely upon inputs of organic material from other marine sources, including ocean phytoplankton and macroalgae from coastal reefs (Figure 14). However, intertidal invertebrates can reach very high abundance (>100,000 individuals m^{-1} of shore) and biomass (>1000 g m^{-1} of shore) on California beaches, such as those in SMB. Suspension-feeding invertebrates that inhabit the wet lower zones, including sand crabs, clams, and a variety of smaller crustaceans and worms, depend primarily on phytoplankton delivered by the wave wash or swash. Many of these taxa have planktonic larval stages that enable dispersal among beaches and regions. In contrast, the upper shore invertebrates are significantly associated with drift seaweeds or wrack and avoid direct contact with the sea. These unique animals include talitrid amphipods, oniscoid isopods and a variety of insects, including flightless species.

The majority of these taxa have relatively low dispersal abilities, and all have direct development in the adult habitat with no planktonic lifestages. Thus, populations of these upper shore taxa can be particularly limited by distance from source populations and are quite vulnerable to disturbance, and the loss of or fragmentation of beach ecosystems.

Drift algae and seagrasses that are stranded on beaches as macrophyte wrack represent an important link between reef and kelp forests and beach ecosystems, especially in California where almost 40% of the invertebrate species of a beach can be associated with wrack most of which is accumulated at or above the driftline (Figure 14) (Dugan et al. 2003). The availability of dry sand habitat has been shown to affect the accumulation and retention of macrophyte wrack in beach ecosystems and on armored shores (Dugan & Hubbard, 2006, Dugan et al., 2008, Revell et al., 2011a). Beaches with high wrack input can support dense populations of invertebrate consumers in the upper intertidal zones that in turn attract a high diversity and abundance of wintering and migratory shorebirds (Hubbard & Dugan, 2003).

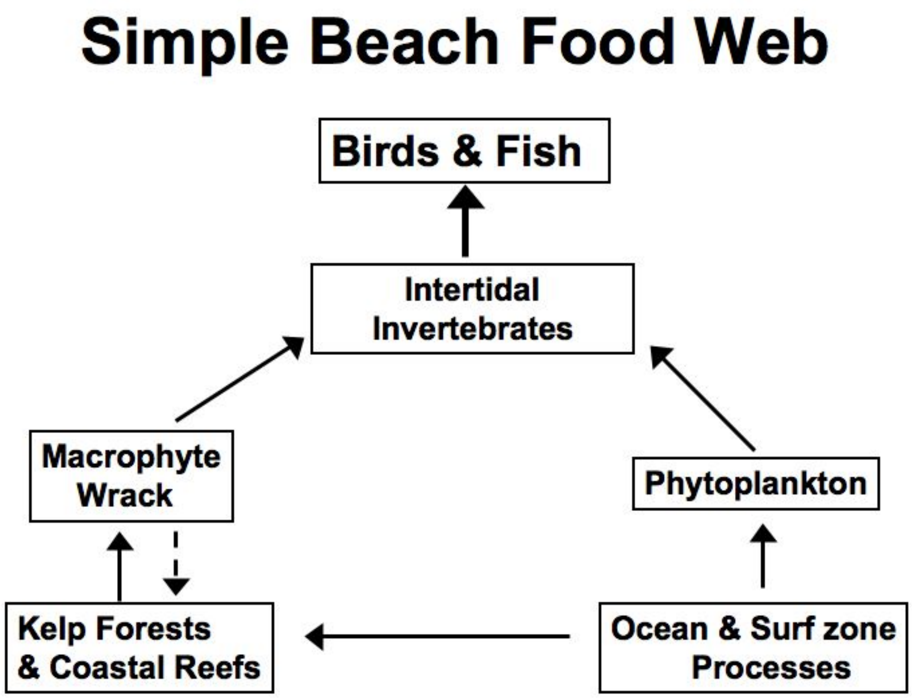

Figure 14 A Simplified Food Web for Southern Monterey Bay Beaches

Upper shore invertebrates are crucial to the important beach ecosystem function of wrack processing and subsequent remineralization (Lastra et al., 2008) providing a nutrient cycling linkage between the nearshore and shore environments (Dugan et al in press). This important ecosystem service is strongly mediated by upper shore invertebrates that can consume large quantities of freshly delivered drift macrophytes, such as kelp. For example, it was estimated that upper beach invertebrate consumers processed >70% of the annual wrack input (>2 tonnes m^{-1} yr^{-1}, primarily kelps) on a South African beach (Griffiths et al., 1983). Dense populations of talitrid amphipods (>90,000 individuals. m^{-1}) were estimated to consume almost 20 kg of freshly stranded *Macrocystis pyrifera* m^{-1} $month^{-1}$ on a southern California beach (Lastra et al., 2008). Recent studies have also found significant relationships between levels of dissolved nitrogen in interstitial and surf zone water with the mass of the standing stock of kelp wrack on beaches. This indicates additional water filtration benefits to water quality as a function of upper shore consumers and beach ecosystems in nearshore nutrient cycling (Dugan et al., in press).

Variation and changes in the availability of wrack have been shown to have strong bottom-up effects on beach ecosystems, altering the abundance and composition of the invertebrate community, and consequently the abundance of prey for higher trophic levels, such as shorebirds and fishes (Dugan et al., 2003). Thus, the wildlife support provided by beach ecosystems can be affected by the availability of macrophyte wrack and associated invertebrate prey. Results of recent research suggest that disturbance to wrack supply or availability to upper shore zones rapidly results in strong negative effects on these wrack-dependent invertebrates (Dugan et al., unpublished). However, results indicate that the ecological recovery of this key component of the beach ecosystem can require many months to years, even when wrack supply is abundant.

SMB beaches provide important resources and food web support for wildlife and fish (Figure 14). Shorebird use of beach ecosystems has been positively correlated with the availability of invertebrate prey, the amount and type of macroalgae wrack, beach slope and beach width (Dugan, 1999; Dugan et al., 2003; Neuman et al., 2008) on California beaches, including shores in the study region. The majority of prey biomass available for birds and fish on beaches in SMB is provided by intertidal invertebrates, such as sand crabs (*Emerita analoga*) whose populations can be strongly affected by beach conditions, as well as alteration of ocean currents delivering planktonic larvae. Another major prey resource on beaches in the study region are the intertidal wrack consumers, such as talitrid amphipods (*Megalorchestia* spp.), oniscoid isopods and insects, which are more available to birds during high wave and tide conditions than the lower intertidal beach animals. These populations are also strongly affected by beach conditions as well by the availability and production of drift macroalgae from kelp forests and reefs.

Shores are vital transitional zones linking terrestrial and marine realms (Polis & Hurd, 1996). Connectivity between beach and dune ecosystems facilitates important reciprocal exchanges of materials including sand, groundwater, nutrients, salt spray, organic matter and biota (McLachlan & Brown, 2006). Waves, tides and longshore currents transport sand, organic matter and plant propagules from the sea to the beach/foredune boundary. Winds transport marine sand from the dry beach into the dunefield, creating and modifying dune structure. Below the primary foredune the deposits of marine macrophyte wrack, driftwood and riverine organic matter delivered by waves can create a foundation for the formation of embryo dunes and hummocks and the subsequent colonization of coastal strand vegetation (Dugan & Hubbard, 2010). In SMB, the results of this active process and exchange between beaches and dunes provide the type of scattered cover, sparse vegetation, and open habitat required for successful nesting and chick-rearing by the western snowy plover. In storm or erosive events, foredunes can contribute sand to the intertidal zone reducing storm effects on biota and grain size (Revell et al., 2011b). A natural dune/beach interface can also enhance survival of beach invertebrates by providing space for temporary landward shifts in distributions to avoid direct storm impacts. At the same time macrophyte wrack, wood and other drift material deposited in the dunes during wave and storm events, provides the structure for subsequent aeolian sand deposition and plant colonization. Mammals, birds and reptiles from the dunes and other terrestrial habitats also access the intertidal beach and strandline for foraging.

Threatened birds, such as the western snowy plover (*Charadrius alexandrinus nivosus*), nest and rear chicks on SMB shores (Lehman, 1994, Page et al., 1995, PWA et al., 2008) making use of the dry sand and coastal strand and dune habitats, zones where geomorphic and ecological impacts of erosion and human interventions and activities can be strongly expressed (Dugan & Hubbard, 2010, Dugan et al., 2008). Seabirds, including gulls, terns, brown pelicans, and cormorants, also regularly roost on beaches, sometimes in large numbers. Fish, such as the California grunion, depend on the vulnerable uppermost intertidal zones of open sandy beaches for spawning, burying their eggs at the driftline for incubation on selected beaches in the SMB region (Thompson, 1918, Martin, 2006). Finally, pinnipeds, including elephant seals, sea lions, fur seals and harbor seals, haul out, pup and raise their young on sandy beaches, again primarily using upper beach zones.

Our understanding of the sensitivity of beach and dune ecosystems to disturbance, including anthropogenic disturbance, greatly lags that of other shore habitats. A prevailing assumption is that beach ecosystems and functions recover rapidly from press or pulse disturbances. That assumption is not supported by recent studies and syntheses of data from California beaches which indicate that recovery times for some intertidal taxa (clams, upper shore invertebrates) may extend over years and even decades (Dugan et al., unpublished, McLachlan et al., 1996). This critical lack of understanding of recovery dynamics and trajectories for beach ecosystems suggests a precautionary approach to addressing beach erosion concerns in SMB is justified and warranted.

3.8.1 Limitations of the Evaluation of Ecosystem Services

Dry beach width vs. ecological value

For shores that experience disturbance, such as grooming, vehicle use, profile contouring, scraping, berm building or nourishment, dry beach width, as defined for these analyses, does not represent a reliable or useful proxy of beach ecosystem condition. Anthropogenic activities such as these create dry sand zones which have relatively little ecological value. For example, groomed beaches often appear to have a wide dry sand zone, however this zone is, in fact, composed of degraded coastal strand and dune habitat, where the native vegetation and topography have been eliminated by the mechanical disturbance and wrack removal associated with grooming. This habitat and biodiversity impact has been documented for groomed beaches in southern California where unvegetated dry sand zones were four times wider, macrophyte wrack cover was >9 times lower, and native plant abundance and richness were 15 and >3 times lower, respectively, compared to ungroomed beaches (Dugan & Hubbard, 2010). The lower ecological value of these wide groomed beaches is also indicated by their reduced species richness, abundance and biomass of wrack-associated invertebrates and lower shorebird diversity and abundance, compared to ungroomed beaches (Dugan et al., 2003). The ecological impacts of nourishment actions, including opportunistic sand placement[9] and other fill activities, are of particular relevance to SMB.

[9] also known Sand Compatibility and Opportunistic Use Program (SCOUP), as defined by the Coastal Sediment Management Workgroup.

While nourishment or fills of beaches can create wider dry sand zones, the ecological value of nourished shores does not scale with dry beach width. This is due largely to the intense disturbance and mortality of intertidal fauna associated with fill activities, including burial and the direct impacts of heavy equipment and sand manipulation (Speybroek et al., 2006). Recovery of ecological value of beaches, including impacted biotic communities and ecosystem functions, following nourishment episodes may be protracted, requiring years, even decades in some case. Ecosystem recovery can be strongly inhibited, if the fill material is too fine, too coarse or poorly sorted compared to native sand (e.g. Peterson et al., 2006).

Affects of Erosion Mitigation Measures on ecosystem function

For the vast majority of the erosion mitigation measures analyzed in this report, there is little to no information on the affects of the measures to ecosystem function. It is likely that ecosystem impacts scale with the size and intensity of the impact. Furthermore, there have been few if any baseline monitoring studies of the sandy beach and dune ecosystem in SMB. While there have been some studies done on Western Snowy plover, this is but one shorebird amongst a rich biodiversity found on these beaches. This is an area recommended for further study.

3.9 THE ECONOMIC VALUE OF BEACHES AND THE COASTAL ZONE

Ecosystem services have value to people, but it is difficult to quantify this value. This section provides an overview of the economic value of beaches including a background on methods economists use to value services, reviews some of the scientific literature, and then discusses relevant case studies in California. The application of this body of knowledge to southern Monterey Bay is then described in Section 3.9 with detailed results and values shown in Section 4..

3.9.1 Types of Economic Values

Beaches and nearby coastal parks and other publicly accessible property provide a variety of services which have economic value ranging from recreational value to providing a buffer against storm damage along the coast to providing various ecological services. Since beaches (below the mean high tide line) in California are public property, there is no market price for this land or for a day at the beach. Thus it is more difficult to estimate the value of beaches to society and economists rely on a variety of techniques to estimate the “non-market value” of beaches. These non-market values fall into a number of quite distinct categories depending upon the type of economic service. Economists have devised an overall framework to group these services, which is illustrated in Figure 15 below. Total economic value is first divided into use value and non-use value and then subdivided further as illustrated in the figure. Although in theory non-use values are important, in practice they are extremely difficult to measure and are largely theoretical constructs for now.

Total economic value				
Use value		Non-use value (Passive use value)		
Direct	*Indirect*	*Option*	*Quasi-option*	*Existence*

Figure 15 Total Economic Value of a Natural Resource

On the other hand a great deal of attention has been paid to estimating the use value of natural resources. As the name implies, direct use value measures services that flow directly from the resource, for example timber from a forest, or bird watching at a wetland. Indirect use values are more difficult to define and measure, but generally involve ecological services, discussed below. In practice, the distinction between direct and indirect use values is sometimes arbitrary. Figure 16 below indicates how one would divide the services of a wetland into direct and indirect use value.

For beaches, by far the most important direct use value is recreation, though other direct use values may also exist (e.g., sand mining). Although estimating the value for non-market activities such as beach recreation presents challenges, there are a number of standard techniques that can be applied and there is now at least general agreement among economists within a reasonable range what the appropriate value is for a day at the beach. Measuring the economic value of beach recreation is more challenging than measuring the value of market goods that are bought and sold. The economic value of a market good is the sum of what individuals are willing to pay for it in the marketplace. Economists consider beach recreation a consumer good. However, the State of California provides beaches for free (though some beaches charge a small fee for parking). Consequently, there are no explicit prices that can be used to compute the value individuals receive from visiting a beach or the total economic benefit (consumer surplus) that accrues to all visitors to that beach.

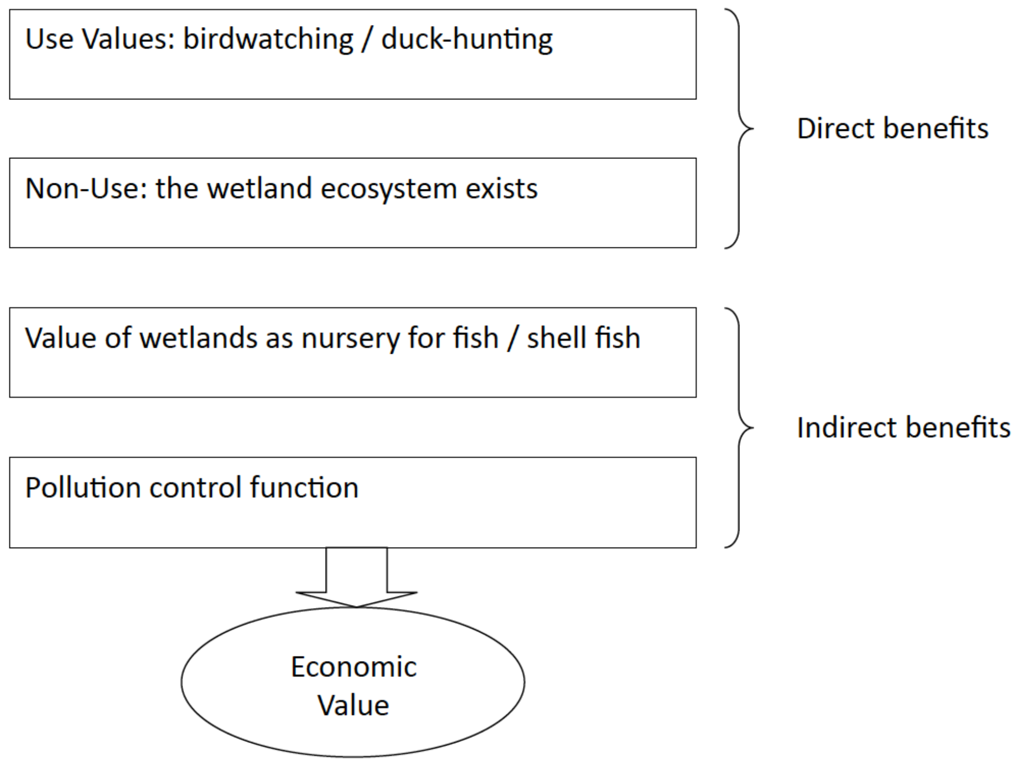

Figure 16 An Illustration of Direct and Indirect Benefits for Wetlands

3.9.2 Techniques for Valuing the Economics of Beaches

However, economists have developed several techniques for estimating the economic value of a day at the beach. The two most common techniques involve either stated preferences, where people are asked how much they are willing to pay (e.g., to go to a specific beach for the day) and revealed preferences, where economists analyze people's actual behavior to estimate their willingness to pay. Contingent valuation (CV) is the general methodology for stated preferences. The chief criticism of CV is that people may not state what their actual preferences are or may misunderstand the question. Designing a sophisticated CV study is also expensive.

Revealed preference models vary in sophistication. The simplest models use travel cost (time and expense) to estimate consumer's willingness to pay (WTP). For example King (King, 2001a, King, 2001b) finds that a day at the beach at Carpinteria and San Clemente is worth between $30 and $45 a day. One downside of the travel cost method is that it is hard to adequately account for substitution—if San Clemente beach were to close (e.g. due to an oil spill) many people would simply go to a different beach. Random Utility Models (RUMs) are a more sophisticated version of travel cost models that look at trips to multiple beaches and account for these substitution effects. Not surprisingly, estimates of WTP from RUMs tend to be lower than simple travel cost methods since most beaches in California have reasonably close substitutes. One serious weakness of RUMs is that they only account for individual substitutions (e.g., if I decide to go to Santa Monica rather than Venice Beach). However, should a large beach close, thousands of people will need to make alternative plans and the capacity of nearby beaches to absorb all of the substitution, in particular increased parking and traffic congestion, is questionable. Thus it is possible that welfare estimates made with RUMs are too low.

The most comprehensive examination of the consumers' valuation of beach visitation was the Southern California Beach Valuation study, which used a RUM to examine beach visitation in Orange and Los Angeles Counties. The results of this study are consistent with an earlier valuation made for the American Trader oil spill case and were not inconsistent with the day use valuations employed by the US Army Corps of Engineers. Unfortunately, none of these models takes into account changes in beach width even though it is a key amenity.

More recently, King, Mohn, Pendleton, Vaughn and Zoulas (King et al., 2010) estimate welfare benefits of enhanced beach width in a random utility model based on data from the southern California beach project (Orange and Los Angeles counties). They find significant welfare benefits from enhanced beach width. Further, they find that water users (e.g., swimmers and surfers) as well as people on the pavement also benefit from increased beach width, though after a point the welfare benefits of increased beach width diminishes. In a related paper, Pendleton, King, Mohn, Webster, Vaughn and Adams use the same data set to estimate welfare losses at southern California beaches when beach width decreases due to erosion and storm surges (Pendleton et al., 2010).

A small number of studies also examine the welfare benefits of increased beach width at beaches on the east coast of the US. Huang and Poor (Huang & Poor, 2004) use stated preference methods to examine the value of protecting against beach loss in the states of Maine and New Hampshire. Although they focus on preserving the status quo rather than changing beaches, they find a general dislike by the public for many of the consequences of beach armoring (e.g., building seawalls or sand retention structures such as groins). Landry, Keeler, and Kreisel (Landry, Keeler, & Kreisel, 2003) examine a Georgia island community using a hedonic model to quantify benefits to property owners and stated preference techniques to determine the benefits of beach preservation and enhancement strategies. They find that in general people prefer wider beaches and they don't like armoring strategies.

Parsons, Massey, and Tomasi (Parsons, Massey, and Tomasi, 2000) use revealed preference data to look at beaches in New Jersey and Delaware, using models, which account for familiarity and favorites, and consider three categories of beach width. They find that, in general, people prefer wider beaches, but only up to a point (about 250 feet in width). Whitehead, Dumas, Herstine, et al. (Whitehead, Dumas, Herstine, et al., 2006) use a random effects Poisson model combining revealed preference and stated preference data and find that people prefer increased beach width, although width is only examined using the Stated Preference data.

All of the studies above are site-specific and most of the beaches in the current study were not included in any of the studies cited above. Also, to be consistent one should use a standard model which is reasonably tractable. The standard methodology in economics is to use a benefits transfer (BT) approach which allows one to apply estimates from similar beaches to a different site. In practice BT is much cheaper (e.g., the Southern California beach study cost well over $1 million) than other methods and also has the advantage of consistency.

For BT to work properly, one must create a methodology for assessing the recreational value of a particular beach. Several federal agencies, most notable the USACE, have developed a scale from 1-100 to assess the value of a recreation day with certain amenities assigned a subtotal of the total 100 points (Table 4). This methodology is described in USACE (USACE, 2004).

Table 4 U.S. Army Corps of Engineers Point Values for Beach Recreation

USACE Benefits Transfer Methodology	
Criteria	**Total Possible Points**
Recreation Experience	30
Availability of Opportunity	18
Carrying Capacity	14
Accessibility	18
Environmental	20
Total	**100**

The USACE criteria indicate out how to assign point values to each beach (or other recreation site) depending upon the criteria. One serious limitation of the USACE criteria is that dry sand beach width (generally above the still water level such as Mean High Water, (MHW) is not specifically accounted for, although “carrying capacity” depends in part on beach width. Another problem with the above scheme is that, since it is additive, one can score a zero on a particular criterion and yet still earn a relatively high day use value. For example, if the recreational experience is zero or low, it matters little whether the site is accessible or has an adequate carrying capacity. Another issue with the USACE methodology is that additional recreation points are given if multiple recreational opportunities are available, but, in practice some beaches cater only to one type of recreation (e.g., surfing, bathing) but do so extremely well—e.g., Trestles for surfing or Carpinteria for families—and the USACE methodology may undervalue these types of recreation.

3.9.3 Coastal Sediment Benefits Analysis Tool

The Coastal Sediments Benefits Analysis Tool (CSBAT) was developed by the Coastal Sediment Management Workgroup (CSMW) to facilitate beach nourishment. The tool considers the costs of sand placement along with hazard reduction and recreational benefits. The effects on the environment are not valued but rather treated as “considerations”. CSBAT was applied as part of the CRSMP for southern Monterey Bay (PWA et al., 2008). This CSBAT approach avoids some of these issues associated with the point system by assuming that the value of each amenity is multiplicative - that is, one should rate each amenity on an appropriately defined scale and then multiply each amenity’s point value to derive a final index. The index can then be translated (as the USACE methodology is) to a day use value.
CSBAT uses these criteria to assess the recreational value of beaches for Southern California. The following six criteria were included in the analysis:

1. Weather: Typically California beaches are overcast early in the morning and clear before noon, though some beaches remain overcast for a significant number of days. In assessing the weather, the number of sunny days, average temperature of the air and water, currents, and wind could all be considered. For example, Monterey suffers from a large number of foggy days, windy and cold weather and colder than average water temperature.
2. Water Quality/Surf: Water Quality has become a critical issue for California, leading to temporary or permanent closures of many beaches. This factor will be revised in future studies and model updates since waves and water quality are quite different attributes, as pointed out by some reviewers.
3. Beach Width and Quality: Beach width is an important criterion, particularly in an examination of the use of opportunistic sediment for beach nourishment. While wider is not always better, as a general rule, everything else equal, people prefer wider beaches. Most beaches in southern California have good sand quality (and little cobble except near shore), so sand quality is not an important issue for this study.
4. Overcrowding: Previous surveys of beach goers generally indicate that overcrowded beaches are considered less desirable (King 2001). Crowding can be measured in a number of ways. Typically, it is measured by the amount of sand available per person, though crowding can also occur in the water, in parking lots, snack bars, etc.
5. Beach Facilities and Services: In addition to criteria 1 to 4 above, beach goers generally prefer restrooms, trashcans, and lifeguards. Most (but not all) also prefer some food facilities and other shops.
6. Availability of Substitutes: If similar beaches are available within a short distance, a beach is less valuable – in particular it may not make sense to nourish a beach if another similar beach is available nearby. However in making an assessment of substitutes one must keep in mind the differing preferences of beach users, e.g., some prefer a City beach with an urban ambiance while other prefer a more "natural" beach. One other critical issue often overlooked in studies of California beaches is congestion and availability of parking. In particular, Los Angeles, San Diego and Orange County have plenty of beaches with similar amenities, but virtually all of these beaches are crowded on summer weekends and parking is often unavailable after noon. For the beaches in this Monterey study, parking is considerably less of an issue, but future model expansion into other geographic areas will analyze parking in more detail.

The functional form used in the CSBAT analysis is a Cobb-Douglas utility function, which is standard in economics. The equation is of the general form:

$$\text{Value of a Beach Day} = M^* \; A^{a} * A_2^{b} * A_3^{c} * A_4^{d} * A_5^{e} * A_6^{f} \qquad \text{(A.4)}$$

where: M is the maximum value for a beach day

$A_1 \ldots A_n$ represent each beach amenity (rated on a scale of 0 to 1)
a…f are the weighting of each amenity value
$a + b + c + d + e + f = 1$.

The CSBAT model has been calibrated with data from existing studies. The Cobb-Douglas function exhibits diminishing marginal utility with respect to dry sand beach width (e.g., adding 50 ft of sand to a narrow beach has a larger welfare benefit, other things being equal, than adding 50 ft to a wider beach) which is consistent with all empirical studies and anecdotal evidence. In addition, the CSBAT model employed here caps beach width benefits at 300 ft, which is consistent with a number of studies indicating that beaches can, in fact, be too wide. However, wider beaches also lower congestion and the benefit of less crowding at wider beaches is taken into account in the model.

The key issue in calibrating the CSBAT model is how beach width increases (or decreases) visitors' willingness to pay. In particular, King finds that doubling the beach width of a typical (somewhat eroded) beach in Southern California increases the value of a beach day by 15-20% (King, 2001a; King, 2001b). The maximum value for a beach day is $14, which is consistent with Chapman and Hanneman's (Chapman & Hanneman, 2001) estimate for the value of a day at Huntington Beach as well as the US Army Corps of Engineers (USACE, 2004) benefit transfer protocol.

3.9.4 Application of the CSBAT Model to the Study Area

We conducted several site visits to the area, interviewed lifeguards, representatives from Surfrider Foundation, and other people with expertise on coastal recreation. From these site visits and interviews we drew a number of conclusions:

1. Although the weather in the area is cooler and has far fewer sunny days than many southern California beaches, nevertheless these beaches are quite popular on warm sunny days and traditional beach activities constitute a significant part of the overall recreational benefits.
2. Walking, hiking, and bird watching are significant activities along the entire study area and the beaches and nearby coastal area provide these activities year round.
3. Surfing is a significant activity at a number of spots in the area, in particular at areas in Sand City, Reservation Road, and Moss Landing. Increasing use of Fort Ord Dunes State Park has occurred as California State Parks has opened the area for visitors.
4. As with most beaches and parks, recreational activity tends to cluster around certain access areas, generally near entrances and parking facilities. The densest recreational activity is at the southern end, at Del Monte Beach. Other significant clusters center around the Best Western hotel and the Sanctuary resort (both of which have a public lifeguard at peak times and ample public parking).
5. Official attendance estimates are only available for certain spots (mostly State Parks). However our site visits and interviews with lifeguards indicate that the official estimates are almost certainly too high. King found that attendance estimates at smaller beaches are often overstated. For example, the CRSMP for southern Monterey Bay reported that Monterey State Beach had an average visitation of 644,677 per year (King, 2001c). To be conservative, we used an estimate of 300,000 per year for each reach.

Although the CSBAT model allows one to distinguish between recreation types and seasonality, given the study limitations, we decided to apply one estimate which represents an average of all types of recreation.

In this study area, it is important to note that recreational use of the beaches in the study area can also be compartmentalized based on the changes to varying nearshore widths. For example, the subtidal areas are visited by surfers and kite surfers, while the intertidal zone is used primarily by beach combers and surf fishermen. The dry sand beach which was the focus of this analysis has typical family oriented types of recreation, bird watching and walking. Finally the dunes are used by hikers as well as hang gliders especially along the Reservation Road area. However given the lack of availability of information on the actual numbers and types of uses, we focused primarily on the dry sand beach width use.

In addition, beaches and dunes can provide important services as storm reduction buffers. Wider beaches reduce storm damages to public and private property inland, reducing inland erosion, property damage, and damages to inland habitat such as lagoons and coastal wetlands. These "hazard mitigation" benefits are typically estimated as the cost of damages avoided. These hazard reduction benefits are included in our analysis as described elsewhere.

3.9.5 Economic Impacts of Recreational Use

The economic and tax revenue impacts of beach use and changes in beach width (or elimination of certain beaches) were also estimated for this paper. The analysis used attendance estimates from the CSBAT model and spending estimates from King and Symes (King & Symes, 2004). The key variable here is the percentage of day trip visitors versus out of town visitors (who spend more). For each site we relied either on existing data or interviews with knowledgeable people to estimate the percentage of day trippers vs. overnighters.

In addition, we assumed that spending per visitor did not change as beach width changed—thus all of the economic and tax revenue impacts estimated in this paper are a result of estimated changes in beach attendance. It is also possible that changes in beach width could affect the composition of overnight/day trip visitors, which would also affect spending/tax estimates, but this impact was considered secondary and not estimated. Tax revenue impacts were based on spending estimates combined with data from the *California Statistical Abstract* (2009).

3.9.6 Indirect Uses and Ecological Value of Beaches and the Coastal Zone

Although beaches are best known for their recreational value, it is by no means clear that other non-use and ecological values are less important or less valuable, particularly considering the fact that many beaches in California (especially as one moves north) do not provide the recreational services of a beach like those in the more densely populated southern California. California's beaches provide habitat for a number of threatened species of flora and fauna such as the Least Tern and Western Snowy Plover; beaches also provide spawning opportunities in the intertidal zone for grunion and many other species. Reducing the size of beaches reduces this habitat and potentially reduces biodiversity. Schlacher et al. (Schlacher et al., 2007) find that human activity on beach habitat has already significantly reduced their capacity to provide ecological services. See Section 3.8 Sandy Shore Ecosystem Services.

Unfortunately, much less is known about these benefits or how to properly measure them. However it makes no sense to completely ignore them. One common parameter used in many studies of beaches, wetlands and other natural resources providing ecological and other services is to place a value per hectare or per acre and use the total area of the resource to derive an economic value. This methodology is not without problems, particularly when one is examining a change in the area of the resource, since ecosystem services may exhibit diminishing returns or certain habitats may also exhibit threshold effects where reducing habitat below a certain level leads to species extinction (Brander, Florax and Vermaat, 2006).

Costanza et al. (Costanza et al., 2006) use an analysis of 94 peer-reviewed papers and 6 other studies, Hedonic analysis and spatial modelling to estimate the economic values of seven types of biomes (including beaches) and the cumulative ecosystem services of New Jersey. They estimate that New Jersey's beaches deliver $42,147 per acre per year in economic/ecological services.
The most comprehensive study of wetland valuation to date was conducted by Brander, Florax, and Vermaat (Brander, Florax and Vermaat, 2006) who examined over 200 studies of the economic value of wetlands. These studies include recreational value, water quality improvements, amenity improvements and habitat/biodiversity value.

Brander, Florax and Vermaat find that the average biodiversity value of a wetland per hectare per year is $17,000 (about $6800 per acre) and habitat value is about $2000 per hectare. They also estimate that wetlands provide $4000 per hectare per year in flood relief, a value that is likely low compared to beaches.

For this study, we decided to use a conservative value of $20,000 per acre (less than the value of a New Jersey beach in a National Marine Sanctuary), which represents a midpoint between Costanza's estimate and some other estimates. We applied this estimate to the beach area and to the undeveloped area behind beaches (e.g., the dune areas) which represents part of the ecosystem. We did not apply this estimate to the developed areas even though there is certainly ecological value there as well. Further, we did not evaluate the changes to ecosystem services caused by a number of factors such as: 1) armoring devices which may limit the mobility of fauna in the tidal zone, 2) the impacts of nourishment on ecosystem services, 3) non-linear effects, and disturbance associated with sand placement. Therefore our model assumes that ecosystem services are proportional to dry sand area but the true relationship is likely to be much more complicated. One approach would be to value natural beaches higher than constructed (or nourished) beaches: In this study, a uniform valuation was applied by acre of dry beach.

Given that the valuation of ecological services is in its infancy, extreme caution should be taken when applying these estimates, since the actual value of these ecological services may be significantly higher or lower than the estimate we applied. Indeed, one could argue that given the uncertainty surrounding these estimates that no number should have been applied. However, policy makers are being asked now to make important decisions based on limited data and science and completely ignoring ecological value is likely to have a greater distortionary effect on the decision making process that using a number which lies in the midrange of current estimates. This is an area that would benefit enormously from future research.

3.9.7 Analysis of Property in the Upland Developed Areas

In contrast to the non-market values generated at beaches and in the undeveloped coastal zone, it is possible to use market data to estimate the value of private property (land and structures) in the developed area. Further, although much of the land and structures are owned by government or quasi-government agencies or by non-profit organizations, it is still possible to make meaningful inferences about the market value of this land, since some transactions data do exist.

Upland erosion places both land and infrastructure at risk to economic damages. We evaluated upland losses in the developed areas by using county parcel data used in the assessment of property for tax purposes. For each reach and erosion mitigation measure, and at each of the four outlined planning horizons (see Section 1.1.3), we estimated the value of the parcels that would be lost as well as losses to the structures on the land due to erosion or inundation.

The general approach applied was to import (County) parcel data into ArcGIS® to identify assets at risk to upland erosion given the analysis provided by ESA PWA. A GIS shapefile that spatially delineated all unique parcels in Monterey County was secured from AMBAG. The entire County parcel layer was clipped based on a 300 foot proximity to the shore. We employed spatial analysis techniques to evaluate if expected upland erosion will intersect with a parcel, thereby placing a parcel at risk to damage. The existing toe of the back beach provides a stationary reference for measuring upland erosion damages within GIS. The distance from a parcel's seaward edge to the toe line was tabulated and compared to projected extent of shore erosion.

In order to simplify the analysis, we adopted the following assumptions when translating erosion inputs to parcel damage functions:

- All parcels parallel the shore; and
- All parcels are perfect squares

These assumptions combined with inputs on a parcels distance to the toe of the beach, parcel area, and future upland erosion rates can be used to tabulate the percent of a parcel at risk. Parcel characteristic data is necessary to translate the extent of expected erosion risk to monetary damages for at risk properties. We were able to identify property characteristics for at risk parcels with county assessor records. These records, commonly known as assessor secure rolls, are designed for tax purposes and part of the public record. Unique field codes, known as assessor identification numbers (AINs) allowed us to link at risk parcels identified in GIS with detailed parcel characteristic records provided by the county assessor.

3.9.8 Valuing At Risk Assets

To assess a property's tax burden, California counties record a parcel's land value and improvement value. Land value represents the total appraised value of the land, including any upgrades or improvements. Improvement value represents the total appraised value of structures, including any upgrades or improvements. California's division of assessed value into land and improvements (structures) appears to provide a streamlined method to tabulate upland erosion damages. Yet, this valuation technique has numerous shortcomings that undermine an accurate appraisal of expected upland erosion damages:

1. In California, Proposition 13 results in property being reassessed only when it changes ownership (improvements are also added to the structure value). Future increase to a property's assessed value are capped at two percent, which leads to a discrepancy between assessed value and actual market value since property values in Monterey have risen at a far greater rate than two per cent a year over the past several decades. In effect, Proposition 13 results in assessed property values that may be far below their respective market value, especially for properties which have not changed hands for many years.
2. County assessors appraise structures with depreciation factors. Depreciation accounts for the remaining economic life of a structure as a function age and character.[10] In this report, we value structures using full replacement value—the cost of reconstructing a new but similar structure in the same region.[11]
3. To account for land damages, we attempted to estimate the full market value of the land (which literally falls into the ocean, and cannot be replaced). As a consequence of Proposition 13, the assessed value of properties that have not been sold recently will fail to fully estimate the true market value of land.
4. County assessor recorded land and improvement values are developed for tax purposes. Because institutional properties (e.g., governmental, non-profit) are in many cases exempt from property taxes, county assessors record land value and in some cases improvement value at zero. However this property is clearly valuable.

Over ninety percent of the at-risk parcels are zoned for residential and institutional (governmental) uses. Given limited financial resources and time, attention was focused on re-estimating the land value and structure values for residentially zoned parcels and the land value for undeveloped government properties.

3.9.9 Residential Land and Structures

At -risk residential parcels were spatially clustered, with each cluster containing similar land use designations (e.g., single-family, multi-family), structure types (e.g., single-family dwelling, condo, townhouse) structure size and lot size. To fill existing data gaps, where no data was available for the value of land and structures, we assumed these values were similar (per sq. ft.) to adjacent property/structures

[10] We investigated the possibility of using depreciated replacement value. However, there were significant data gaps for the condition and/or character of buildings (as was the case in this analysis), depreciation value is calculated only as a function of building age. In our case, the resulting estimates vastly underestimate values of older home in average and/or good condition.

[11] For evaluating flood damages, the USACE measures depreciated replacement costs while FEMA generally uses full replacement costs. The primary rationale for FEMA's use of full replacement costs lies in FEMA's commission to allocate the finances required to repair or replace damages assets apart from an asset's existing economic condition. In the event of erosion, land will and structures will literally fall into the ocean, presenting a different paradigm to valuing replacement costs.

To calculate a structure's full replacement value, we applied assessor structure characteristic inputs (e.g., size, type) to mean cost per sq ft replacement values. These values, identified by the National Institute of Building Sciences (NIBS), represent average nationwide costs. The cost of construction (e.g., wages, material, transportation) varies by region. To account for the difference of national construction costs to those in the Monterey region, we secured region-specific building cost indices maintained by Engineering News Report (ENR). We adjusted NIBS values with indices from the San Francisco region and accounted for inflation from the reported 2006 base year to the present (2010). Accounting for both region-specific building costs and inflation, NIBS cost per sq ft factors increased by nearly 30 percent.

Residential land value is affected by location and classification among many other variables. Location-based variables (e.g., urban/rural, parks, roads, air quality) and classification-based variables (e.g., single-family/multi-family, commercial, institutional, mixed use) can be both static and dynamic. Teasing out the relative contribution of these variables respective to a parcel's total land value is difficult, often requiring the use of hedonic modeling efforts that were not feasible for this level of analysis.

Lacking data to make reasonable inferences for estimating residential land we used multiple listing services (MLS) to evaluate recent home sales and pending home sales adjacent to at risk property. Properties at risk were generally clustered allowing us to relate and extrapolate bundled (i.e., land and improvement value).

To estimate the value of the land, we subtract our estimates of structure value from the identified total property value. For parcels where no data were available, we used lot size data in conjunction with estimates from similar property values to produce estimates of land values per sq. ft. factors.

3.9.10 Other Structure and Land Values

Governmental publicly owned parcels at risk from upland erosion are primarily undeveloped. As discussed, tax exemptions result in county assessors recording the land value of these parcels at zero. Yet, from an economic framework, these undeveloped parcels have economic value. To estimate the value of government land in the developed upland area, we evaluated recent land trust transactions along the California coast. The sale price of these transactions ranged from $1 to $20 per sq. ft. These prices, while wide-ranging, are well below market value. In many cases, land trusts transfer their deed of ownership to a public agency for future management and vice versa. To estimate the value of government owned parcels, we assume that these parcels will remain undeveloped and under the county's ownership or be transferred to a local land trust for management. We conservatively estimate the value of these parcels at $2.50 per sq ft. It should be considered a possibility, not withstanding existing land use provisions (e.g., development rights, easements), this undeveloped land could be sold in an open and competitive market. If this were the case, the cost per sq. ft. would greatly exceed our default value.

For all additional parcels at risk, we use recorded assessed values to estimate structure and land loss. Some parcels at risk to erosion support commercial and industrial facilities, agricultural production and recreational hunting. In future analyses, we encourage an evaluation of these damages, focusing on potential economic impact losses for these industries as well as an incorporation of changes to coastal hazards resulting from rising sea levels.

In addition we accounted for two additional infrastructure costs in our analysis. First the Monterey Regional Water Pollution Control Authority (MRWPCA) has several pump stations and a pipeline (the Monterey Interceptor), much of which runs on the beaches in this study. We obtained information on the replacement cost of this infrastructure and its location by reach from the MRWPCA (Appendix 4). The total replacement cost is approximately $130 million. Our analysis assumes that the infrastructure would be removed/replaced if and when the dry sand beach width reaches 65 feet.

Streets and Roads also represent a significant infrastructure cost. We estimated the total area of these streets and roads and assumed they would have to be moved or replaced during the planning horizon when erosion occurs in the developed area. We selected $200 per sq. ft. (could be higher, say up to $500 per sq. ft.) (see Section 3.6) as a cost for movement/replacement/elevation for the purposes of this cost-benefit analysis. We did not estimate the costs of replacing local electric, sewage and water lines (other than MRWPCA) or other municipal infrastructure. Some or all of this cost should be implicitly part of the market price of structure/land lost that we did incorporate into our analysis.

Property Damage Functions

Land and structure values assigned to each at-risk parcel are applied to erosion damage functions to estimate losses to each reach over our future planning horizons (0-5, 5-25, 25-50, and 50-100). We estimated the losses by introducing the following damage functions for all management strategies less setbacks:

- Developed parcels face a complete loss of structure and land value when intersecting an erosion hazard zone.
- Undeveloped parcel damage is a function of the percent of parcel (surface area) within the erosion hazard zone, regardless of parcel size.

In modeling costs following the use of setbacks, we made use of the following assumptions:

- Erosion continues unimpeded until it reaches 20 ft. of a developed parcel.
- When erosion is within 20 ft. of a developed parcel, revetments are constructed.
- Parcels landward of setbacks will not face land or structure damages.
- Incurred damages (costs) reflect the capital construction cost of a revetment, $4,500 per linear ft (see section 3.6 Cost Estimates).
- Revetment construction, other structural measures and beach nourishment were assumed to occur roughly every 25 years, at time frames of 0-5, 26-50 and 51-100. Note that the last action at year 100 was not included (that is, three constructions at 25 year intervals but not a fourth). This favors the structural measures and beach nourishment measures and biases the analysis against the land use management measures.

To estimate final damages, damage functions were linked to parcel characteristic data, re-estimated land and structure values for the aforementioned categories, and inputs on the percent of a parcel within expected erosion zones.

3.9.11 Benefit/Cost Analysis and Baseline

All of the above data were incorporated into a benefit/cost analysis over a 100 year planning horizon. Future benefits and costs were discounted at a rate of 5% per year and all estimates reported are 2010 present values representing the entire 100 year time horizon. All estimates are in real 2010 dollars. The recreational and ecological benefits were estimated and discounted for each year over the 100 year period. The costs of nourishment and armoring devices such as seawalls are estimated and discounted during the year the cost is incurred, following the construction cost estimates (see Sectin 3.6). The replacement cost of the MRWPCA was estimated during the year when the beach width reached 65 ft. (if it ever did). The analysis of land and building losses as well as street/road losses was assigned to the beginning of the planning horizon in which the loss was estimated to occur.

The baseline scenario for the benefit/cost analysis was selected to represent the most likely actions to occur within the existing coastal zone management framework. We have defined the base line conditions as construction of revetment to protect development. While this may not be the outcome that many desire, it is consistent with historic and recent actions and expected trends in the area. Thus if the benefits of one particular policy response (e.g., nourishment) exceed the costs (implying a benefit/cost ratio greater than one) that should be interpreted as meaning that the policy is an improvement upon the status quo (do nothing). If the benefits are lower than the cost (i.e., the B/C ratio is less than one) that implies that the particular policy is worse than the status quo. All of the B/C analysis was done over the entire planning horizon since it would not make sense to examine a policy (e.g., nourishment) on a shorter horizon when the costs/benefits should be amortized over the life of the project (100 years in this case). Looking over a shorter time horizon would effectively throw out part of the analysis and render the results less meaningful.

It is important to note that this benefit – cost analysis attempts to include the value of the natural ecology and other ecosystem services. At present, most shore management decisions consider these parameters in a regulatory context, that is, as qualitative elements to be protected. The regulated restrictions on impacts to the public, including the environment, would still govern over the benefit cost analysis. This is particularly important because, for example, protection of endangered species habitat at a particular location is a legal matter largely unfettered by lost opportunity or other costs.

The benefit – cost analysis is applied to multiple coastal erosion mitigation measures. The benefit-cost results are described in Section 6 for each erosion mitigation measure analyzed.

4. DETAILED EVALUATION

The following section provides an overview of each erosion mitigation measures being assessed in the cost benefit analysis. The erosion mitigation measures are divided into three (3) measures: Land Use Planning Measures, Non Structural Measures, and Structural Measures

In this section, each erosion mitigation measure is defined, analyzed for effectiveness and benefit costs, and discussed using the evaluation criteria described in Section 3.2.

4.1 LAND USE PLANNING

Land Use Planning is an approach to addressing erosion that encompasses a wide range of creative and evolving techniques designed to encourage development and redevelopment landward of coastal hazards. Where coastal development exists on eroding shores, land use planning typically includes some form of managed retreat. It is a way to phase or manage infrastructure relocation as portions of the built environment are affected by the natural process of erosion. This approach is supported by natural resource managers and cited in various policy recommendations, guidance documents and climate change adaptation strategy reports. This study includes five (5) types of managed retreat under a larger, broader definition of a managed retreat approach: Managed Retreat (relocation / removal), Fee Simple Acquisition, Rolling Easements, Conservation Easements, and Transfer of Development Credits.

For example, the California Coastal Commission's (Commission) Regional Cumulative Assessment Project (ReCAP) identifies measures such as conservation easements, Rolling Easements, transfer of development credits, Fee Simple Acquisition, structural adaptation and setbacks based on an economic lifetime of 75 to 100 years as recommendations for improving the management of coastal hazards. The Commission's Beach Erosion and Response guidance document also cites the use of various managed retreat techniques as a way to minimize armoring of the shore, including transfer of development credits, habitat adaptation and setbacks. Pursuant to the Governor's Executive Order requiring state agencies to plan for sea level rise and climate impacts, the California Natural Resources Agency oversaw the development of California's Climate Adaptation Strategy. This report includes discussion of managed retreat techniques such as structural adaptation, setbacks and Rolling Easements. The ReCAP report found that current day coastal policies are resulting in the loss of public shore due to protection of private property.

Levina et al. (Levina et al., 2007) reviews some of the climate impacts and vulnerability driving managed retreat issues affecting the Gulf of Mexico shore. They point out in agreement with Titus (Titus, 1998) that managed retreat is a land use strategy that is operationalized mainly on the local level. The authors suggest a strategy of restricting land use to prevent development. First, the authors suggest using land use planning through setbacks, density restrictions, and rezoning. The authors acknowledge legal feasibility and cost issues including alleged property takings if all economic value of the properties is removed. Next, they discuss purchase of development rights as another expensive alternative, and mention that this option is of limited utility because of the cost. Drawing from Titus (Titus, 1998), a purchase of land area the size of the state of Maryland would be required to preserve coastal lands within the flood plain for the entire US. They further point out that Rolling Easements pose fewer takings problems than setbacks or other more intrusive alternatives.

It is important to note that managed shore retreat and realignment is an integrated land use management strategy for addressing erosion, an otherwise natural process, within the context of the human built environment. It is a new, holistic approach to protecting and/or relocating current development, and ensuring that future development is located away from known and anticipated coastal hazards such as erosion. Erosion and the processes it is influenced by, takes place at a large regional geographic scale. Managed retreat, therefore, adopts this same viewpoint and considers all public and private costs and benefits within to inform decision-making.

The longer-term and wider view perspective of managed retreat stands in stark contrast to traditional erosion mitigation techniques. Historically erosion mitigation occurred at a very small geographic scale, with decisions often times based on protecting a single structure, and with a view only to the short-term impacts.

4.1.1 Managed Retreat (Relocation / Removal)

Description

Managed Retreat is a broad strategy that can encompass the use of all erosion mitigation measures while allowing long term shore recession over time. Often, managed retreat is really "retreat and then manage" over a period of decades until erosion hazards become significant again. This nuance and the negative connotation of the word "retreat" has led some to use the term "Managed Realignment." Herein, the concept of Managed Retreat refers to the gradual removal or relocation of structures away from unstable erosion-prone areas. Managed shore retreat and realignment allows shore migration and mitigate coastal hazards by limiting, altering or removing development in hazardous areas. The CRSMP for Southern Monterey Bay recommends allowing erosion to continue in undeveloped areas, thereby supplying sand to the littoral cell, and limiting erosion in developed areas (PWA et al., 2008).

Managed Retreat is most effective in situations where erosion threats have been anticipated and plans made well in advance of an imminent threat to structures. Figure 17 below is a schematic of managed retreat. The top figure (Current) depicts existing conditions with coastal development within the erosion hazard zone and shore armoring. The shore is narrow with limited ecosystem services. As erosion progresses and sea level rises, the coastal hazards become more severe. Hence, with managed retreat, the development and armoring are removed as soon as practicable, the natural shore geometry is restored and the natural ecology recovers (Post – middle). The next schematic shows different shore conditions as recession continues and the shore responds to storms (Eroded). Over time, the shore recedes but the beach ecosystem services are maintained at the expense of upland areas. Management activities include monitoring, planning for future realignments of development and actions desired over the short term. One perspective is to consider planning and management actions related to a moving framework defined by the shore and coastal hazard zones. Fixed property and infrastructure are affected as the shore management zone moves toward them, requiring advance planning and action to minimize costs and maintain ecosystem services and equitably allocate benefits and costs, including consideration of private property and public infrastructure. Therefore, some short term actions could include beach nourishment, dune planting, public purchase of private property, and other land use erosion mitigation measures. Armoring can also be used but typically only as a temporary measure to allow time to implement the retreat strategy, including planning, funding, design, permitting and legal activities. An example can be found in Pacifica State Beach where a critical sewer and flood management pump facility was not relocated but rather protected with a seawall, with a plan to relocate at the earliest practicable opportunity. Similarly, a private restaurant on piles was left in place with the expectation that it will be relocated landward when coastal hazards exceed the foundation design criteria or if the owner is willing to sell the property to the public.

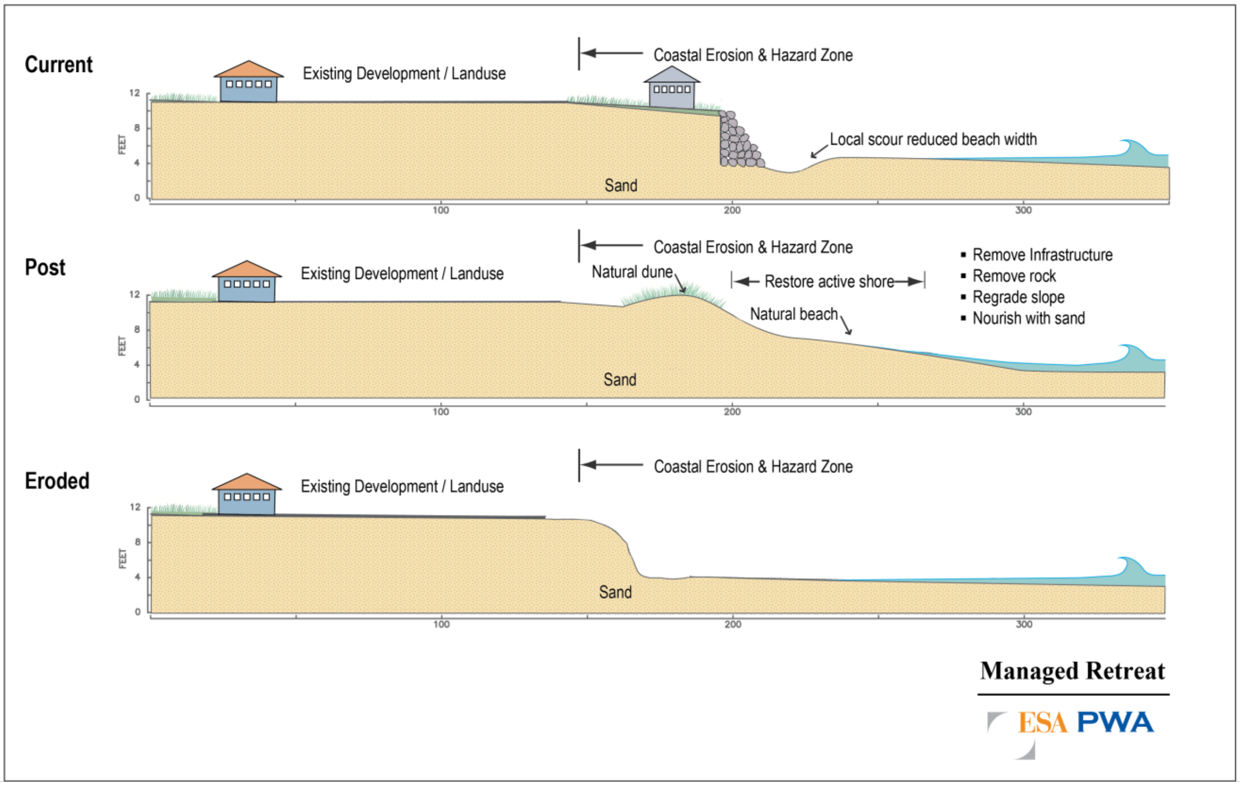

Figure 17 Managed Retreat (Relocation / Removal)

The concept of managed retreat and shoreline realignment often creates confusion because it is both an over-arching long term shoreline management strategy as well as a short term erosion mitigation measure. For example, armoring over the short term combined with purchase of private property by the public would not be included in an erosion mitigation measure but would be allowed in a longer term strategy. Through multiple projects, ESA PWA has applied managed retreat strategies by phasing removal of infrastructure as both funding, political will, and acceptability of risk are identified.

In prior work by the SMBCEW, Managed Retreat and Realignment was treated as an erosion mitigation measure rather than a strategy that could employ multiple measures. The managed retreat and realignment measure described in the following section is consistent with the prior SMBCEW definitions but would more accurately be called abandonment of property, removal of structures and relocation of people and infrastructure functions. Hence, the erosion mitigation measure analyzed in detail is called “Managed Retreat (relocation / removal)”. A summary of evaluation criteria for managed retreat is shown in Table 5.

General Applicability

Managed Retreat (relocation / removal) is generally applicable to all privately or publicly owned development located in coastal erosion hazard zone, which is defined by unstable areas threatened by coastal erosion and flooding over the planning time frame.

Specific Applicability

The strategy of managed retreat and realignment is appropriate for all of southern Monterey Bay (see discussion, above), but the erosion mitigation measure defined by the SMBCEW of Managed Retreat (relocation / removal) is considered most applicable to reaches with limited development in the coastal hazards zone. Therefore this measure is most relevant for application to Subregions 5, 6, 7 and 8 to address critical erosion areas at the Sanctuary Beach Resort and the Marina Coast Water District facilities.

There are few documented examples of the Managed Retreat (relocation / removal) hazard mitigation measure as defined by the SMBCEW. The following examples are more akin to the managed retreat and realignment strategy, as they employed Fee Simple Acquisition of private property and limited redevelopment in the future coastal hazard zone, as well as other erosion mitigation measures.

In the City of Monterey, the Window on the Bay Park is a good example of a managed retreat strategy that was initiated in the 1970s to enhance community identity. This project has the two-fold purpose of providing waterfront and recreational access, and allowing the City to make traffic safety improvements to the central portion of Del Monte Avenue (City of Monterey, 2012). The City of Monterey, with financial support from the Coastal Conservancy and other funders, purchased numerous industrial sites and privately owned parcels along the waterfront and removed the infrastructure while enhancing the recreational and ecological function of the area. The City has been negotiating to obtain the remaining privately owned parcels along this waterfront area (City of Monterey, 2012). This park is an obvious centerpiece for the largely visitor serving community and a reminder of the connection that the city has with Monterey Bay.

A good example of a managed retreat erosion mitigation measure occurred at Stillwell Hall, an officers' club located on the dunes at Ford Ord. As erosion encroached on the property, the Army constructed a revetment to protect the structure. Over time as erosion continued the beach fronting the revetment was lost as a result of passive erosion (Figure 8). When Fort Ord was decommissioned and California State Parks received the property, the structure was demolished and the revetment removed. Within three years, the beach was restored through natural erosion processes (Figure 18).

Figure 18 Stillwell Hall on Fort Ord. Photo on left taken in 2002 shows the building and revetment, and photo on right from 2005 shows the site, with recovered beach, after the removal of building and revetment. Photos from California Coastal Records Project

Table 5 Summary of Evaluation Criteria for Managed Retreat

Evaluation Criteria	
Reduce threat to existing structures	No
Maintain Beach Width	Yes
Environmental Impacts	No Generally reduces impacts by moving development away from sensitive coastal lands
Recreational	Yes
Safety and Public Access	Yes
Aesthetics	Yes
Adaptability to Future Conditions	Highly adaptable
Cumulative Impacts	None. Reduces impacts of development
Certainty of Success	Highly certain

Discussion

Although this may be the most straightforward method for protecting development that is under imminent or long-term threat of being damaged or destroyed, it is often assumed to be technically or financially infeasible. Often there is not sufficient space or land available for the structure to be relocated, and the property owner is often responsible for the full cost of the relocation. Accordingly, this approach has been most typically used for public property and by government agencies such as the California Department of Parks and Recreation in this region.

Potential variations to the measure definition include:

- building relocation incentives
- managed retreat strategy including other measures
- relocation easements
- rebuilding restrictions
- purchase and lease back

Effectiveness – Maintaining beach width vs. protecting upland property
With Managed Retreat (relocation / removal), and the land use planning tools that permit erosion to continue, the dry sand width remains constant as the beach migrates inland, eroding the upland property (Figure 19). The increasing erosion rates are represented as steepening slopes of the upland lines for all three reaches. The triangles in the plot show the point at which upland development is likely impacted on average for each reach. Prior to that point in time, upland erosion is only affecting undeveloped land, after that point in time, the erosion affects development.

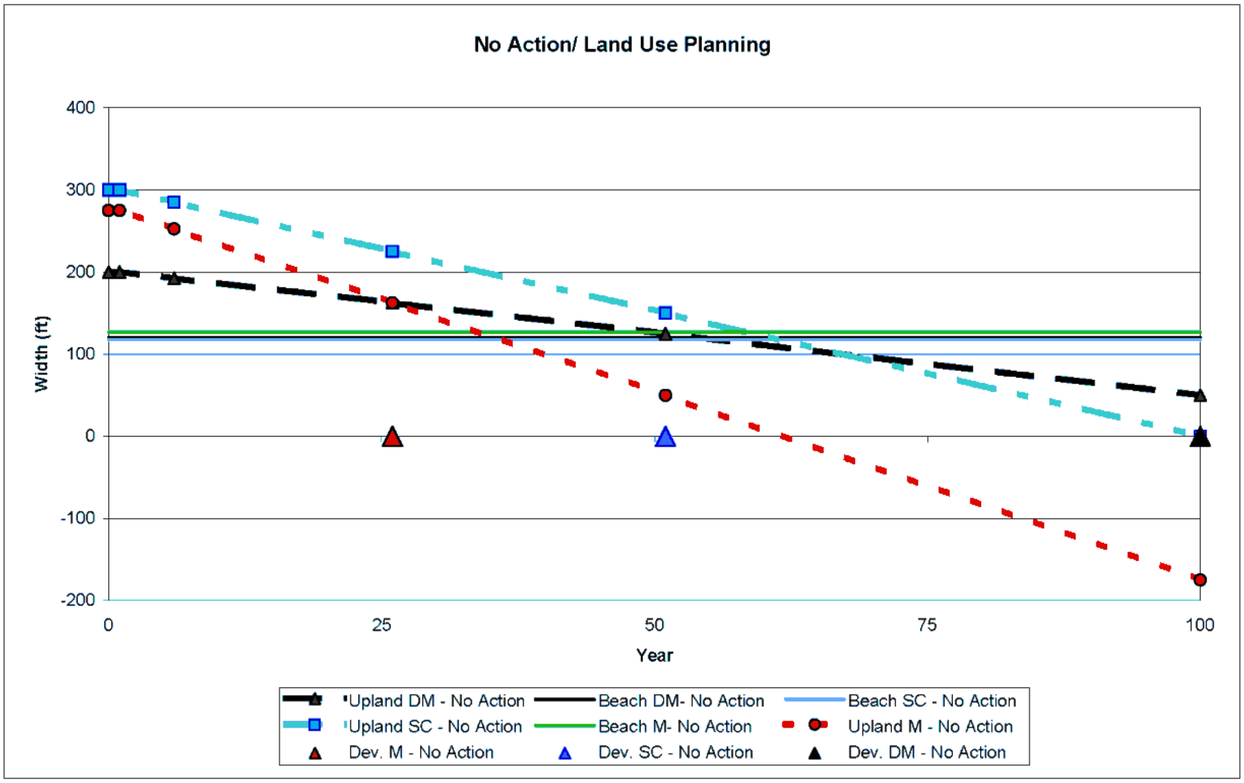

Figure 19 Effectiveness of Land Use Planning Measures at maintaining dry sand beach widths and upland property

Examples of Managed Retreat in California
The Pacifica ***State Beach Improvement Project*** is an example of managed retreat constructed between 2002 and 2004. To address flood threats to homes and businesses, the City removed the most vulnerable structures. In 2002, the City partnered with the Pacifica Land Trust and the California Coastal Conservancy to purchase two homes and their surrounding acreage for $2.2 million. The city plans to relocate the one remaining shore structure—a Taco Bell restaurant—to the other side of Highway 1 as part of a planned retreat strategy being phased in over time. The project is considered a strong success, having weathered seven years of Pacific storms and swells while providing an improved recreational experience for beachgoers. This application of “managed retreat” allowed beach restoration with a relatively small quantity of sand and cobble placement, and flood and erosion control without massive structures. The project was awarded Best Restored Beach 2005 by the American Shore and Beach Preservation Association.

Surfer's Point at the mouth of the Ventura River is another example of a managed retreat project that is currently under construction. Erosion during the 1997-98 El Niño damaged a bike path and threatened a parking lot. In response, through an engaged local surfing stakeholder community, relocation of the parking lot off the upper beach was combined with cobble nourishment and dune creation. This project will result in an additional 250' of natural beach habitat, and enhance resiliency to storms and sea level rise as well as improve recreational and ecological functioning of the beach.

Example of Managed Retreat from the United Kingdom

In the United Kingdom, managed realignment has been pursued as a result of the loss of the natural shore ecosystem following shore armoring to protect development. (Shih & Nicholls, 2007). Historically, sea walls and levees have been built and re-fortified to guard against flood risk. An expenditure of over $6.25 Billion dollars will be required to maintain existing levels of tidal defense standards and account for climate change related to SLR and increasing storm surges. Managed realignment would allow defenses to be moved back and thereby allow space for estuarine habitat. The United Kingdom Department of Environment Food and Rural Affairs (DEFRA) first introduced managed realignment as a system of flood defense in 1993. DEFRA recognized the need to incorporate managed realignment as part of an overarching strategy to protect both property and habitats. Loss of natural shores harms the robustness of coastal defenses because they play an important role in dissipating wave energy. The major obstacle to managed realignment in the UK is the poor integration of national flood and coastal defense policies with local land use planning (Shih & Nicholls, 2007). In some cases managed realignment has been linked to Fee Simple Acquisition, with the government purchasing flood prone land and then leasing the land back to the original owners. As risk increases, or events reduce the utility of the properties, the lease is not renewed, and the government manages the land for natural flood defenses.

Regulatory Viability

Existing regulations would not affect the ability to develop and implement managed retreat projects. However, the potential for court challenges over takings/eminent domain exists, depending upon the specific approach used to implement relocation. See Section 5 for discussion of regulatory risk and takings issues.

Ecological Impacts

Generally, this mitigation measure has little to no impact on the sandy beach ecosystem unless erosion rates are so rapid or extensive that conditions and ecology change. It is possible that inland habitat could be impacted unless it can also spread inland over time. Therefore, Managed Retreat (relocation / removal) can be optimized by considering ecological criteria including habitats inland of the beach such as dunes and lagoons.

Cost and Benefits

The cost of Managed Retreat (relocation / removal) depends on the type and value of existing development and their locations relative to the coastal hazard zone and its rate of inland migration. See Section 3.5.2 for assumptions used in this measure. The overall cost can be the summation of the value of property and development. This cost is compensated by the benefit of ecosystem services. One of the most difficult elements of this measure is uncertainty over who pays and who benefits, and quantification of benefits. Typically, this measure is part of a strategy that includes public cost to rebuild public infrastructure and compensate private property owners for their property net the costs associated with shore armoring.

4.1.2 Transfer of Development Credit (TDC)

Description

Transferable Development Credit (TDC) programs allow the transfer of the development rights from one parcel to another parcel (Figure 20). TDC programs are tools used by land use planners to direct development away from certain sensitive areas (source sites) and into areas that can better accommodate it (receiver sites).

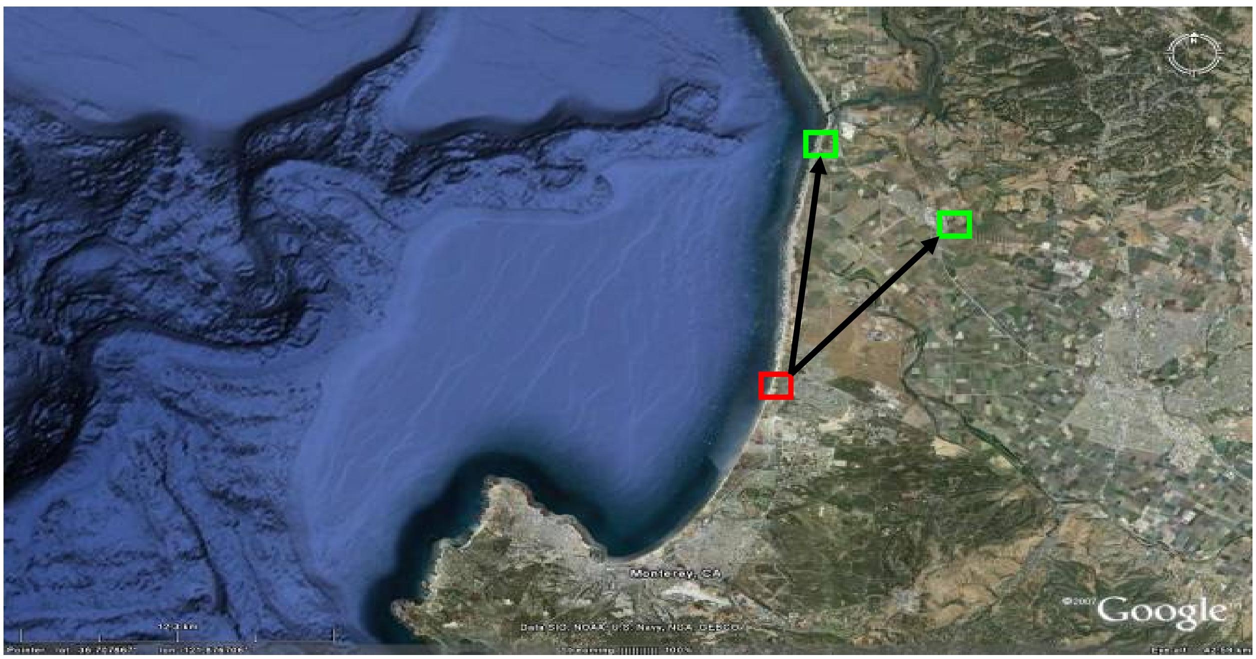

Figure 20 Transfer of Development Credits

General Applicability

TDC, also known as Transferable Development Rights, could be applied where undeveloped sensitive or hazardous parcels exist (to transfer potential development from) and desirable areas to transfer potential development to are available. TDC programs are widespread throughout the country and vary based on local land use planning priorities and needs. While the design specifics are left to the discretion of a local government, in general a TDC program identifies source sites (from which a TDC is taken away) and receiver sites (to which a TDC is added). The owner of a source site can sell a TDC to the owner of a receiver site. The seller typically retains ownership of the “sending” property, but relinquishes the right to develop it, while the buyer is able to intensify development on the receiver site more than would otherwise be permitted under existing zoning. Source or sending sites may be sensitive land areas such as endangered species or wetlands habitat, or areas prone to coastal hazards such as erosion or landslides. Owners of source sites receive monetary compensation from the sale of the TDC and in the form of potentially smaller property taxes, while owners of receiver sites have assurance of future development rights on their site. TDC programs may provide a higher level of certainty over traditional zoning efforts because of the specificity of the amount and location of future development.

Specific Applicability

This management alternative is most relevant for application to Subregion 4 (Table 6).

In the case of Southern Monterey Bay, there are only 3-4 ocean front parcels that are zoned for development. Therefore, this measure would likely require transfer to inland properties rather than a direct exchange of similar property. While transferring development to areas inland of the hazardous areas is attractive, there are several potential complications. For example, transfer from one municipality to another (e.g. Sand City to Seaside) would have a net effect on tax revenues and expenditures for the two municipalities.

Table 6 Summary of Evaluation Criteria for TDC

Evaluation Criteria	
Reduce threat to structures	Yes – relocates future development before it becomes a hazard
Maintain Beach Width	Yes
Environmental Impacts	No
Recreational	Yes – transfer of coastal development allows recreation on the shore where development would have been
Safety and Public Access	Yes – Precludes safety issues associated with development in coastal hazard zone and allows public access
Aesthetics	Yes, Increased due to reduced shore armoring / development.
Adaptability to Future Conditions	Highly adaptable
Cumulative Impacts	Net Positive for coast.
Certainty of Success	Highly Certain

Discussion

Monterey County has implemented one of the most effective TDC programs in the country along the Big Sur Coast. In order to protect the scenic viewsheds along Highway 1, the county set up a program that transfers development from the west (ocean) side of the highway to the east (landward) side. Along the Big Sur Coast, the TDC program was implemented through revisions to the zoning code that established source sites on buildable viewshed lots (on the west/viewshed side of Highway 1) and receiver sites (on the east/non-viewshed side) after a noticed public hearing. Source sites were deemed to have an allocation of two TDCs per site. Receiver sites cannot exceed an overall density of more than one residential unit per net acre, nor increase density more than twice the requirements of the Big Sur Coast Land Use Plan. A TDC is transferred when there is a binding commitment between the buyer and seller in the form of a private contract. A TDC transfer is validated when the receiver site is issued a development permit reflecting the increased development, and the source site has a permanent, irrevocable scenic easement (scenic easement can make exceptions for agricultural or recreational use, but must preclude residential or commercial development). The county also established a revolving fund to purchase and retire TDCs (County of Monterey, 2009).

A local government entity designs and administers the program and must take into consideration how suitable source and receiver sites will be established and regulated, the development of an allocation system, how much market demand exists, if the program is mandatory, and the extent of its role in brokering transactions and validation of transfers. If transactions cross local jurisdictions, agreements for tax revenue sharing and royalties also need to be devised (Kwasniak, 2004).

TDC programs do, however, require extensive planning and sustained implementation and enforcement over the long term. An integral key to success will be the willingness of the local community to participate in such a program, which will undoubtedly be linked to financial incentives made available. Some potential complications can occur if transfers are between jurisdictions, one jurisdiction could lose part of its tax base and also lose part of its developable land inventory. Some consideration of the net benefit to the community (e.g. tax receipts vs. required government services) may be needed. Other considerations could include access to services, water limitations, agricultural conversion and zoning changes.

A good example of a large, multi-jurisdictional TDC program exists in the New Jersey Pinelands National Reserve. This program is administered by the New Jersey Pinelands Commission (Pinelands Commission). Established by the New Jersey legislature, the Pinelands Commission implements the 1979 New Jersey Pinelands Protection Act and the Federal National Parks and Recreation Act of 1978 via the Pinelands Comprehensive Management Plan (CMP). The CMP features a TDC program that spans over a million acres and 56 municipalities in an effort to plan development consistent with protecting its ecological, archaeological, agricultural, historical, recreational and scenic resources. The Pinelands Commission is made up of 15 members, appointed by a combination of the governor, the Pinelands counties and the U.S. Secretary of the Interior, and holds monthly public hearings to discuss specific development projects and regulatory issues. The Pinelands Commission designated specific source and receiver sites and determined that TDCs would vary according to development potential. For example, one TDC per 39 acres for uplands and woodlands; two TDCs per 39 acres if located above a watershed; 0.2 TDCs per 39 acres for wetlands in which development threat was low; two TDCs per 39 acres for wetlands used for commercial harvesting of cranberries and blueberries. One TDC in the receiver site allows the owner to build an additional four residential units beyond the density threshold. The Pinelands Commission created scarcity by making the receiver sites twice as abundant as the total number of TDCs, thus ensuring market demand (Mittra, 1996).

TDC programs have been challenged in court and have withstood legal scrutiny. In *Ojavan Investors, Inc.* v. *California Coastal Commission* litigation against the Coastal Commission was filed questioning its capacity as manager of a TDC program. Landowner Bogart in Malibu's Latigo Canyon sued the Commission in response to a cease and desist order issued by the Commission when it discovered that Bogart had sold 19 lots subject to TDC development restrictions without telling the buyers about the restrictions. The landowner challenged the TDC restrictions on both statutory and constitutional grounds.

Both the trial court and appellate court found in the Commission's favor, and large civil penalties were imposed on Bogart.

There are two ways to run a TDC Program, both of which require fairly extensive planning as well as administrative oversight—each costly functions for local government. First, local government will have to establish parameters for sending and receiving areas. In particular, government will have to decide where denser development would be acceptable (i.e., determine receiving areas), and what types of development would be unacceptable in the conservation, or sending, areas. The government then has to assign credits according to some metric (e.g., conservation criteria, development potential) to each parcel in the sending area. Organizing a TDC system takes skilled land use planners, because the incentives created must be adequate to encourage the sale and purchase of credits in a functional market system. For example, the metric chosen for the credits must reflect some real value of the land so that sellers will sell, and the receiving area must be an attractive place for buyers to increase density. Additionally, a TDC program must operate within an economic and policy framework that manages long-term growth to ensure that the value of credits will be predictable. (For example, if public services/resources aren't sufficient to support density growth in a receiving area, the value of the credits will fall. Sufficiently increasing public services/resources in the sending area could have costs for local government). Setting up the TDC system thus will have upfront costs for local government.

In addition, managing the TDC system will result in recurring administrative costs to local government. Under the first option for managing a TDC system, developers purchase credits through an open market system, but still must present evidence of purchase to the local government and receive approval from government to increase density. Government's facilitation and authentication has continual administrative costs. Under the second TDC option, local government brokers the purchase of credits between parties, or manages a TDC bank. (This is the system developers sometimes prefer.) The second option has even greater administrative costs.

Regulatory Viability
The success of numerous and varied TDC programs across the country is evidence of its regulatory viability.

Ecological Impacts
The beach and dune ecology is maintained. Net ecological impacts vary on a case-by-case basis, however impacts are generally reduced assuming that the receiver site is selected appropriately and the project is implemented within regulatory requirements.

The cost of TDC depends on willing property owners and the net compensation by public entities who may broker a TDC to a lower value receiver site. See Section 3.5.2 for the assumptions used in this measure. There may be costs in terms of reduction of tax revenues and potential development sites.

4.1.3 Conservation Easements

Description

A conservation easement is a legally enforceable agreement attached to the property deed between a landowner and a government agency or a non-profit organization that restricts development "for perpetuity" but allows the landowner to retain ownership of the land (Figure 21).

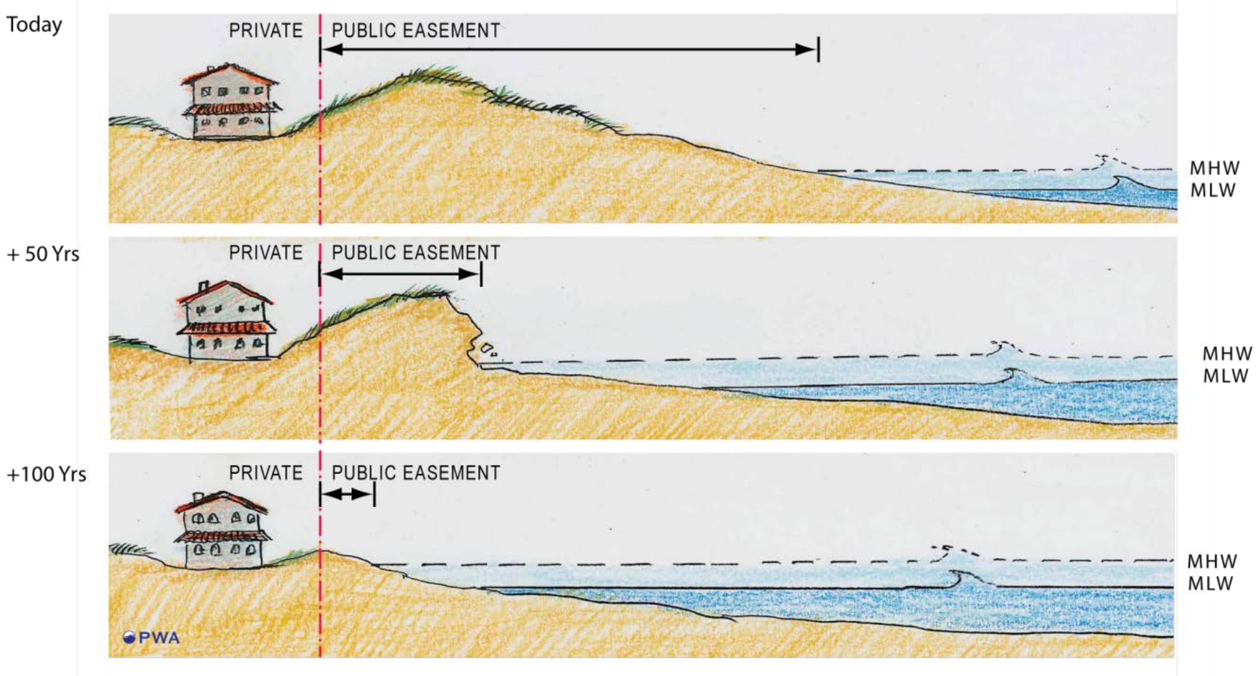

Figure 21 A Conservation Easement

General Applicability

Conservation easements can be applied to any coastal parcel, but typically where a large and or valuable parcel with environmentally sensitive elements exists, and the landowner is willing to enter into the agreement.

A comparison of the relative ecological, agricultural and public recreation benefits of conservation easements versus fee-simple holdings purchased in the San Francisco Bay Area was conducted recently. Researchers found that 190 organizations hold 24% of the land base in some sort of protected status, and that conservation easement holdings comprise a larger area than fee holdings on average. Easements were more often used to protect grasslands, oak woodlands, and agricultural land, while fee-simple properties were more often used for chaparral and scrub, redwoods, and urban areas. While easements help connect existing open space, they are less likely to allow for public recreation. Lastly, the researchers identified the need for centralized spatial analytical tools for assessment of conservation contributions (Rissman, 2008).

Specific Applicability

This management alternative is relevant for application all Subregions to address critical erosion areas located in the back of the beach or in sensitive dune habitats (Table 7).

In Southern Monterey Bay, some specific sites where conservation easements could be applied include: the sand mine site owned by CEMEX, the proposed EcoShore resort, and/or potentially part of the Naval Postgraduate school campus.

Table 7 Summary of Evaluation Criteria for Conservation Easements

Evaluation Criteria	
Reduce threat to structures	Yes. In terms of preventing development in the easement
Maintain Beach Width	Yes
Environmental Impacts	No. Reduces likelihood of environmental impacts
Recreational	Yes. Reduces likelihood of recreational impacts or improves
Safety and Public Access	Yes. Maintains existing levels unless easement includes access clause in which case can improve
Aesthetics	Yes
Adaptability to Future Conditions	Yes. Maintains portions of upland property undeveloped
Cumulative Impacts	None
Certainty of Success	Highly Certain

Discussion

A conservation easement is a strictly voluntary endeavor undertaken by a landowner who either sells or donates the rights to develop that land. While the conservation easement remains the landowner's private property, the development restrictions are permanent because they are attached to the deed and "run with the land". These restrictions continue in perpetuity no matter how many times the property is bought and sold in the future. This development restriction causes the value of the property to fall, however it can result in various tax advantages for the landowner at the federal and state level.

The government agency or non-profit organization to which the conservation easement is donated or sold to becomes the easement holder. Easement holders are responsible for the monitoring costs associated with the compliance and enforcement of its legal terms. Conservation easements are devised on a one-off basis and the specific legal parameters agreed to by both parties may vary considerably. While the general purpose is to preserve private land in an undeveloped state, an easement can also grant public access rights.

Conservation easements are sometimes required by state or local land use planners as a condition of issuing a development permit. This requirement is typically used to mitigate for the impacts of the development.

It is this wide variance in the type of design, enforcement and easement holders that precludes general summaries or trends regarding the efficacy of conservation easements across the country. As there is no national registry or system in place to track the identity of the easement holders, there is very little feedback regarding the impact to ecological and social resources available as a consequence. It is thought that conservation easements became more popular than Fee Simple Acquisitions because of a private property backlash against governmental management (Merenlender, 2004). These concerns are reinforced by another study that concluded major improvements in quality of design, ease of tracking and monitoring, standards for termination and amendment, and other standardized management tools are needed across the board. This study also emphasized the need for local governments to consider the lifetime monitoring costs of an easement as opposed to a Fee Simple Acquisition (Pidot, 2005).

The formulation of conservation easements can be improved by considering long term erosion and the effect of sea level rise. Acquisition could be made more strategically, rather than opportunistically, with an eye towards connectivity, critical habitat and community participation. It is possible to allow for climate change adaptation within conservation easement agreements by drafting flexibility into the design. Including performance standards, best management practices as they evolve over time and termination or modification can be useful (Land Trust Alliance, 2009).

Regulatory Viability

As conservation easements are voluntary by definition, the only regulation needed is enforcement of the legal terms. There would appear to be a wide range of enforcement, which probably results in a wide range of impact effectiveness and overall viability of the easement.

Ecological Impacts

The ecological impact is beneficial by definition.

Cost and Benefits

The cost of conservation easements depends on willingness of seller, costs associated with maintenance and monitoring of easements, as well as the implementing mechanism. See Section 3.5.2 for the assumptions used in this measure.

In general, someone has to file, hold, and enforce a conservation easement on the sending parcel to ensure that future land use planning bodies cannot decide to allow development in the sending area. Either local government or a third party (e.g., an NGO) could hold the easement. Filing/management/enforcement of the easement can have costs.

There may not be a public cost to acquire the easement if the easement is included as a condition to a coastal development permit for some related development activity.

There may be administrative cost to filing, managing the holding of, and enforcing the easement, depending on whether the local government or a third party (e.g., an NGO) holds the easement. Also, there could be lost property tax revenue and altered property values.

Benefit Cost Analysis

Tables 8 through 10 presents the benefit and cost analysis for conservation easements. The baseline scenario includes the use of a revetment and the recreational and ecological benefits represent the differences between the baseline scenario of a revetment. Similarly the cost estimates net out the differences between the costs involved with a measure versus a revetment. A positive cost represents an additional cost over the baseline (revetment). Recreational and habitat values were estimated every year over a 100 year period and discounted at a 5% rate. Similarly the MRWPCA cost represents the present value of replacement of the sewer component in the year in which we estimated failure/replacement/ movement would occur (if applicable), which was when estimated beach width reached 65 feet. The other costs, structural adjustment costs, and private and public property losses, comprise estimates of losses during the planning horizon. The net benefits subtract costs from benefits—a higher value is better. The benefit/cost ratio represents the ratio of net benefits to costs. In some cases the costs or benefits are negative, yielding a negative B/C ratio, which is meaningless and represented as NA (not applicable).

There is limited generalized data on the costs of conservation easements. In actuality, easements vary widely and depend on site characteristics, types of sensitive resources, ease of development and desirability of location. In general, governments and private agencies can purchase conservation easements at substantially below market value. Consequently, for this analysis, we assumed that private land/structures could be purchased at half (50%) the market cost. Since much of the public land has already been purchased at well below market rates, we used these lower purchase prices instead.

Table 8 Present Value of Benefits and Costs for Conservation Easements: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 2,649,094	$ 7,362,147	$ 5,508,566	$ 3,093,987	$ 18,613,794
Total Habitat Value above Baseline	$ 838,842	$ 1,971,606	$ 2,267,272	$ 657,134	$ 5,734,853
Sum Benefits	$ 3,487,936	$ 9,333,753	$ 7,775,838	$ 3,751,121	$ 24,348,648
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	$ 10,277,227	0	$ 10,277,227
Cost of Private Property Compensation	$ 500,000	$ 1,296,000	$ 1,917,500	$ 913,500	$ 4,627,000
Cost of Pubic Property Compensation	$ 30,235	$ 104,492	$ 44,597	$ 32,101	$ 211,425
Construction/Nourishment Cost	$ -	0	$ -	$ -	$ -
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ (42,669,765)	$ 1,400,492	$ (517,756)	$ (3,934,065)	$ (45,721,094)
Net Benefits	**$ 46,157,701**	**$ 7,933,261**	**$ 8,293,594**	**$ 7,685,185**	**$ 70,069,742**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 9 Present Value of Benefits and Costs for Conservation Easements: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,331,640	$ 18,929,245	$ 8,068,351	$ 3,086,197	$ 40,415,432
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 16,933,333	$ 25,930,217	$ 7,750,579	$ 2,829,750	$ 53,443,878
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 6,132,956	$ 16,595,763	$ 9,549,512	$ 3,517,853	$ 35,796,085
Structural Adjustment Costs	0	0	0	$ 23,642,591	$ 23,642,591
MRWPCA	0	$ 25,970,041	0	0	$ 25,970,041
Cost of Private Property Compensation	$ 104,100	$ 372,756	$ 315,847	$ 954,320	$ 1,747,023
Cost of Pubic Property Compensation	$ 93,608	$ 366,571	$ 164,061	$ 93,863	$ 718,103
Construction/Nourishment Cost	$ -	0	$ -	$ -	$ -
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ (179,802,292)	$ 26,709,368	$ (52,674,591)	$ 4,358,833	$ (201,408,682)
Net Benefits	**$ 185,935,249**	**$ (10,113,604)**	**$ 62,224,102**	**$ (840,979)**	**$ 237,204,767**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 10 Present Value of Benefits and Costs for Conservation Easements: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,446,180	$ 19,139,101	$ 8,157,800	$ 3,120,411	$ 40,863,493
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 21,357,208	$ 31,537,626	$ 10,675,252	$ 4,083,353	$ 67,653,439
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 8,581,612	$ 29,511,804	$ 18,833,052	$ 7,203,765	$ 64,130,233
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	$ 2,525,340	0	0	$ 2,525,340
Cost of Private Property Compensation	$ 1,376,487	$ 2,310,244	$ 14,246,730	$ 913,500	$ 18,846,962
Cost of Pubic Property Compensation	$ 1,072,797	$ 3,739,491	$ 1,677,756	$ 32,101	$ 6,522,145
Construction/Nourishment Cost		$ -			$ -
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ (247,750,716)	$ 8,575,075	$ (57,960,268)	$ (27,315,797)	$ (324,451,706)
Net Benefits	**$ 256,332,328**	**$ 20,936,729**	**$ 76,793,320**	**$ 34,519,562**	**$ 388,581,939**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results
The results of the cost benefit analysis shows that Conservation easements have a net positive cost benefit primarily as a result of avoidance of the construction costs associated with the revetments (Tables 8, 9, 10). There are positive net benefits of this measure at each planning horizon except at Sand City in the 6 to 25 year horizon when the MRWPCA costs are triggered. The total benefits over the entire study for the 100 year planning horizon total about ~$695 million with that made up of ~$106 million in recreation and ecosystem benefits.

The main benefits of conservation easements in the tables above are that they do not require building a revetment or other shore protection measure and thus one saves hundreds of millions of dollars. There are unknown costs of monitoring of the easement conditions that are not factored into the cost benefit analysis.

Land use measures entail other costs in the form of private and public property losses as well as the eventual replacement of the coastal sanitary sewer system. Tables 8 – 10 indicate that conservation easements have higher net benefits than the baseline of shore armoring. Note that the net costs are negative in specific time periods (e.g. the 6-25 year period) when the extent of erosion reaches development, triggering a loss of land and infrastructure.

4.1.4 Fee Simple Acquisition

Description
In the context of this study, Fee Simple Acquisition is the purchase of vacant or developed land in order to prevent or remove property from the danger of coastal hazards such as erosion.

As an erosion avoidance measure, this technique would transfer the erosion risks from the current property owner to the group or entity willing to acquire the property. Normally, the Fee Simple Acquisition is done to remove the property from being developed and prevent the construction of buildings or other capital improvements that would eventually be in danger from erosion. Fee simple acquisition is not likely to be effective when the property is in public ownership. However, one hybrid approach could include a fee simple purchase followed by a lease or rent back option until the property becomes inhabitable. This hybrid may enable public investment to recover some of the initial purchase cost.

General Applicability
Fee simple acquisition refers to buying property and can apply to any property that is available for purchase.

Specific Applicability
This management alternative is most relevant for application to Subregions with private property (Subregions 1, 2, 4, 6 and 7) to address critical erosion areas where structures exist or can be developed (Table 11).

Fee simple acquisition was used to purchase property at Window on the Bay (See section 4.1.1 for additional information). The City of Monterey bought the property from private landowners and converted it into a public park. Perhaps the best use of Fee Simple Acquisition would be the outright purchase of the sand mine through Fee Simple Acquisition.

Table 11 Summary of Evaluation Criteria for Fee Simple Acquisition

Evaluation Criteria	
Reduce threat to structures	Yes, if development is not permitted or is removed
Maintain Beach Width	Yes
Environmental Impacts	No.
Recreational	Yes
Safety and Public Access	Yes
Aesthetics	Yes.
Adaptability to Future Conditions	Yes, depends on new owner limiting/not developing
Cumulative Impacts	None
Certainty of Success	Highly Certain

Discussion

Fee simple acquisition is typically the purchase of private property by a local government in an attempt to defray the current or future costs of erosion prevention that is currently or will be borne by the public. This alternative is a local solution to a local erosion risk. Therefore, the various elements of the acquisition plan will vary.

In one case study in South Carolina, it was shown that moving development away from the beachfront is a difficult form of erosion management due to the high cost and the potential for a takings lawsuit. Hawes (Hawes, 1998) states that the federal Constitution might require fee acquisition in case of a takings determination.

In another example, a local governmental agency in the United Kingdom was able to design an acquisition plan that included a partial repayment of some of the costs. DEFRA purchased land that was prone to flooding and leased back the least risky areas to the original owners. Over time, as the risk increased or natural events reduced the usefulness of these properties, fewer leases were renewed. Eventually, there were no private landowners and the DEFRA now manages the land for natural flood defenses.

The City of Pacifica, as part of an overall managed retreat strategy used Fee Simple Acquisition, acquired 2.2 acres of beachfront property at fair market value on Linda Mar Beach in order to remove or relocate structures in danger of erosion. Several homes were demolished, while others are being readied for relocation (Pacifica Land Trust, 2003).

One potential hybrid that could be considered would be Fee Simple Acquisition of the property with a lease or rent back option. This would enable the jurisdiction or public entity to recover some of the purchase cost. An example of such an approach could potentially be the Ocean Harbor House where the City of Monterey already owns several units and rents them under the Section 8 (low income) program. Should the City acquire more properties, this may be a way to enable the most vulnerable properties to be acquired, rented for a period of time, and then abandoned or removed once they become damaged or unusable.

Regulatory Viability

Land purchase is a well-defined practice that is typically viable from a regulatory perspective.

Ecological Impacts

Generally little to no ecological impacts unless development occurs, or human disturbance is increased to the area.

Cost and Benefits

Potentially high based on perception of developed land value, potential loss of tax revenues, transfer of legacy burdens. For this alternative, we assumed that parcels were purchased at Fair Market Value (see section 3.5.2 for the assumptions used in this measure). Conceptually this is likely to require the highest upfront costs although the cost may be less when a parcel is threatened by erosion and the owner is considering constructing shore armor rather than after the property is damaged.

Benefit Cost Analysis

The benefit cost analysis for Fee Simple Acquisition (Tables 12 – 14) yield similar results compared to conservation easements. The only difference is that here we assume that a government or other agency must acquire all the land/property at market value. In practice, though the additional costs are smaller relative to other costs although a local government agency would save money using conservation easements initially, although if including the long term cost of monitoring the easement, the cost/benefit is less certain. Note that the net benefits rise when revetment construction is expected in the baseline, because there is a cost savings (no revetment) for the fee simple purchase measure. However, losses to property occur more continuously as the shore erodes. It should be noted that the cumulative net benefits and the ratio of benefits to costs are always positive. This indicates that purchasing property at fair market value is competitive with shore armoring in terms of benefits and costs if ecosystem services and recreation are included. Of course, most shore armoring projects do not include ecosystem services in their objectives, and the cost benefit is typically limited to the cost of armoring relative to the loss of property.

Table 12 Present Value of Benefits and Costs for Fee Simple Acquisition: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 2,649,094	$ 7,362,147	$ 5,508,566	$ 3,093,987	$ 18,613,794
Total Habitat Value above Baseline	$ 838,842	$ 1,971,606	$ 2,267,272	$ 657,134	$ 5,734,853
Sum Benefits	$ 3,487,936	$ 9,333,753	$ 7,775,838	$ 3,751,121	$ 24,348,648
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	$ 10,277,227	0	$ 10,277,227
Cost of Private Property Compensation	$ 1,000,000	$ 2,592,000	$ 3,835,000	$ 1,827,000	$ 9,254,000
Cost of Pubic Property Compensation	$ 60,470	$ 208,984	$ 89,193	$ 64,203	$ 422,850
Construction/Nourishment Cost	$ -	0	$ -	$ -	$ -
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ (42,139,530)	$ 2,800,984	$ 1,444,340	$ (2,988,463)	$ (40,882,669)
Net Benefits	**$45,627,466**	**$ 6,532,769**	**$ 6,331,498**	**$6,739,584**	**$65,231,317**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 13 Present Value of Benefits and Costs for Fee Simple Acquisition: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,331,640	$ 18,929,245	$ 8,068,351	$ 3,086,197	$ 40,415,432
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 16,933,333	$ 25,930,217	$ 7,750,579	$ 2,829,750	$ 53,443,878
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 6,132,956	$ 16,595,763	$ 9,549,512	$ 3,517,853	$ 35,796,085
Structural Adjustment Costs	$ -	$ -	$ -	$ 23,642,591	$ 23,642,591
MRWPCA	$ -	$ -	$ 25,970,041	$ -	$ 25,970,041
Cost of Private Property Compensation	$ 208,199.48	$ 745,511.77	$ 631,694.56	$ 1,908,640.08	$ 3,494,046
Cost of Pubic Property Compensation	$ 187,216.07	$ 733,141.86	$ 328,122.00	$ 187,725.40	$ 1,436,205
Construction/ Nourishment Cost	$ -	$ -	$ -	$ -	$ -
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ (179,604,584)	$ 1,478,654	$ (26,224,641)	$ 5,407,016	$ (198,943,557)
Net Benefits	**$ 185,737,541**	**$ 15,117,110**	**$ 35,774,153**	**$ (1,889,162)**	**$ 234,739,642**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 14 Present Value of Benefits and Costs for Fee Simple Acquisition: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,446,180	$ 19,139,101	$ 8,157,800	$ 3,120,411	$ 40,863,493
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 21,357,208	$ 31,537,626	$ 10,675,252	$ 4,083,353	$ 67,653,439
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 8,581,612	$ 29,511,804	$ 18,833,052	$ 7,203,765	$ 64,130,233
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	$ 2,525,340	0	0	$ 2,525,340
Cost of Private Property Compensation	$ 2,752,975	$ 4,620,489	$ 28,493,460	$ 1,827,000	$ 37,693,923
Cost of Pubic Property Compensation	$ 2,145,594	$ 7,478,982	$ 3,355,511	$ 64,203	$ 13,044,289
Construction/Nourishment Cost	$ -	$ -	$ -	$ -	$ -
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ (245,301,432)	$ 14,624,811	$ (42,035,782)	$ (26,370,196)	$ (299,082,599)
Net Benefits	**$ 253,883,044**	**$ 14,886,994**	**$ 60,868,834**	**$ 33,573,960**	**$ 363,212,833**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that Fee simple acquisition has a net positive cost benefit primarily as a result of avoidance of the construction costs associated with the revetments(Tables 12, 13, 14). There are positive net benefits of this measure at each planning horizon. The total benefits over the entire study for the 100 year planning horizon total about ~$665 million with that made up of ~$106 million in recreation and ecosystem benefits.

4.1.5 Present Use Tax Incentive

Description

A Present Use Tax Incentive occurs when local government assesses property taxes based on a property's present use, also referred to as its current use, rather than its market value to reward landowners with undeveloped land. The idea is that market value can reflect potential developed values, and taxing at this higher value actually encourages development.

General Applicability

The Present Use Tax Incentive measure is applicable to any parcel with a market value and taxed value in excess of its existing use.

Specific Applicability

This management alternative is most relevant for application to the following Subregions 1, 2, 4, 6, and 7 to address critical erosion areas where structures exist or can be developed (Table 15).

One example in Monterey County is the CEMEX Corporation which owns two parcels 376 and 26 acres (Figure 5). The larger which has the structural improvements is assessed at $15.1 million ($40,000 / acre) while the smaller at $73,222 ($2,800 / acre). Assuming the difference in value per acre is development, raising the value and tax rate on the smaller property would potentially incentivize development while maintaining taxes at the undeveloped rate would be a Present Use Tax Incentive. (Note: These values were obtained from information provided to us that has not been verified: An assessment of property values was not accomplished in this study.)

Table 15 Summary of Evaluation Criteria for Present Use Tax Incentives

Evaluation Criteria	
Reduce threat to structures	No except for lowering expectations of ROI and reducing likelihood of build out on undeveloped parcels
Maintain Beach Width	Yes, unless existing development applies for structural protection
Environmental Impacts	No change from existing land use
Recreational	No change from existing land use
Safety and Public Access	No change from existing land use
Aesthetics	No change from existing land use
Adaptability to Future Conditions	Slightly improves because no increase in development intensity
Cumulative Impacts	None, except reduction in tax revenues
Certainty of Success	Moderately Certain

Discussion

Local governments define the types of property that qualify for a present use tax assessment. This typically includes agricultural and forestlands, wetlands and various types of open space, but will vary based on local regulations. As evidenced across the nation, an increase in population and urban sprawl usually leads to an increase in property taxes as land becomes scarce and its value increases especially along the urban fringe. Families that retain large portions of land over generations often struggle to meet rising property taxes as the value of their land skyrockets. If a landowner qualifies for a present use tax assessment, the tax burden will be reduced and allow the landowner to avoid subdividing and selling off property in order to pay increasing property taxes. The benefit to the public is twofold as open space or sensitive habitats are preserved and an increase in density avoided.

In California, the Williamson Act was passed in 1965 and functions as a Present Use Tax Incentive. This statute taxes agricultural land for it present use and thus discourages agricultural conversion and a change in land use to more intensive development. Qualifying properties must encompass an area of at least 100 acres and be designated as an agricultural preserve. A contract is then drawn up between a local government and a private landowner that restricts the use of their land to agricultural or open space use. Landowners cede some use rights but are taxed at low open-space rates rather than at full market value. In addition to the public benefits cited above, local governments also receive a subsidy from the state (according to formula including quantity and quality of land preserved) that compensates them for revenues lost. The contract is a rolling term ten-year contract with an automatic yearly renewal unless either party files a notice of nonrenewal. Cancellation and exit of the contract before the ten-year minimum has elapsed is possible under limited circumstances, but the landowner will incur a penalty. Currently there are over 16 million acres of open and agricultural spaces currently preserved under the Williamson Act program.

The Mills Act, passed by the California Assembly in 1976, is another statue that functions as a Present Use Tax Incentive. This Act reduces the property tax on historic structures to discourage the destruction of historic buildings and redevelopment of parcels. Qualifying historic property owners are individuals who actively participate in the restoration and maintenance of their property. Qualifying properties are appraised based on income potential rather than full market value. A rolling term ten-year contract is drawn up between a local government and the property owner that stipulates the tax relief allowed in return for the maintenance of historic aspects of their property. Local governments do not receive subsidies from the state to reimburse them for lost revenues.

Regulatory Viability

Requires state law changes, likely inconsistent with Prop 13, but existing precedent with Williamson and Mills Act. Without a specific change to state laws, the regulatory viability of this is not likely to support a present use tax for oceanfront parcels which could reduce their land value and discourage build out.

Ecological Impacts

No adverse effects to the coast ecology are anticipated. By definition, this measure would not be pursued unless the potential for adverse impacts is reduced.

Cost and Benefits

The cost of Present Use Tax Incentives is probably limited to the cost of negotiating the incentive and reduction in tax revenues to local jurisdictions.

4.1.6 Rolling Easements

Description

Rolling Easements are open space or conservation easements that move or ambulate with some identified reference feature (Figure 22). As the coast retreats the easement line migrates along with it, inland on a parcel, then any development is removed and becomes part of that easement. This approach ensures maintenance of beach width and protection of the natural shoreline by requiring humans to yield the right of way to naturally migrating shores. Rolling easements may be implemented by statute or, more typically, by specifying that a conservation easement “roll” or move landward as the shore erodes.

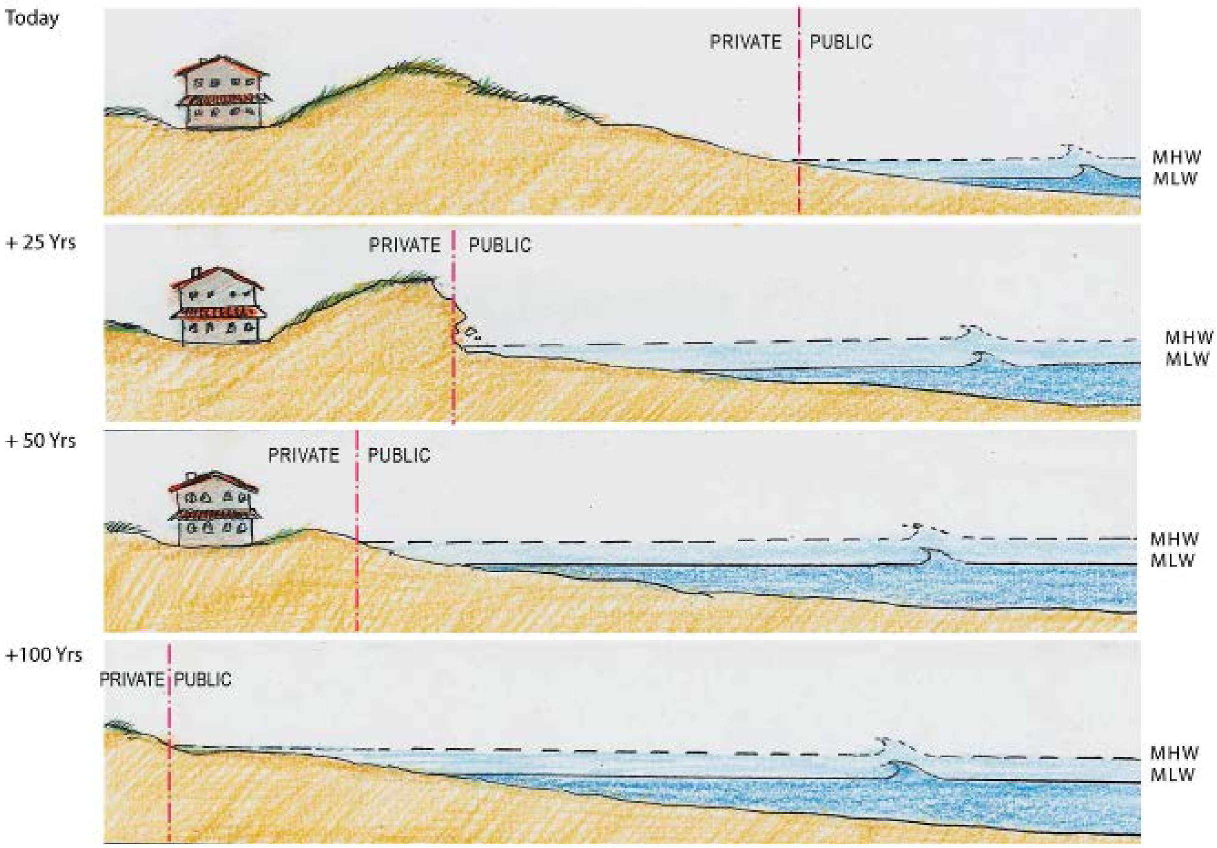

Figure 22 A Rolling Easement that follows an ambulatory shoreline

General Applicability

Rolling Easements are generally applicable to any parcel bounded on one side by a movable natural boundary (Table 16).

Specific Applicability

This management alternative is most relevant for application to Subregions 1, 2, 4, 6, and 7 to address critical erosion areas where structures exist or development can occur (Table 16).

Table 16 Summary of Evaluation Criteria for Rolling Easements

Evaluation Criteria	
Reduce threat to structures	No
Maintain Beach Width	Yes
Environmental Impacts	No
Recreational	Yes
Safety and Public Access	Yes.
Aesthetics	Yes.
Adaptability to Future Conditions	Yes
Cumulative Impacts	None
Certainty of Success	Highly Certain

Discussion
Rolling easements are based on some of the general concepts of common law regarding public and private ownership of land. California considers the mean high tide water line (MHW) a demarcation of the division of public and private land determined by the average of high tides over 18.6 years. This demarcation naturally fluctuates over time, by negligible amounts over the short-term but by large amounts over the long-term. In the long-term, this demarcation will retreat inland and encroach on private property. This landward encroachment of the MHW and the increased vulnerability of some coastal structures to inundation during high tide and/or storm events are often used to justify coastal armoring. Coastal armoring is an attempt to force the MHW to remain in a fixed location.

The practice of armoring the shore to protect private property impacts the public in several ways. First, it essentially permanently demarks the MHW line because coastal armoring remains in a fixed location while the beach erodes around it, causing the public beach area to eventually vanish. The impact of this permanent demarcation is to artificially continue to claim private property rights in an area that would normally become public property under the public trust doctrine. This situation normally results in decreased public access to the shore or total elimination of public access along and to the shore in specific areas. Second, armoring the shore increases the otherwise natural erosion rate to adjacent areas. The impact of this is a further loss of public beaches. Third, coastal armoring alters ecosystem function along the shore and potentially seaward as the coastal armoring affects physical and biological processes in the area of the armored shore.

A different approach to the encroaching MHW would be to implement a rolling easement approach. For example, the most seaward ten-feet of a landowner's property could be designated as a rolling easement, or +10 ft. above MHW. Similar to a conservation easement, this rolling easement could be donated or sold by the property owner to a government agency or non-profit organization, or the landward progression of the MHW over time simply could be recognized by the state as having altered the private/public property boundary along the shore, requiring no payment to the property owner. The landowner continues to own his/her property, but may not install coastal armoring to encumber the delineation of the private/public property line. The explicit or implicit rolling easement remains ten-feet wide at all times by moving landward as the shore (private/public boundary) retreats. This approach prevents the loss of wetlands and other important coastal zone habitats because they are allowed to naturally migrate inland. Rolling easements should discourage reinvestment in structures built on the property that are likely to be encumbered by the advance of the rolling easement as there is an acknowledged impermanence to the parcel's current size and condition. Over time, as the easement encompasses structures on the landowner's property, these structures would be required to be removed at the landowner's expense, as they may not remain within an easement without specific agreement. The rolling easement would lead to the eventual removal of the development in close proximity to the coast within the area covered by that easement. This approach is obviously less expensive for a local government than Fee Simple Acquisition and also allows the landowner to remain on and use the property for some amount of time and remove structures incrementally. Rolling easements that are established and/or recognized explicitly prior to landward construction should encourage the development of structures designed for cost effective incremental removal.

Rolling easements have both costs and benefits. More transaction costs can be anticipated in densely developed coastal areas. Like all easements, Rolling Easements will require some regular inspection and potential enforcement

Titus (1998) posits that Rolling Easements are an efficient means of adapting to rising sea levels because they impose no costs until the MHW moves, they have plenty of time to be incorporated into reasonable investment-backed expectations of property owners, and they may foster consensus on coastal development policies because property owners are compelled to admit the existence of sea level rise before they can argue that they should not be subjected to Rolling Easements.

Local governments can modify their planning policies to discourage the loss of public tidelands. Specifically, they can change their master plans and zoning regulations to explicitly indicate which areas of the coast could be armored and which should remain natural; include sea level rise projections and historical erosion rates into land use decisions regarding subdivisions of coastal property; and begin to plan the types of armoring that will be used in areas designated for protection (Titus 1998).

While California statutory law is silent on the topic of Rolling Easements, the state Coastal Commission has begun to impose a "no future seawall" condition on Coastal Development Permits for ocean front properties. This approach has arisen due to a provision in the state's coastal statute that prohibits new development from requiring armoring when it is approved or in the future. The "no future seawall" conditions serve an important means of notice to property owners and should adjust their investment-backed expectations regarding the development potential of their ocean front properties.

Regulatory Viability

Rolling easements are highly viable in a regulatory context if voluntarily agreed to; viability is uncertain if the government relies on operation of the common law to recognize rolling easement. One of the attractive aspects of Rolling Easements is that they arguably allow states to reclaim title to property without incurring liability for a regulatory taking under *Lucas*. Caldwell & Segall argue that the public trust and other common law principles that underlie Rolling Easements are background principles under *Lucas*, and therefore, Rolling Easements should not pose takings problems (Caldwell & Segall, 2007). Kleinsasser concurs, finding that the public trust doctrine "underlies modern takings analysis." Thus, the public trust doctrine provides a strong basis for states to claim title to newly submerged lands as the mean high tide moves inland. Although not yet challenged in court, requiring a rolling easement as a condition of approval would appear to meet both the nexus and proportionality requirements stipulated by the US Supreme Court and allow California to impose Rolling Easements on a case by case basis (Caldwell & Segall, 2007).

States like California that read the public trust expansively are best positioned to implement Rolling Easements in terms of both the geographic scope of the doctrine and the public rights it protects. Moreover, the California Coastal Act contains an express policy of expanding public access to the beach to the greatest extent feasible. To achieve this goal, the State may require dedication of easements or payment of mitigation fees as a condition of building permits. The ability to require easements gives the State significant powers to expand public beach access as long as the required dedications meet the

Supreme Court's essential nexus test from *Nollan*. It should be noted, however, that the California Coastal Act includes a provision that suggests that coastal property owners have a qualified right to defend existing structures on their properties. California courts have found that this provision does not in fact accord an unqualified statutory right to defend a littoral property that overrides the Coastal Commission's general permitting authority and ability to deny armoring permits. Nonetheless, uncertainty remains over whether the qualified right to armor *existing* structures under the Coastal Act would functionally prevent implementation of a rolling easement program for certain properties. (Peloso and Caldwell, 2010).

Ecological Impacts

Unknown, but likely beneficial to the sandy beach ecosystem with site specific impacts to sensitive dune habitats and species.

Cost and Benefits

Cost of Rolling Easements (Tables 17 – 19) depends on implementing mechanism, purchase price, and when the easement is acquired or imposed. See section 3.5.2 for the assumptions used in this measure. It is likely to reduce tax revenue from waterfront properties if ocean front properties experience devaluation due to easements. However, this approach may result in maintaining stronger property values for non-waterfront properties in the community (Kriesel & Friedman, 2002).

There may not be a "cost" to acquiring the easement if the government prevails against a challenge on a public trust or related common law theory, but such resolution may require litigation, which could involve significant legal costs. Alternatively, the functional rolling easement (in the form of a "no future armoring" policy) is implemented using a condition to a coastal development permit (CDP), and thus is considered "costless."

Ultimately, the rolling easement could result in lost property tax revenue and decreased property values—but this is decades away. Also, one can assume there will be administrative costs associated with enforcing a rolling easement. Many of these were not factored into the analysis.

Table 17 Present Value of Benefits and Costs for Rolling Easements: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 2,649,094	$ 7,362,147	$ 5,508,566	$ 3,093,987	$ 18,613,794
Total Habitat Value above Baseline	$ 838,842	$ 1,971,606	$ 2,267,272	$ 657,134	$ 5,734,853
Sum Benefits	$ 3,487,936	$ 9,333,753	$ 7,775,838	$ 3,751,121	$ 24,348,648
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	$ 10,277,227	0	$ 10,277,227
Cost of Private Property Compensation					
Cost of Pubic Property Compensation					
Construction/Nourishment Cost	$ -	0	$ -	$ -	$ -
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ (43,200,000)	$ -	$ (2,479,853)	$ (4,879,666)	$ (50,559,519)
Net Benefits	**$ 46,687,936**	**$ 9,333,753**	**$ 10,255,691**	**$ 8,630,786**	**$ 74,908,166**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 18 Present Value of Benefits and Costs for Rolling Easements: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,331,640	$ 18,929,245	$ 8,068,351	$ 3,086,197	$ 40,415,432
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 16,933,333	$ 25,930,217	$ 7,750,579	$ 2,829,750	$ 53,443,878
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 6,132,956	$ 16,595,763	$ 9,549,512	$ 3,517,853	$ 35,796,085
Structural Adjustment Costs	$ -	$ -	$ -	$ 23,642,591	$ 23,642,591
MRWPCA	$ -	$ -	$ 25,970,041	$ -	$ 25,970,041
Cost of Private Property Compensation					
Cost of Pubic Property Compensation					
Construction/ Nourishment Cost	$ -	$ -	$ -	$ -	$ -
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ (180,000,000)	$ -	$ (27,184,458)	$ 3,310,650	$ (203,873,808)
Net Benefits	**$ 186,132,956**	**$ 16,595,763**	**$ 36,733,970**	**$ 207,203**	**$ 239,669,893**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 19 Present Value of Benefits and Costs for Rolling Easements: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,446,180	$ 19,139,101	$ 8,157,800	$ 3,120,411	$ 40,863,493
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 21,357,208	$ 31,537,626	$ 10,675,252	$ 4,083,353	$ 67,653,439
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 8,581,612	$ 29,511,804	$ 18,833,052	$ 7,203,765	$ 64,130,233
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	$ 2,525,340	0	0	$ 2,525,340
Cost of Private Property Compensation					
Cost of Pubic Property Compensation					
Construction/Nourishment Cost	$ -	$ -	$ -	$ -	$ -
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ (250,200,000)	$ 2,525,340	$ (73,884,753)	$ (28,261,398)	$ (349,820,812)
Net Benefits	**$ 258,781,612**	**$ 26,986,465**	**$ 92,717,805**	**$ 35,465,163**	**$ 413,951,045**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that Rolling Easements have a net positive cost benefit primarily as a result of avoidance of the construction costs associated with the revetments (Tables 17, 18, 19). There are positive net benefits of this measure at each planning horizon. The total benefits over the entire study for the 100 year planning horizon total about ~$738 million with that made up of ~$106 million in recreation and ecosystem benefits.

4.1.7 Structural Adaptation

Description

Structural Adaptation is the modification of the design, construction and placement of structures sited in or near coastal hazardous areas to improve their durability and/or facilitate their eventual removal (Table 20). This is often done through the elevation of structures or specific site placement. Structural Modification: Reconfiguring development to withstand progressively increasing coastal hazards. Examples are pile foundations that allow wave run-up and erosion to progress without damage to structures, and waterproofing or reinforcing for severe events.

General Applicability

Structural adaptation can be applied to any parcel or infrastructure although the cost and technical feasibility of an effective modification would be required (Table 20).

Specific Applicability

This management alternative is most relevant for application to Subregions 1, 2, 4, 6 and 7 to address critical erosion areas where structures exist or can be developed.

Theoretically, this could be done to elevate development such as the Ocean Harbor House, or Sanctuary Beach resort to reduce the risk to the structures. In fact, prior to the seawall construction, the seaward buildings were underpinned with columns and beams. This could also be applied to the Highway 1 corridor or Del Monte, adapting to higher water levels and erosion by elevating the roadway onto a causeway .

Most applicable to SMB is the elevation of roads on piles to enable erosion and shoreline transgression, particularly along vulnerable stretches of coast such as may be needed along Del Monte or stretches of Highway 1.

Table 20 Summary of Evaluation Criteria for Structural Adaptation

Evaluation Criteria	
Reduce threat to structures	Yes, although not permanently
Maintain Beach Width	Potentially
Economic Costs	Depends on adaptation likely increases costs
Environmental Impacts	Depends on type of adaptation and site characteristics
Recreational	Maintains
Safety and Public Access	Maintains
Aesthetics	Potential impact depends on type of adaptation
Regulatory Viability	Yes, may require revisions to construction or architectural standards
Adaptability to Future Conditions	Yes, potentially limited over long term
Cumulative Impacts	Potential impact to aesthetics
Certainty of Success	Certain

Discussion

Structural adaptation encompasses a wide range of ways to address the impacts of rising sea level and coastal hazards on structures. For existing structures that are or will be subjected to these threats, structural adaptation includes relocation, modification (such as elevating a road or a house). For structures yet to be built, structural adaptation focuses on modification of the traditional design and placement of structures to anticipate future environmental conditions. Examples include building structures on stilts or placing structures further landward than required by regulations.

Communities that participate in the National Flood Insurance Program must adopt and conform to building restrictions based on flood risk. For example, development in the “high velocity” V-zone of wave run-up and wave propagation must be constructed on piles with the lowest structural member above the 100-year flood elevation. Existing properties may be required to upgrade (structural modification) if significant improvements such as house remodel are accomplished.

Another structural adaptation approach could be to build the structure in a modular unit manner or to construct the foundation such that the structure could be readily moved away from hazardous areas.

Regulatory Viability

Structural modification is viable in the regulatory context if implemented through building codes and development standards in much the same way that structures must meet seismic standards.

Ecological Impacts

Little is known about the potential effects of structural adaptation in SMB. Effects would likely be site specific. Generally, the elevation of structures and roadways that would enable habitats to migrate landward would have a less damaging effect on the sandy beach ecosystem and maintain sand supply.

Cost and Benefits

The benefits and costs of structural adaptations have been modeled in a simple way in this analysis. See section 3.5.2 for the assumptions used to analyze this measure. We examined the loss of major roads using the lower end of the cost estimates which ranged from $200 to $500 a square foot. Using air photo analysis, we estimate the approximate square footage of the roads and costs of elevating on piles portions of Del Monte Ave, Highway 1, and some of the frontage roads

4.1.8 Habitat Adaptation

Description

Habitat Adaptation prepares for future shore retreat by designing habitats compatible with anticipated changes to environmental parameters. This provides habitats room to transgress, dunes that rollover, or migrate inland and upslope under a passive approach, or a more active adaptation approach in which habitats or more salt tolerant vegetation (crops) could be planted (Table 21).

General Applicability

Habitat modification is generally applicable to habitats that have continuity with undeveloped adjacent lands.

Specific Applicability

This measure has limited applicability to sand beaches in southern Monterey Bay, except to allow erosion to occur which is addressed in other measures. This management alternative is most relevant for application to Subregions 1, 2 and 3. Agricultural crop adaptation would be most relevant to Subregions 7 and 8.

Table 21 Summary of Evaluation Criteria for Habitat Adaptation

Evaluation Criteria	
Reduce threat to structures	Yes, although not permanently
Maintain Beach Width	Potentially
Economic Costs	Depends on adaptation, likely increases costs, potentially large increase if need to purchase upland adjacent lands
Environmental Impacts	Depends on type of adaptation and site characteristics
Recreational	Maintains
Safety and Public Access	Maintains
Aesthetics	Potential impact depends on type of adaptation
Regulatory Viability	Yes, may require revisions to construction or architectural standards
Adaptability to Future Conditions	Yes, potentially limited over long term
Cumulative Impacts	Potential impact to aesthetics
Certainty of Success	Certain where applicable

Discussion

A passive form of habitat adaptation occurs as wetland or shore habitats transgress or move inland and upward in response to sea level rise, although this is only possible when adjacent upland properties are undeveloped. A more planned strategy is to actively design and plant transitional flora, or flora that can thrive in both the current and future environmental setting. This strategy may include planting this transitional flora over time as needed and can be viewed as an adaptive management technique.

One key element of habitat adaptation is the maintenance of habitat connectivity as an essential part of climate change adaptation, which points to the need for continuous monitoring of conditions for which species are suited to shift with climate change or continuing erosion (Oregon Global Warming Commission, 2008). This connection between beaches and dunes is also crucial during storm events as much of the sandy beach ecosystem seeks refuge during high wave events.

For example, on agricultural lands habitat adaptation efforts may be to switch to more salt tolerant crops as there is a rise in sea level or sea water intrusion.

Wetlands and marsh habitats can be expanded by introducing sand, sediment and/or planting seagrass. EPA gives an overview of climate impacts in coastal areas and reviews adaptations options, including some habitat-related efforts (USEPA, 2009).

Regulatory Viability

Habitat adaptation is generally considered viable within a regulatory context except where impacts to existing valuable habitats might occur, especially with protected species.

Ecological Impacts
By definition, habitat adaptation would only occur if there were an expectation of net ecological benefit. However, the extent of ecological benefit depends on site specifics and scale of habitat alterations and adaptations.

Cost and Benefits
The cost of habitat adaptation was not estimated.

4.1.9 Setbacks for Development

Description
Use of setbacks is a technique, implemented at a local policy level, which requires new development to be located so that it can be safe from erosion and slope failure for some identified time period (Figure 23). Eventually the development can be expected to be at risk from erosion, and there will be the future question about whether the development should be removed or whether it should be protected.

Figure 23 Erosion Hazard Zones similar to those used to delimit development setbacks

General Applicability
Any coastal parcel potentially facing erosion and flood hazards being developed or redeveloped

Specific Applicability
Setback policies differ across the region, with varying methods of calculating the distance. This erosion mitigation measure is the current status quo for coastal management of erosion. Specifics of each setback

is decided by the local jurisdiction and submitted to the California Coastal Commission for approval as part of the LCP process (Table 22).

This management alternative is relevant to all areas with private property, and most relevant for application to the Subregions 1, 2, 3, 4, 6 and 7 to address possible new developments and redevelopments in these Subregions. The actual setbacks adopted in Local Coastal Programs (LCPs) are calculated differently for each of the jurisdictions in the study area and are summarized below.

State Parks in Fort Ord:
State Parks uses a 700-foot setback zone in anticipation of the 100-year erosion line.

Marina:
A setback line is determined at the time of a proposed development by a qualified geologist. It must be great enough to protect the economic life, at least 50 years, of the proposed development and east of the tsunami hazard zone.

Sand City:
A setback line is determined from the most inland extent of wave erosion and is based on at least a 50-year economic life for the project. South of Bay Avenue, in no event shall the setback be less than 200 feet from the mean high water line, as established by the City.

All new development in the coastal zone requires the preparation of geologic and soils reports to address impacts and recommended mitigation, and identify appropriate hazard setbacks or the need for protective structures. Protective structures must not reduce or restrict public access, adversely affect shore processes or increase erosion on adjacent properties (verbatim). An active recreation beach and public amenity zone, defined as between the mean high water line and the building envelope, shall be established.

The repair and expansion of a shore protective structure south of Tioga Avenue may only be permitted to protect Vista del Mar Street. Construction and maintenance of new shore protective devices, between existing ones, north of Tioga Avenue is only permitted where technically feasible based upon a geologic report. Construction of new protective structures on the old landfill site may be allowed if warranted by the geologic report and includes removal of debris.

Seaside:
A setback line for development adjacent to Roberts Lake and Laguna Grande is determined as a minimum of 50 feet from marsh or riparian vegetation (reduced to 20 feet for recreational trails and platforms). The setback line for all development proposed within an area subject to ocean storm waves and tsunamis is determined by the requirement that both the public and structural safety can be assured for a 75-year period without constructing any protective structures. The setback line determination is made by a qualified coastal engineer in a report detailing all of the required information. Public access impacts are mitigated by a requirement that all development proposed within a local coastal plan area must have at least a ten-foot wide lateral access easement as a condition of approval.

Monterey:
The California Coastal Act allows a city to create a local coastal program for specific segments within the city and to submit its proposed land use plan for certification prior to its proposed implementation plan. The City of Monterey currently has four of five land use plans certified by the California Coastal Commission, with the fifth land use plan and all implementation plans pending.

The Skyline land use plan segment was certified in 1992. It requires that new development create a drainage and erosion control plan to minimize runoff, prevent erosion, and avoid sedimentation and pollution downstream. It also requires a scenic setback of a minimum of 100 feet from Highway 68.

The Del Monte Beach land use plan segment was certified in 2003. It requires a site-specific geotechnical study and that new development not require shore protection for the life of the project. A deed restriction to waive all rights to protective devices associated with development on coastal dunes is required.

New development must be set back from the eroding coastal dunes sufficiently to protect it for the 100-year economic life of the project and is not allowed in tsunami run-up or storm wave inundation areas (excepting coastal dependent uses and public access improvements). Existing structures located within these areas may not construct additions or demolitions/rebuilds (excepting new development consistent with takings law and public utilities that cannot be feasible located elsewhere). For proposed development along the bay, the coastal erosion rate and tsunami and storm wave areas are determined by and included in the site-specific geotechnical studies. New development may not increase the erosion rate.

Future sea level rise is required to be included in the siting and design of new shore development and shore protection devices. Specifically, an increase in the historic rate of sea level rise must be reviewed and considered. Development must be setback and elevated to minimize or eliminate, to the maximum extent feasible, hazards associated with the anticipated rise in sea level over the expected 100-year economic life of the structure.

The anticipated landward migration of the sand dunes over the expected 100-year economic life of the structure must also be accounted for in proposed development occurring with the sand dunes. Sand dune migration should include anticipated sea level rise and historic dune erosion rate, among other requirements. Development must be setback from the frontal dunes and elevated to minimize or eliminate, to the maximum extent feasible, hazards from waves and inundation, as well as the anticipated rise in sea level over the expected 100-year economic life of the structure.

Where the construction of protective structures may be allowed, a geotechnical analysis must establish that the protective structure is necessary and that it is the least environmentally damaging feasible alternative. Other alternatives, such as relocating the structure or sand replenishment, are preferred. Constructed protective structures may not encroach on public land.

New development is subject to a setback line that is sufficient to prevent the need for protective structures for the life of the project. The setback may not be less than the 100-year coastal erosion line as determined using the most current methods and information.

The Harbor land use plan segment was certified in 2003. Where the construction of protective structures may be allowed, a geotechnical analysis must establish that the protective structure is necessary and that it is the least environmentally damaging feasible alternative. Other alternatives, such as relocating the structure or sand replenishment, are preferred. Protective shore structures built to protect existing legal structures and public beaches are required to include a beach maintenance program to prevent or to mitigate for loss of beach near the structure. Specific regulations for the Catellus east site apply.

New development is subject to a setback line that is sufficient to prevent the need for protective structures for the life of the project. The setback may not be less than the 100-year coastal erosion line as determined using the most current methods and information. If an existing shore protective structure needs maintenance or replacement, alternative designs and project management plans must be considered.

Proposed new development must have a site-specific geotechnical study and not require shore protection structures for the life of the project. A deed restriction to waive all rights to protective devices associated with development on coastal dunes is required.

New development is not allowed in tsunami run-up or storm wave inundation areas. Existing structures may demolish and rebuild and/or build additions only consistent with takings law and other specific exceptions. For proposed development along the bay, the coastal erosion rate and tsunami and storm wave areas are determined by and included in site-specific geotechnical studies.

Existing legal structures that do not conform to the LCP may be maintained if it does not increase the extent of nonconformity. Additions and improvements must comply with the current local coastal program.

Future sea level rise is required to be included in the siting and design of new shore development and shore protective devices. Specifically, an increase in the historical rate of sea level rise must be reviewed and considered. Development must be setback and elevated to minimize or eliminate, to the maximum extent feasible, hazards associated with the anticipated rise in sea level over the expected 100-year economic life of the structure.

The Laguna Grande/Roberts Lake land use plan segment has not yet been certified. Erosion must be minimized in new development by stabilizing and maintaining steep dunes and steep slope areas.

Table 22 Summary of Evaluation Criteria for Setbacks

Evaluation Criteria	
Reduce threat to structures	No for existing development, yes for future development, redevelopment
Maintain Beach Width	Yes
Economic Costs	Potential increase due to reduction in buildable footprint on parcels
Environmental Impacts	No. None within setback but the total depends on site specific development
Recreational	Yes. No impacts until medium/long term
Safety and Public Access	Yes. No impacts until medium/long term
Aesthetics	Yes. No impacts until medium/long term
Regulatory Viability	Yes, has been implemented, but potential opposition from landowners
Adaptability to Future Conditions	Yes until end of setback life (e.g. 50, 75 years)
Cumulative Impacts	None in short term, potentially in long term
Certainty of Success	Certain in short term, Uncertain over medium/long term

Discussion

A setback is usually established by determining where the building can be placed at present that will be located away from hazards for the expected life of the structure. Often it is determined by where other adjacent properties have been built (e.g. development line).

There are various means to determine setbacks, including a factor of safety approach, some planning horizon multiplied by the average annual recession rate, or some calculation of future recession based on specific sets of assumptions about future conditions.

Under the factor of safety (FS) approach, an acceptable factor of safety is determined against slope instability (normally taken as FS. $\geq$ 1.5 for static conditions and FS. $\geq$ 1.1 for dynamic or pseudostatic conditions) and add to that both the anticipated amount of erosion over the identified time period and a buffer.

Under the erosion rate method, some knowledge of historic changes over time must be known. This method has been implemented in the Hawaiian islands of Maui and Kauai, which is calculated using historical erosion rates times a 50 and a 75 year planning horizon, respectively. These laws are written specifically to acknowledge that it is either the above calculation or a set distance inland to provide for those locations where historic erosion rate information is either not known or invalid due to extenuating circumstances.

This siting strategy should prevent the need for armoring until the identified time period is over. However one of the largest shortcomings is that once the setback has been eroded nearly through, the structure is often protected resulting in the host of impacts associated with shore armoring.

In a review of setback lines established by various coastal states, benefits and drawbacks are identified. Perceived benefits include the ability to avoid armoring the beach during the specified time period, protecting beach width and maintaining natural coastal processes. Setbacks may also specify parameters for rebuilding after a catastrophic storm. In Maine and North Carolina, for example, repairs to existing nonconforming structures that will cost more than 50 percent of the structure's value must comply with the setback requirements. In New Jersey, setback regulations stipulate how to address issues of accretion as well. One drawback, however, is that erosion data is dynamic and requires continual updating. As an example, South Carolina updates their erosion data every eight to ten years. Another drawback may be potential takings litigation if property is deemed unbuildable due to application of a setback line. Lastly, setback lines simply defer risk and decision making to the future, when erosion has advanced and structures are once again at risk (NOAA, 2009).

Setback regulations may evolve over time, as in the case of Hawai'i. The state requires an arbitrary setback line, not based on erosion data. This setback line has proved insufficient as there has been widespread public beach loss. The island of Maui instituted additional regulations in 2003 that take into account historic erosion rates. Under the new ordinance, all development must either (a) be set back by an amount 50 times the annual erosion rate, plus 25 feet, or (b) adhere to the pre-existing statewide setback, whichever was more restrictive. Existing nonconforming structures seaward of the setback line or shore areas with protective structures were grandfathered in, likely to avoid a takings problem (NOAA, 2009).

North Carolina has established a tiered setback scheme that varies by building size and type. Most setback lines, measured from the first stable natural vegetation, are based on annual erosion rates. Structures of less than 5000 square feet must be set back by an amount equal to 30 times the average annual erosion rate. Adjustments to the setback line are made for areas that have much higher or lower erosion rates as compared to other areas. Additional requirements apply to larger structures like hotels and condos: buildings of 5,000 square feet or more must be set back by an amount equal to 60 times the average annual erosion rate or 120 feet from the vegetation line (NOAA, 2009).

Effectiveness – Maintaining beach width vs. protecting upland property

Under the use of setbacks as erosion mitigation measures, the intent is to remove the development as far back on the parcel so as to minimize future risk to the development. In practice, this only works for a certain time period which is determined by the erosion rate and time period. In Figure 24 below, the dry sand width remains the constant as the beach migrates inland, eroding the upland property during the initial time period. However, at some point in the future as the setback is eroded into, the development begins to be threatened and historically the property owner has applied for a coastal development permit to place shore armoring. In the case below we assume once erosion gets within 20' of the development then a revetment is constructed. This immediately loses a portion of the dry sand beach evidenced by the stair case drop in the beach width due to placement loss. Once the revetment is constructed, then the upland property ceases to erode, but the dry sand beach width erodes. It is also important to note that in the example below, we only calculate changes at a 5, 25, 50 and 100 years, so if the beach is still present in year 50 as in the case of Sand City, we assume that the beach width will persist until the next calculation point at 2100. In reality of the Sand City example, we expect the beach to disappear long before 2100, and in Marina we expect the beaches to disappear before 2050. As interpreted, the long term effect of a setback policy in Southern Monterey Bay will be to lose all of our dry sand beaches by 2100, with beaches in Marina and Sand City likely disappearing in the next 50 years.

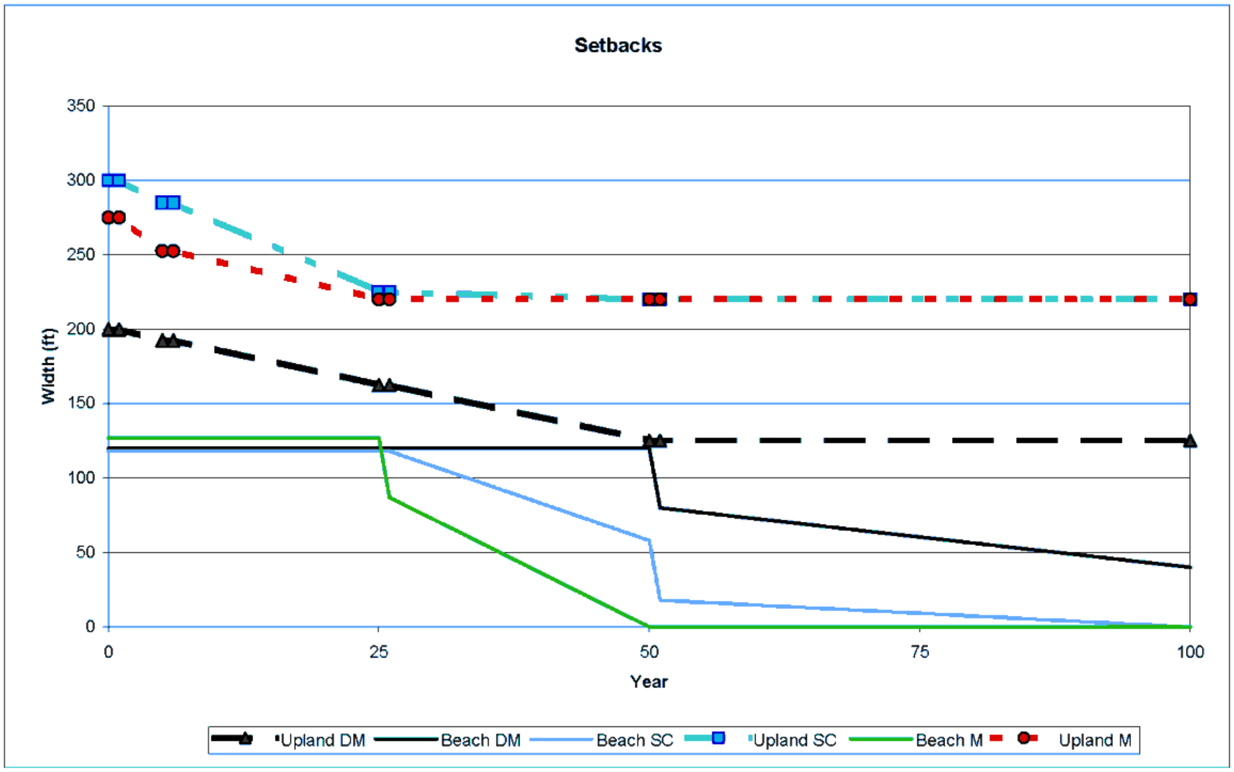

Figure 24 Effectiveness of setbacks at maintaining dry sand beach widths and upland property over time

Regulatory Viability

Yes, but if strict adherence to setbacks results in *no* development being permitted on a property, then the risk of regulatory taking liability increases dramatically.

Ecological Impacts

Generally, low for the sandy beach ecosystem, site specific impacts to upland dune habitats until setback is eroded and shore armoring is allowed at which point, ecological impacts would increase dramatically.

Cost of development setbacks (Tables 23 – 25) are relatively minor compared to some of the other land use planning tools. See Section 3.5.2 for the assumptions used in this measure. The largest cost is likely to be used for obtaining the site specific erosion rate and/or vegetation line data necessary to calculate the setback distance. Also, there may be significant administrative costs to implementing/enforcing setbacks and avoid takings claims, or fair market value compensation due to landowners with successful takings claims.

Table 23 Present Value of Benefits and Costs for Setbacks: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 2,454,388	$ 5,209,529	$ 5,616,133	$ 1,013,802	$ 14,293,851
Total Habitat Value above Baseline	$ 770,696	$ 1,235,423	$ 1,465,504	$ 131,076	$ 3,602,699
Sum Benefits	$ 3,225,084	$ 6,444,952	$ 7,081,637	$ 1,144,878	$ 17,896,550
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	$ 10,277,227	0	$ 10,277,227
Cost of Private Property Compensation	$ 142,686	$ 1,153,592	$ 2,321,062	$ 1,398,504	$ 5,015,845
Cost of Pubic Property Compensation	$ 60,470	$ 208,984	$ 89,193	$ 64,203	$ 422,850
Construction/Nourishment Cost	$ -	0	$ -	$ 4,879,666	$ 4,879,666
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ (42,996,844)	$ 1,362,576	$ (69,597)	$ 1,462,707	$ (40,241,158)
Net Benefits	**$ 46,221,927**	**$ 5,082,376**	**$ 7,151,234**	**$ (317,829)**	**$ 58,137,709**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 24 Present Value of Benefits and Costs for Setbacks: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 9,933,495	$ 14,356,028	$ 1,975,171	$ -	$ 26,264,694
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 16,933,333	$ 25,930,217	$ 7,276,000	$ 2,398,093	$ 52,537,642
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 5,734,811	$ 12,022,547	$ 2,981,753	$ (0)	$ 20,739,111
Structural Adjustment Costs	$ -	$ -	$ -	$ 23,642,591	$ 23,642,591
MRWPCA	$ -	$ 25,970,041	$ -	$ -	$ 25,970,041
Cost of Private Property Compensation	$ 208,199	$ 745,512	$ 378,881	$ 1,092,315	$ 2,424,907
Cost of Pubic Property Compensation	$ 187,216	$ 733,142	$ 328,122	$ 187,725	$ 1,436,205
Construction/Nourishment Cost	$ -	$ -	$ -	$ 20,331,941	$ 20,331,941
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ (179,604,584)	$ 27,448,695	$ (52,447,496)	$ 24,922,631	$ (179,680,755)
Net Benefits	**$ 185,339,396**	**$ (15,426,148)**	**$ 55,429,249**	**$ (24,922,631)**	**$ 200,419,865**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 25 Present Value of Benefits and Costs for Setbacks: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,446,180	$ 19,139,101	$ 8,157,800	$ 3,120,411	$ 40,863,493
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 21,357,208	$ 31,537,626	$ 10,675,252	$ 4,083,353	$ 67,653,439
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 8,581,612	$ 29,511,804	$ 18,833,052	$ 7,203,765	$ 64,130,233
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	$ 2,525,340	0	0	$ 2,525,340
Cost of Private Property Compensation					
Cost of Pubic Property Compensation					
Construction/Nourishment Cost	$ -	$ -	$ -	$ -	$ -
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ (250,200,000)	$ 2,525,340	$ (73,884,753)	$ (28,261,398)	$ (349,820,812)
Net Benefits	**$ 258,781,612**	**$ 26,986,465**	**$ 92,717,805**	**$ 35,465,163**	**$ 413,951,045**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that Setbacks have a net positive cost benefit primarily as a result of deferring construction costs associated with the revetments until a later date (Tables 23, 24, 25). The benefits decline over time once the revetment is built and the beach narrows reducing the recreation and ecosystem benefits. The total benefits over the entire study for the 100 year planning horizon total about ~$495 million with that made up of ~$54 million in recreation and ecosystem benefits.

4.2 REGIONAL EROSION MITIGATION MEASURES – SOFT ENGINEERING APPROACHES

Soft Engineering Approaches refers to sand management measures primarily. This follows the practice vernacular that shore armoring are "hard" structural measures and sand placement is a "soft" non-structural measure. All the alternatives in the Coastal Regional Sediment management Plan were "soft" sand management measures (PWA et al., 2008).

4.2.1 Cessation of Sand Mining from the Beach

Description

Sand mining removed sand from the beach, backshore, nearshore, or in floodplains prevents this sand from being available for beach building. Reduction on the volume of sand extracted from the active shore area should expand the width and area of beach that is available to keep storm waves from damaging backshore development.

General Applicability
Any jurisdiction with regulatory authority over a sand mine operation.

Specific Applicability
This management alternative is most critical to for application to Subregions 6 and 7, but important to the entire southern Monterey Bay littoral cell to address critical erosion throughout (Table 26).

CEMEX INC owns two parcels 376 and 26 acres (Figure 5). The larger which has the structural improvements is assessed at $15.1 Million while the smaller one at $73,222, based on public records readily available but not verified. Both of these have ocean frontage with the smaller one located to the north of the larger developed parcel.

Table 26 Summary of Evaluation Criteria for Cessation of Sand Mining

Evaluation Criteria	
Reduce threat to structures	Not directly, but indirectly regional benefits to all SMB by increasing sediment supply and reducing erosion rates
Maintain Beach Width	Yes
Economic Costs	Unknown – depends on mechanism to cease, ability to acquire comparable sources of sand. No local loss of tax revenue
Environmental Impacts	No. Improves
Recreational	Yes. Improves
Safety and Public Access	Yes. Improves
Aesthetics	Yes. Improves
Regulatory Viability	Probably Feasible – likely require regulatory and/or judicial action to resolve
Adaptability to Future Conditions	Yes improves sediment supply
Cumulative Impacts	Benefit to entire region – potential increase in cost of construction grade materials
Certainty of Success	Certain to improve sediment supply, certain to reduce erosion rates, although magnitude less certain along entire study region

Background
The first sand mine in southern Monterey Bay started at Marina in 1906 by surface mining of the dunes (which does not impact beach erosion). By 1950, there were five additional sand mines that operated below MHW using drag-lines to dredge sand directly from the ocean. These mines were closed in the late 1980's when the USACE did not renew their mining permits as they determined that sand mined from the ocean caused severe coastal erosion. The mining production at Marina increased in 1965 by introducing a dredge to obtain sand from a pond created in the back beach, which captures littoral sand transport from the ocean by overwash of the berm during storms. The mine subsequently increased its production to match the total output of all previous mines combined. Therefore, even after the closure of the five drag-line mines, the total amount of mined sand derived from the ocean has remained essentially unchanged at about 200,000 cu.yd./year for the last sixty years.

Southern Monterey Bay was identified by the USGS (Hapke et al., 2008) as the most erosive shore on average in California. A comprehensive study called the Sand City Shore Erosion Study (Moffatt & Nichol, 1989) concluded that sand mining had greatly increased coastal erosion in southern Monterey Bay. A conclusion of the CRSMP for southern Monterey Bay (PWA et al., 2008) was that a primary cause of high erosion rates in SMB is the sand mine operated by CEMEX (who bought the mine in 2000) within the City of Marina.

Impact of Cessation of Mine

A quantitative measure to answer how much erosion would be mitigated by stopping sand mining requires an estimate of the change in beach erosion rates and subsequent decreases in dune erosion owing to cessation of sand mining. Erosion rates in the southern subcell of southern Monterey Bay decreased significantly after the drag-line sand mining stopped in Monterey and Sand City in the late 1980’s (Table 4, Thornton et al., 2006, PWA et al., 2008). This decrease in erosion rates can provide an estimate of the impact of stopping sand mining. The sand mines were located 3.0, 3.1 and 3.5 miles from Wharf II and mined an average of 110,000 cu.yd./year between 1940 and 1988. The cumulative alongshore percent decrease in erosion rate from the time of intensive mining in Monterey and Sand City (1940-1984) compared with the time after closure of these mines and the intensified mining at the CEMEX mine in Marina (1985-2005) as a function of distance from Wharf II is shown in Figure 25. For example, the average percent decrease in erosion rate between Wharf II and mile 3.7 is 60%. A number of conclusions can be made: 1) a significant decrease in erosion rate occurred after stopping sand mining within the southern subcell ranging from 72% near Wharf II to 60% at mile 3.7; 2) the percent declines continuously to the Salinas River, indicating that the CEMEX mine impacts the entire southern Monterey Bay littoral cell; 3) the impact of continued mining is most profound within +/-2.5 miles of the CEMEX mine, which includes the entire shore of the City of Marina; and 4) beach erosion actually has increased by at least 10% when considering the entire southern Monterey Bay littoral cell (the percent decrease in erosion rate goes negative starting at mile 8.5). The results suggest that, as a first approximation, stopping sand mining would result in at least a 60-72 percent decrease in beach erosion in the southern subcell between Wharf II and mile 3.7. Since the amount of sand mined in Marina by CEMEX is approximately 200,000 cu.yd./year, which is almost twice the amount mined in Monterey and Sand City before closure, it is expected that there might be an even greater percentage decrease if it were stopped. It is estimated that the 60-70% decrease in erosion is a lower bound if the mining were stopped as the mining in Marina is assumed to have continued to cause erosion in the southern subcell owing to interruption of the littoral drift from the north and the nearly twice as much mined sand in Marina.

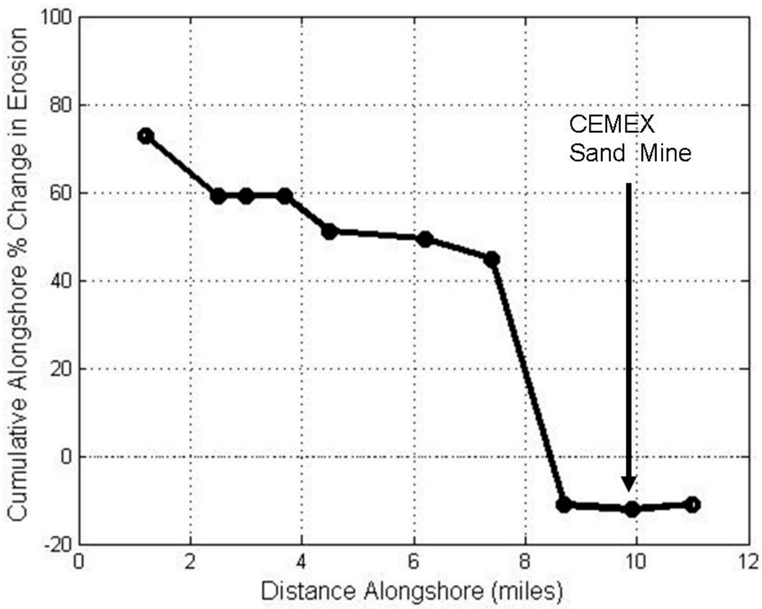

Figure 25 Cumulative alongshore percent decrease in erosion rate from time of intensive mining in Sand City and Monterey (1940-1984) compared with the time of the closure of these mines and intensified mining at the CEMEX mine in Marina (1985-2005) as a function of distance from Wharf II

Revised sediment budgets are presented in Table 27, which provide quantitative volumes of sand available to the littoral system resulting from mine closure. The sediment budget after the closure of the operations dredging sand directly from the ocean in the late 1980's is included for comparison. It is assumed that if the CEMEX sand mine is closed, beach erosion will decrease by at least 60 percent (average of southern subcell). A basic assumption is that dune recession occurs at the same rate as beach erosion (Reid, 2005). Therefore in revising the sediment budget presented in the CRSMP for southern Monterey Bay in Table 8 (PWA, 2008), the dune erosion and the beach and shoreface loss quantities are simply multiplied by a factor of (1-0.6) = 0.4.

A second revised sediment budget is presented in Table 27 under the scenario that CEMEX is limited to 80,000 cu.yd./year, which is the amount of sand mined at the Marina site at the time the Coastal Commission came into being. It is assumed that the beach and dune recession would be reduced by the percent of mining decrease (120,000/200,000) times the 0.6 decrease assumed if the mining stopped altogether, which equals 0.36. The multiplier factor applied to the dune and beach erosion is then (1 – 0.36) = 0.64.

Table 27 Revised sand budget for littoral cell between Wharf II and the Salinas River for closure of CEMEX sand mine operation and a decrease in mining operation to 40%

		Volume (yd^3/year X 1000)		
Budget Component		1984 – 2005	mine closure	mine 40%
1) Inputs	Salinas River	10	10	10
	Dune Erosion	200	80	128
	Net alongshore transport from the South	?0	?0	?0
2) Outputs	Sand Mining	200	0	80
	Dune Accretion by wind	28	28	28
	Offshore	268-398	38-90	130-213
3) Change in Storage	Beach and Shoreface loss	-250 to -380	-100 to -152	-160 to -243
	Residual = (1) – (2) – (3)	0	0	0

The sediment budget gives an independent estimate of how much additional sand would be available to the southern Monterey Bay littoral cell if the CEMEX operation were curtailed or closed based on incorporating the rates of dune erosion from Figure 25. The differences between the beach and shoreface losses of the in sediment budget (1984-2005) and mine closure of 150 to 228,000 cu.yd./year is consistent with stopping the current mining amount of 200,000 cu.yd/year.

Jurisdiction

There presently is no permit required for the CEMEX sand mine operation. The USACE determined recently (Hicks letter, July 8, 2010) that they do not have jurisdiction based on Section 10 of the Rivers and Harbors Act of 1899 since the connection between the ocean and the pond is above MHW. Even though the mine is within City of Marina, the city has no jurisdiction and derives no direct tax revenue. Since CEMEX was plowing sand into the pond and the pond elevation is below MHW, the operation comes under Section 4 of the Clean Water Act. An injunction was placed on CEMEX in 2009 prohibiting them to bulldoze sand from the berm into their pond on this basis, but does not restrict the amount of mining. It can be argued that the Coastal Commission has jurisdiction over increases in mining since its inception in 1972. The Sierra Club requested (letter dated February 2009) that the Coastal Commission require a permit for all sand mined in excess of 80,000 yd3/year by CEMEX at Marina, which is the amount of sand mined in 1972. The request has been under jurisdictional review since.

Effectiveness – Maintaining beach width vs. protecting upland property

Under cessation of sand mining from the beach as erosion mitigation measures, the effect would be to substantially reduce erosion rates of upland property (Figure 26). This would indicate that the dry sand beach widths would remain the same while upland property is eroded. For comparison, examine Figure 26 below with Figure 17 (Land Use Planning Measures). The primary difference is that under the cessation of sand mining, upland property that would be eroded in 50 years with existing erosion rates would likely remain for nearly 100 years.

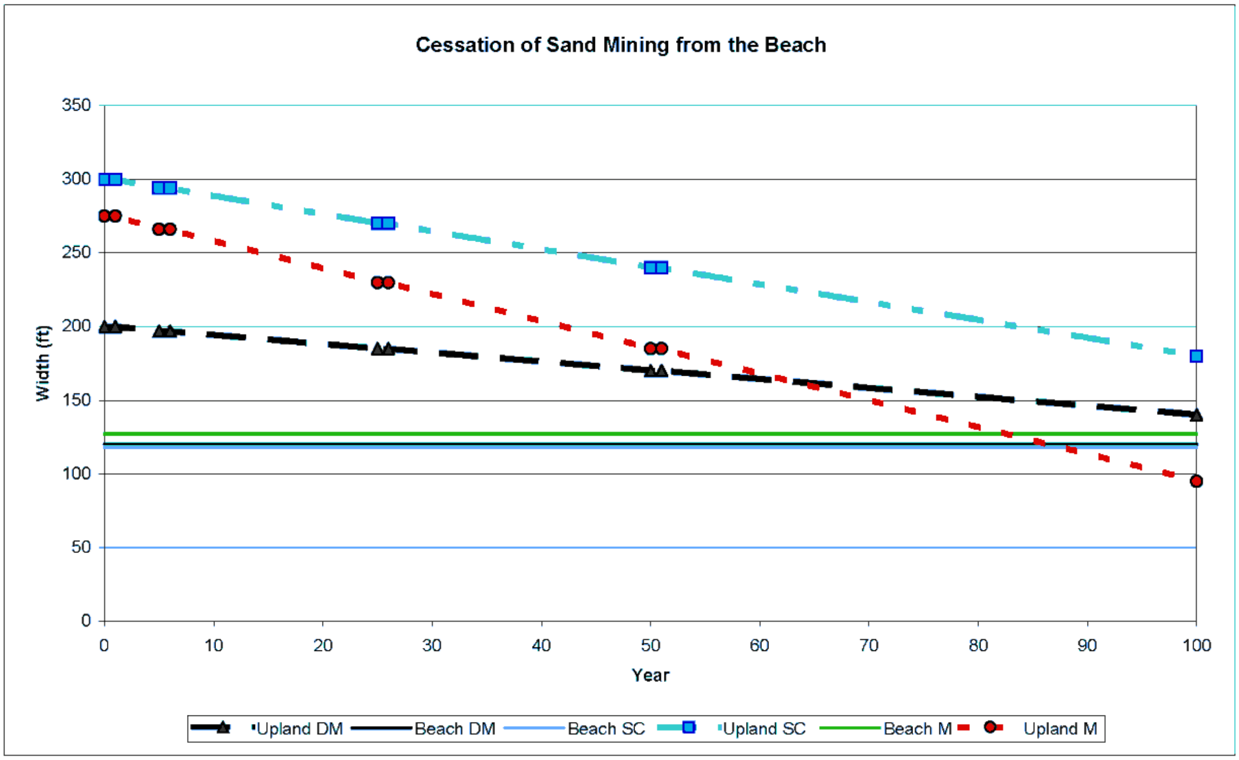

Figure 26 Effectiveness cessation of sand minding from the beach at maintaining dry sand beach widths and upland property over time

Regulatory Viability

Cessation of sand mining is considered viable since it is a man made action that can stop and was stopped at other sand mines in the area around 1990. However, the specifics of the Marina sand mining operation complicate regulatory analysis. However, a regulatory and/or judicial intervention may be required to resolve jurisdictional and regulatory compliance issues.

Ecological Impacts

The ecological impact of cessation of sand mining is expected to be strongly positive in that erosion will slow to natural levels and the adverse impacts caused by mining will not continue to accumulate. This cessation would have a positive benefit to dune habitats.

Cost and Benefits

Tables 28 through 30 present the benefit and cost analysis for ceasing sand mining. See Section 3.5.2 for the assumptions used in this measure. The baseline scenario includes the use of a revetment and the recreational and ecological benefits represent the differences between cessation of sand mining and the baseline scenario of a revetment. Our analysis did not include the losses to CEMEX from stopping the mining. The cost of closing the sand mine would avoid the expense of armoring and replacing the MRWPCA sewer infrastructure and other properties and the cost savings is greater than a present value equal to $124.5 million in 2010 dollars.

Table 28 Present Value of Benefits and Costs for Ceasing Sand Mining: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 2,532,610	$ 6,087,683	$ 6,665,503	$ 2,050,106	$ 17,335,903
Total Habitat Value above Baseline	$ 866,100	$ 2,266,079	$ 2,678,726	$ 814,197	$ 6,625,102
Sum Benefits	$ 3,398,710	$ 8,353,763	$ 9,344,229	$ 2,864,303	$ 23,961,005
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ 3,186,638	$ 3,186,638
Cost of Private Property Compensation	$ 1,000,000	$ -	$ 295,000	$ 1,044,000	$ 2,339,000
Cost of Pubic Property Compensation	$ 24,188	$ 83,594	$ 35,677	$ 21,044	$ 164,502
Construction/Nourishment Cost	$ -	0	$ -	$ -	$ -
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ (42,175,812)	$ 83,594	$ (12,426,402)	$ (627,984)	$ (55,146,605)
Net Benefits	**$ 45,574,522**	**$ 8,270,169**	**$ 21,770,632**	**$ 3,492,287**	**$ 79,107,610**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 29 Present Value of Benefits and Costs for Ceasing Sand Mining: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,134,107	$ 16,744,324	$ 5,684,049	$ 2,015,504	$ 34,577,985
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 17,160,486	$ 28,384,159	$ 9,658,491	$ 2,953,380	$ 58,156,516
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 6,162,577	$ 16,864,785	$ 9,073,122	$ 2,570,791	$ 34,671,276
Structural Adjustment Costs	$ -	$ -	$ -	$ 23,642,591	$ 23,642,591
MRWPCA	$ -	$ -	$ 11,309,061	$ -	$ 11,309,061
Cost of Private Property Compensation	$ 83,280	$ 287,815	$ 127,074	$ 167,554	$ 665,723
Cost of Pubic Property Compensation	$ 73,398	$ 264,164	$ 128,787	$ 77,087	$ 543,436
Construction/Nourishment Cost	$ -	$ -	$ -	$ -	$ -
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ (179,843,323)	$ 551,979	$ (41,589,577)	$ 3,555,291	$ (217,325,630)
Net Benefits	**$ 186,005,900**	**$ 16,312,806**	**$ 50,662,699**	**$ (984,500)**	**$ 251,996,905**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**0.7**	**NA**

Table 30 Present Value of Benefits and Costs for Ceasing Sand Mining: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 10,110,428	$ 15,338,379	$ 4,688,750	$ 1,779,922	$ 31,917,479
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 21,830,823	$ 33,018,605	$ 10,832,113	$ 4,143,354	$ 69,824,894
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 8,719,474	$ 27,192,061	$ 15,520,863	$ 5,923,276	$ 57,355,674
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	$ -	0	0	$ -
Cost of Private Property Compensation	$ 2,173,557	$ 1,077,184	$ 5,134,238	$ 1,044,000	$ 9,428,979
Cost of Pubic Property Compensation	$ 858,237	$ 2,966,069	$ 1,268,600	$ 21,044	$ 5,113,949
Construction/Nourishment Cost	$ -	$ -	$ -	$ -	$ -
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ (247,168,205)	$ 4,043,252	$ (67,481,916)	$ (27,196,355)	$ (337,803,224)
Net Benefits	**$ 255,887,680**	**$ 23,148,808**	**$ 83,002,779**	**$ 33,119,631**	**$ 395,158,898**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that Ceasing Sand Mining from the Beach have high net benefits primarily as a result of deferring construction costs associated with the revetments and reducing erosion rates which reduce private and public costs as well as costs associated with the replacement of the MRWPCA infrastructure (Tables 28, 29, 30). The total benefits over the entire study for the 100 year planning horizon total about ~$726 million with that made up of ~$114 million in recreation and ecosystem benefits.

As one can see in the tables above, ceasing sand mining yields substantial benefits in each reach. Indeed the present value of increased habitat and recreational value over the entire 100 year period for all three reaches is approximately $45 million dollars. If one assumes that cessation of sand mining is an effective alternative to revetments the savings are even greater.

4.2.2 Opportunistic Sand Placement (SCOUP)

Description

Opportunistic sand is sand that is extracted from a flood channel, debris basin, navigation channel, harbor area, a by-product of construction or other source, where the main reason for extracting the sand is not to use it for beach nourishment. It is considered opportunistic sand if it can be made available for beach nourishment as a complement to the effort to remove it from its initial location (Figure 27). Opportunistic sand placement is also known as part of the Sediment Compatibility and Opportunistic Use Program (SCOUP) of the Coastal Sediment Management Workgroup (CSMW).

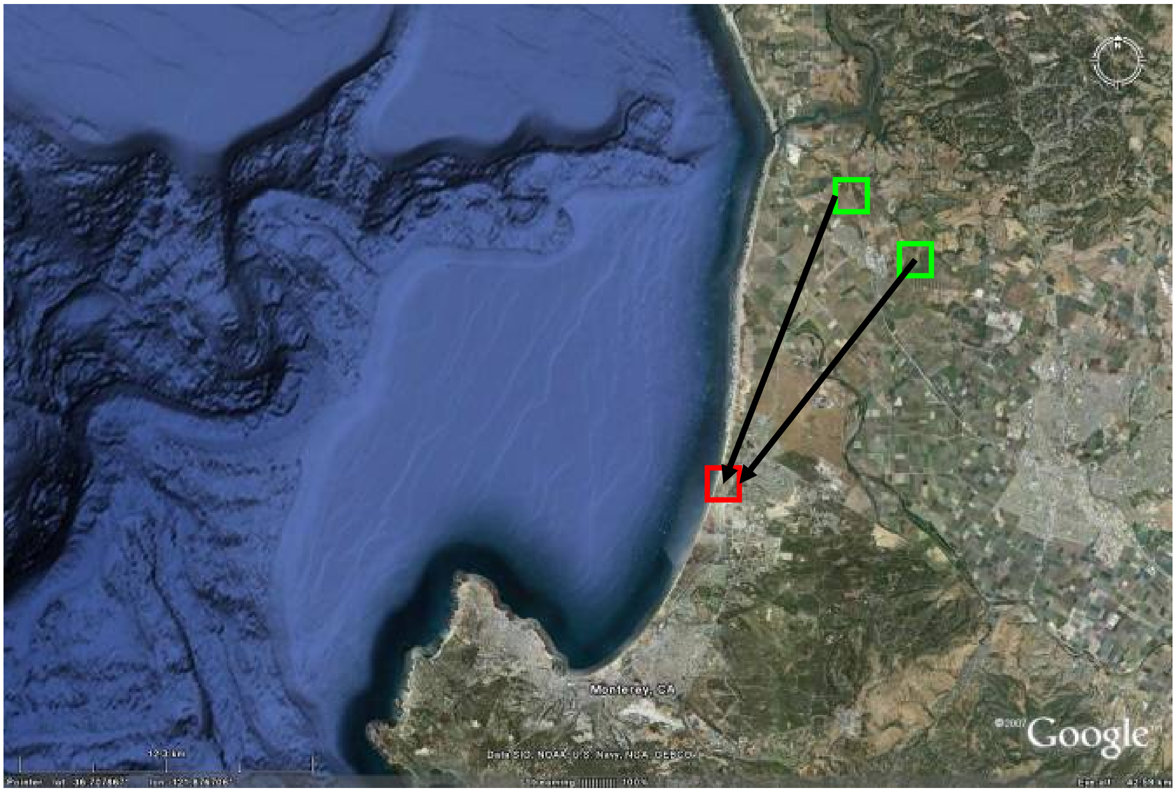

Figure 27 Opportunistic Sand Placement – Conceptual Schematic

General Applicability

An opportunistic placement program requires the identification of potential sources and placement sites. Typically an interim location to stockpile sediments is required to obtain enough material to have a positive benefit to beach sand volumes. As a stand-alone measure opportunistic sand placement would be unlikely to mitigate for erosion on a regional scale and is considered to have an incremental short-term benefit that would improve the effectiveness of other measures.

Specific Applicability

This management alternative is most relevant for application to Subregions 1-2 to address critical erosion areas in these Subregions. Within SMB as a whole, the regional application of opportunistic sand placement is not likely to resolve erosion issues (Table 31).

Table 31 Summary of Evaluation Criteria for Opportunistic Sand Placement

Evaluation Criteria	
Reduce threat to structures	Potential- depends on volume of material
Maintain Beach Width	Yes
Economic Costs	Potentially high transportation costs, potential loss of revenue from selling sediment for other uses
Environmental Impacts	Yes, degree depends on methods of acquisition and placement, distance from source to receiver site, scale of impacts to biologic communities, potential turbidity short term impacts
Recreational	Yes, Improves
Safety and Public Access	Yes, Improves but potential adverse change to wave breaking
Aesthetics	Depends on sediment compatibility
Regulatory Viability	Feasible but uncertain, needs regional permit to streamline stockpiling and placement; would require amendments to the MBNMS Designation Document
Adaptability to Future Conditions	Yes
Cumulative Impacts	Reduces by maintaining sediment supply to the coast
Certainty of Success	Reasonable certainty, depends on volumes of material and compatibility with existing beach sand

Discussion

Opportunistic beach nourishment (or beneficial use of sediment) was initiated in the state of California in 2001 in the Santa Barbara littoral cell, under the authority of the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON), a regional joint powers agency that deals with coastal erosion and beach problems in Santa Barbara and Ventura County. The objective of this program was to obtain a five-year permit from all necessary regulatory agencies to allow the opportunistic beach-quality sediments to be placed on beach fill sites without the need for individual project permits. This program was successfully implemented and recently renewed its five-year permit in 2009.

The opportunistic sand use program (SCOUP) is a project facilitated by CSMW. CWMW developed a template for development of a program for the beneficial use of sediments generated by other activities (referred to as “opportunistic” sediment sources) for nourishment of coastal areas (SCOUP Program; Moffatt & Nichol, 2006). The SCOUP was initially designed in San Diego and developed programmatic guidance for permitting and approvals. It identified locations where the sediment should be placed (called “receiver” sites), specified sediment requirements and tests, as well as other factors that make individual, small sediment placement projects feasible. The SCOUP process and the resulting documents can help raise the awareness of regional sediment management among non-coastal entities that sediment is a resource to our coastal communities. The SCOUP is implemented regionally to account for local conditions including local sediment sources and receiver sites, as well as local constraints such as sensitive ecologic resources and seasons.

Additional documents also provide good references for beach nourishment in Southern Monterey Bay. The related *Regional General Permit 67 Discharges of Dredged or Upland-Derived Fill Materials for*

Beach Nourishment (US Army Corps of Engineers and associated certification by Regional Water quality Control Board) provides a template for possible use in Southern Monterey Bay, even though it applies only to southern California. Another pertinent template, for example, is the Initial Study and Mitigated Negative Declaration (MND) for the SCOUP Oceanside Pilot Program (City of Oceanside and EDAW, 2005). Multiple other documents are listed in the southern Monterey Bay CRSMP bibliography, notably including the CSMW *Review of Biological Impacts Associated with Sediment Management and Protection of California Coastal Biota* (draft), which addresses key environmental issues associated with effects of beach nourishment. Finally, recent research and publications examining the discharge of sediment with larger fractions of finer (not sand) sediments at Santa Cruz and Tijuana Slough have produced information on impacts of turbidity that will be considered (USGS 2007; Jon Warrick, USGS personal communication).

Sand size is a factor in sand movement. If a beach is nourished with sand that is coarser than what is there through natural processes, the nourishment sand normally will remain on the beach longer than a similar volume of less coarse sand. An extreme example would be if rocks and cobbles were substituted for sand grains. The grain size change can alter the beach slope as well as the look and feel of the beach.

Back-Passing:

Back-passing takes sand that was being carried downcoast by waves and currents and relocates it farther upcoast so it can be carried past certain sections of coast more than one time. Back-passing is often considered for locations where the downcoast area is a sand sink (a canyon or a harbor) and the upcoast area is one that needs more sand. Back-passing does not add to the total volume of sand in the littoral system, but recycles sand through a portion of the transport area where it can be most beneficial. On possible example could be sand capture at the head of the Monterey submarine canyon and backpassing sediment to the southern bight (Subregions 1-4)

Effectiveness – Maintaining beach width vs. protecting upland property

Under the use of opportunistic sand placement as an erosion mitigation measure beach width remains constant, and the upland property erosion is reduced for the reaches where erosion rates are below -1.5ft/year (Figure 28). As interpreted, this would require roughly 75,000 cy of sand to be placed every 2 to5 years: a rate of once every 5 years was used. However, the CRSMP (PWA et al., 2008) identified this volume based on maintenance dredging of Monterey Harbor once every 25 years or so. This volume was estimated to compensate for erosion for 2 to 3 years in the low erosion area of the southern bight (Monterey area). Consequently, the effectiveness of this placement rate is limited. Also, the availability of 75,000 cubic yard every 5 years (or around 400,000 cubic yards every 25 years) is uncertain and unlikely. Still, it is expected that opportunistic sand placement would be a worthwhile over the short term where erosion rates are low and finer sands more consistent with inland sediment sources exist. For shore reaches with erosion rates greater than 1.5 feet/year, opportunistic sand placement may be incrementally worthwhile but is not likely to have much effect on mitigating upland erosion.

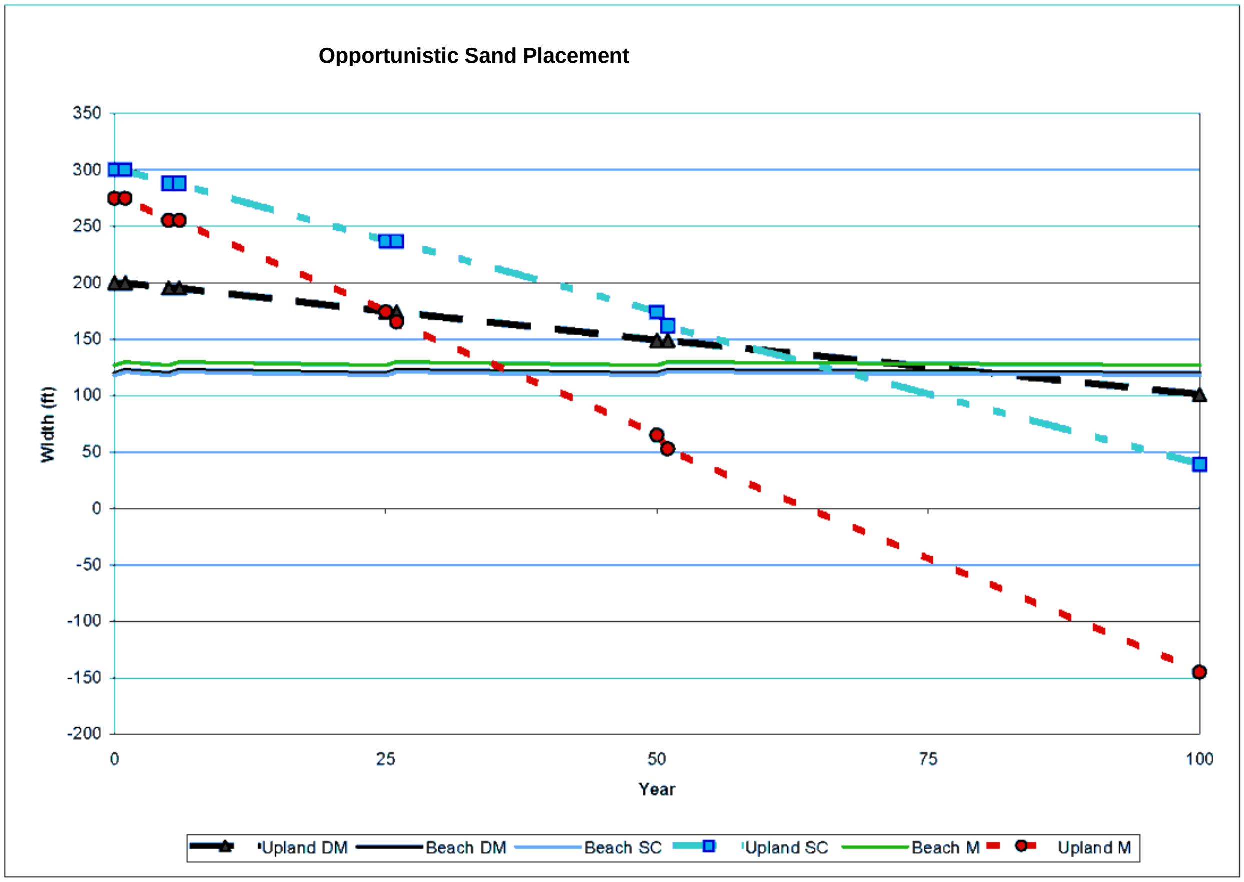

Figure 28 Effectiveness of opportunistic use of sand (SCOUP) at maintaining dry sand beach widths and upland property over time (about 75,000 cubic yards every 5 years)

Regulatory Viability

Uncertain, depends on the specific placement methods and impacts. The southern Monterey Bay region is relative to the southern California areas where a SCOUP has been developed and where beach nourishment has been accomplished. The Monterey Bay National Marine Sanctuary (MBNMS) is located immediately offshore and imposes more extensive environmental restrictions. Dredging and dredged material disposal are prohibited activities except where authorized through disposal site designations by the Environmental Protection Agency (USEPA). This prohibition is formalized in the Sanctuary Designation Document (Code of Federal regulations (CFR) Title 15, Section 922), and to revise this prohibition to allow for the placement of sand obtained through dredging would require environmental review under the National Environmental Protection Act (NEPA) and potentially review by the appropriate Congressional Committee.

Ecological Impacts

There is little site-specific information available for the likely ecological impacts of opportunistically placed sediments on the ecological value of the habitats of SMB. Disturbance to foraging and nesting shorebirds is one likely effect as is compaction of sediments, especially when vehicular traffic is involved in the placement. The impacts will vary based on the actual placement method and the receiver site specifics on sensitive species and habitats. Any opportunistic sand placement program for SMB would require mitigation measures to avoid impacts to sensitive habitats and species. Our research indicates that the proposed placement rate every 5 years could have an adverse effect on beach ecology due to the frequent disturbances, indicating that site specific and project specific studies are needed in addition to a programmatic type of analysis such as the CSMW Biological Impacts Analysis presently underway.

Cost and Benefits

For opportunistic sand nourishment, the findings from the physical process analyses (Figure 28) show that the long-term effectiveness of this measure to reducing erosion is doubtful. Since it is not an effective long term erosion mitigation measure we assessed the incremental benefit of placing sand on the beach to demonstrate its benefits as an additional element of a longer term strategy (Tables 32, 33, 34). It is assumed that much of this opportunistic material is acquired at little to no cost. In many cases, there may actually be a cost savings to the entity providing the sediment source by avoiding or reducing transportation and disposal costs. For this analysis the cost increment to transport and place the sand is a project cost.

Table 32 Incremental Benefits of Opportunistic Sand Placement: Del Monte

		Erosion Rate: 1.5 ft/year	
Subregion length: 2.4 km	**per Subregion**	**per km**	**per ft**
Total Benefits	$ 1,974,062	$ 822,256	$ 250.70
Total Costs	$ 192,000	$ 80,000	$ 24.38
B/C	**10.28**	**10.28**	**10.28**
Net Benefits (benefits – costs)	$ 1,782,062	$ 742,526	$ 226.32

Table 33 Incremental Benefits of Opportunistic Sand Placement: Sand City

		Erosion Rate: 3.0 ft/year	
Subregion length: 10 km	**per Subregion**	**per km**	**per ft**
Total Benefits	$ 5,291,067	$ 529,017	$ 161.27
Total Costs	$ 800,000	$ 80,000	$ 24.38
B/C	**6.61**	**6.61**	**6.61**
Net Benefits (benefits – costs)	$ 4,491,067	$ 449,107	$ 136.89

Table 34 Incremental Benefits of Opportunistic Sand Placement: Marina

		Erosion Rate: 4.5 ft/year	
Subregion length: 13.9 km	**per Subregion**	**per km**	**per ft**
Total Benefits	$ 6,281,588	$ 451,913	$ 137.74
Total Costs	$ 1,112,000	$ 80,000	$ 24.38
B/C	**5.65**	**5.56**	**5.56**
Net Benefits (benefits – costs)	$ 5,169,588	$ 371,913	$ 113.36

It is apparent that in the short term, an opportunistic program would have a very high benefit cost ratio especially in the Southern Bight (Subregions 1 and 2) where erosion rates are lowest. Additional analyses could be completed, beyond the scope of this Alternatives Study, to optimize the cost benefit analysis for use in determining and prioritizing the optimal receiver and stockpile sites.

4.2.3 Beach Dewatering – Introduction

Generally, beach dewatering involves the removal of water from the beach to increase the natural accretion processes. Dewatering works on the hypothesis that a dry beachface will improve swash infiltration and thus deposit sediment on the beach. In theory, the lowering of the beach face groundwater during a falling tide promotes a small incremental enhanced accretion during each swash over the dewatered beach and integrated over many waves cycles may result in significant accretion of sand. There are three primary methods that have been tried with varying success around the world. The first is *Active Dewatering* associated with the pumping of water from the beach (Figure 29), the second is *Passive Dewatering* in which ground water in the beach is lowered passively through a tube connecting lower levels in the beach (Figure 30), and the third, methodology involves pumping of the beach groundwater from greater depths and causes a larger depression in the water table which is filled by the beach groundwater, thus lowering the beach face water table (Figure 31).

Beach dewatering systems have been promoted as a cost effective alternative to hard structures and nourishment. Field observations show that beach erosion is enhanced during ebb tide and accretion is promoted during flood tide, which is explained by observations that erosion and accretion are associated with beach face permeability (Bagnold, 1940) and variations in beach ground water dynamics (Grant, 1948; Emery and Foster, 1948). These observations led to beach dewatering as a technique to artificially lower the water table as a potential means to mitigate beach erosion. Waves swashing up and down the beach face are the mechanism for sediment transport. As waves run up and down a beach they interact with the ground water beneath the beach face. The beach water table is low during the flood tide in comparison with mean sea level, and water percolates into the beach as the waves run above the exit point of the ground water table (unsaturated region). As a consequence, the carrying capacity of the swash decreases resulting in sediment deposition. Subsequently backwash of the wave is reduced and less sediment is transported offshore. These combined effects enhance on-shore sediment transport, and hence accretion. Conversely, during ebb tide, a relative high water table exists and water exfiltrates from the beach face, which causes the opposite effects to occur with enhanced offshore sediment transport and resulting beach erosion. This simple explanation is complicated by the observation that a thinning of boundary layer occurs during infiltration, which increases shear and the sediment carrying capacity acting to oppose accretion (Nielsen et al., 2001). Conversely, Conley and Inman (1994) found that exfiltration thickens the boundary layer, reducing shear and decreasing offshore sediment transport, but at the same time causes a reduction in weight of sediments making them more mobile to be eroded. These and other complicating effects are reviewed by Masselink and Puleo (Masselink and Puleo, 2006) and they point to a lack of understanding of many of the physical processes. It is concluded that at this time the basic physical mechanisms that may contribute to the success of a beach drain concept are not fully understood.

The first qualitative field observation of beach accretion associated with pumping the ground water at the shore was to obtain purified sea water for an aquarium in 1981 (Vesterby, 2004). It was found that the efficiency of the pump declined after a year of operation because the fronting beach had accreted 25-30m, which was associated with pumping of the ground water. The well was subsequently moved closer to the shore and the beach again accreted a similar amount. The observed correlation between lowering of the ground-water table with beach accretion led to beach dewatering projects in the early 1980's in Denmark and commercial interest. The objectives of these dewatering projects are to promote onshore sediment transport to widen and stabilize the beach by artificially lowering of the beach water table as a practical alternative to more traditional methods (Machemehl et al., 1975; Davis et al., 1992). Dewatering works on the principal that small incremental enhanced accretion occurs during each swash over the dewatered beach and integrated over many waves cycles results in significant accretion of sand.

Active Dewatering

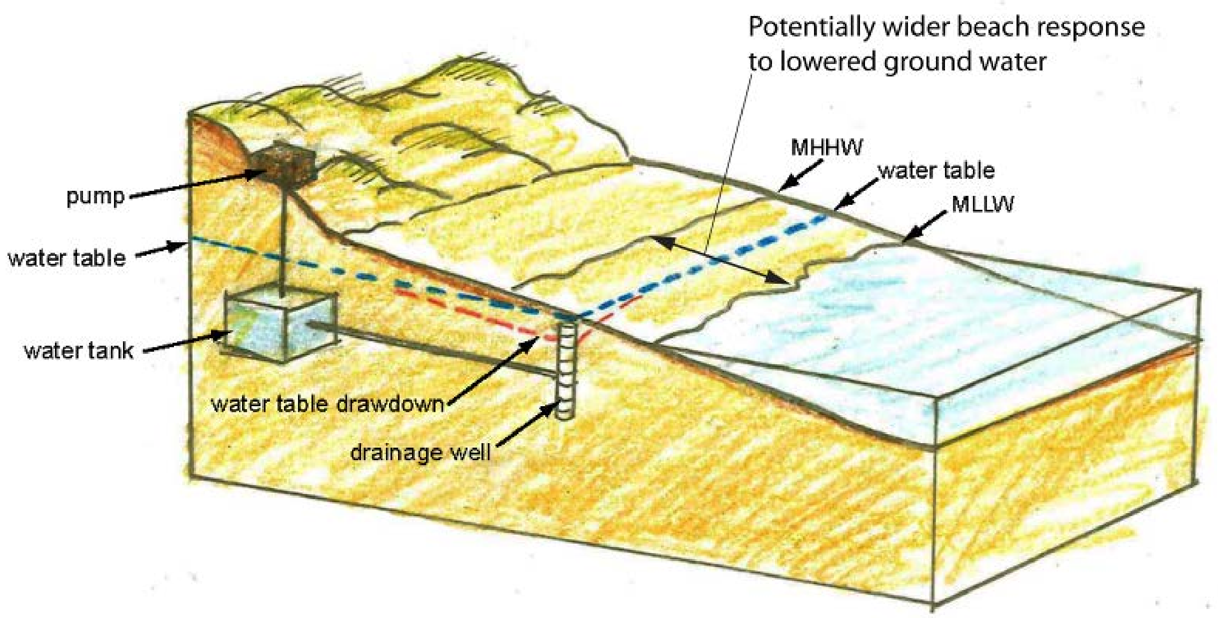

Figure 29 Schematic of Active Dewatering

General applicability

Active dewatering is potentially applicable to any sandy beach regardless of tide range, or sediment grains size or heterogeneity.

Specific Applicability

This measure is most relevant for application to Subregions 1-3 because the erosion rates and storm erosion amounts are less in these Subregions and the fixed dewatering facilities are less likely to be damaged or exposed (Table 35).

Table 35 Summary of Evaluation Criteria for Active Dewatering

Evaluation Criteria	
Reduce threat to structures	Potentially by widening beach
Maintain Beach Width	Yes, except in storm / large wave conditions
Economic Costs	Ongoing maintenance and pumping costs, reinstallation following storm impacts
Environmental Impacts	Potentially to sandy beach invertebrates
Recreational	No impacts unless pipes exposed
Safety and Public Access	No impacts unless pipes exposed
Aesthetics	No impacts unless pipes exposed
Regulatory Viability	Probably, likely requires Coastal Commission, State Lands Commission, and Sanctuary permits/approvals
Adaptability to Future Conditions	Adaptable in short term, questionable in medium to long term without relocating pumps and dewatering pipes
Cumulative Impacts	Potential impacts to sandy beach ecosystem, energy expenditure to run pumps
Certainty of Success	Relatively certain (qualitatively but not quantitative), except in storm / large wave conditions

Description

Active beach dewatering pumping techniques include pumping a closed system that pulls water from the beach and gravity flow to a well that is then pumped. A typical system is a 1000 feet horizontal drainage pipe located parallel to the shore buried 6-10 feet below MSL in the back-beach with a pumping discharge rate of 1000 gpm. The beach drainage system was patented and is commercially marketed as Beach Drain by StaBeach, or BDM. As of 2004, 35 BDM systems had been installed around the world, including the US (2), Australia (5), France (5), and Italy (7) UK (1) Germany (1).

Design parameters to be considered for installation of a beach drain system include:

1. Hydraulic conductivity (determined by sediment size, sorting and composition)
2. Wave climate (magnitude and direction)
3. Tides

The BDM systems reportedly work best where a beach is exposed to minor long-term erosion, suffering from high ground water table at the beach, and has a moderate wave climate. The BDM is not recommended as primary shore protection at severely exposed or highly protected locations and locations exposed to severe long-term erosion (Mangor, 2001). The longest installation of these systems was about 10 years. The experience has been that severe storms eventually erode back the beach to expose the drain pipes that destroys the system before the beach can recover, which is what happened to the Nantucket system after about 5 years (New York Times, July 8, 2007). Bowman et.al. points out that a sufficiently long return interval for even moderate storms is important to insure that the beach has adequate time to recover, or the system will be damaged (Bowman et.al., 2007).

Regulatory Viability
Active dewatering is probably viable in a regulatory context but may be hampered by uncertainty in performance. Likely requires Coastal Commission, State Lands Commission, and Sanctuary permits/approvals.

Ecological Impacts
There is little understanding of the ecological effects of passive dewatering on the sandy beach and dune ecosystem although it is likely to influence the tidal migrations of the sandy beach invertebrates which occurs on a daily basis.

Cost and Benefits
Owing to the uncertainty in the viability of this system, cost benefit analysis is not included.

4.2.3.1 Beach Dewatering - Passive

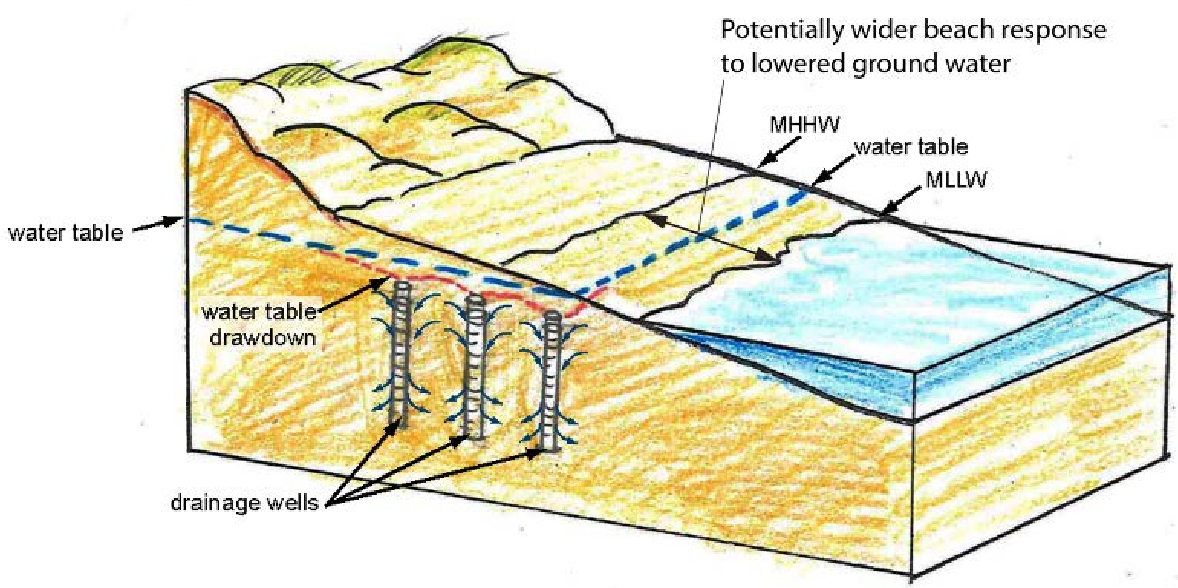

Figure 30 Schematic of Passive Dewatering

General Applicability
Passive dewatering is believed to be potentially applicable to any sandy beach with a meso to macro scale tide range, high sediment transport, and a mix of sediment grains size

Specific Applicability
This measure is most relevant for application to Subregions 1-3 because the erosion rates and storm erosion amounts are less in these Subregions and the passive dewatering facilities are less likely to be damaged or exposed (Table 36).

Table 36 Summary of Evaluation Criteria for Passive Dewatering

Evaluation Criteria	
Reduce threat to structures	Potentially yes
Maintain Beach Width	Potentially yes, except in storm / large wave conditions
Economic Costs	Ongoing maintenance and leasing costs, less than active system
Environmental Impacts	Potentially to sandy beach invertebrates
Recreational	No impacts
Safety and Public Access	No impacts
Aesthetics	No impacts
Regulatory Viability	Probably, likely requires Coastal Commission, State Lands Commission, and Sanctuary permits/approvals
Adaptability to Future Conditions	Potentially improves
Cumulative Impacts	Potential impacts to sandy beach ecosystem, energy expenditure to run pumps
Certainty of Success	Uncertain, except in storm / large wave conditions where erosion is expected

Discussion

Beach dewatering by gravity flow includes wells with a discharge pipe to the sea (Figure 29) and individual point wells (Figure 30). The point wells have been patented by Skagen Innovation Center (SIC) of Denmark and commercially marketed as Pressure Equalizing Modules, PEM's. The PEM's are vertical drain pipes approximately 6 feet in length and 2.5 inches in diameter with perforations in the bottom 3 feet. The slots allow water to flow in and out of the pipes, but exclude sand. They are typically spatially distributed in 3-5 cross-shore rows spaced 30 feet apart and separated 300 feet apart in the alongshore for one mile or more. The PEM system works during a falling tide when the sea water level in the beach intersects the perforated part of a particular PEM resulting in water flowing into the upper part of the pipe and flowing out the lower part of the pipe. The efficiency of the PEM is gained by the lack of flow resistance within the pipe. A program to assess the field performance of the PEM's was funded for one million Euros in 2004 by SIC and the Danish government and the independent results are reported by Burcharth (Burcharth, 2008). The PEM system was installed in January 2005 in two sections with test sections at the ends and in between over 11 km on the Danish coast. The foreshore and beach was composed of medium to very coarse sand with grain size diameter in the range 0.3-2.5 mm. Beach profiles were measured quarterly for three years. The beach profile analysis concluded there was no clear correlation between movements in the coastline position or changes in volume with the location of the PEM's as compared with the test sections. In addition, the PEM's were tested with pressure transducers and simulated with numerical modeling. The conclusion of the modeling was that the PEM's under certain conditions might increase the drainage in the beach, but the effect will be small. The report summarized that the PEM's will under certain conditions have a positive effect of increased drainage and perhaps accretion of sand, but the effect is marginal and almost impossible to detect in the background of the large natural morphological changes of a natural beach system. Therefore, it was concluded the effect of the PEM's is not sufficient as a coastal protection method on exposed coasts.

PEM systems have been deployed in the US (2), Denmark (5), Sweden (4), Ghana (2), Malaysia (3), and Australia (2). Two applications were reported at the 2008 ICCE to give positive results by (Jakobsen and Brogger (Jakobsen & Brogger, 2008) and Brogger and Jakobsen (Brogger & Jakobsen, 2009), but their conclusion created considerable argument from the audience on their methodology and analysis. The latest US application was in 2007 in Hillsboro, Florida. An independent review by Bob Dean found that the surveys did not show any discernable patterns that establish a positive or negative influence of the PEM installation on shore change. The study was complicated by two small nourishments placed nearby and the fact that shore data tends to be "noisy" owing to seasonal and storm induced variability. Thus, the results were found inconclusive and Dean concluded "that the PEM system is not exerting a substantial shore stabilizing influence."

Ecological Impacts

There is little understanding of the ecological effects of passive dewatering on the sandy beach and dune ecosystem although it is likely to influence the tidal migrations of the sandy beach invertebrates which occurs on a daily basis.

Regulatory Viability

Would require Coastal Commission, State Lands Commission, and Sanctuary permits/approvals.

Cost and Benefits

The PEM system installation and monitoring costs are $100K per mile and are leased at $100K per year per mile which includes monitoring and maintenance as quoted by the PEM representative. After the 5 years, the system can be purchased. Currently there has not been a trial in California and the representatives may entertain a reduced rate trial. Benefits are difficult to ascertain given uncertainty about performance but given the low cost compared to some of the structural alternatives and thus an experiment to examine its performance may be warranted.

4.2.3.2 Beach Dewatering – Desalination Wells

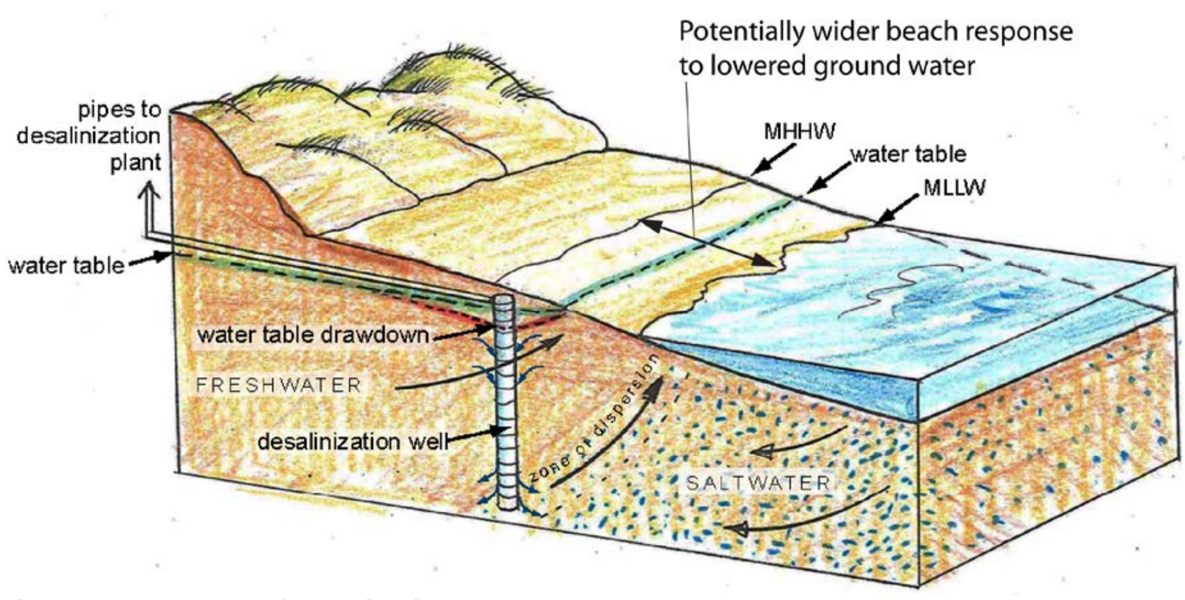

Figure 31 Example of Desalination Wells

General Applicability

Active desalination dewatering is believed to be potentially applicable to any sandy beach with some kind of groundwater basin or aquifer

Specific Applicability

This management alternative is most relevant for application to Subregions 4 and 5 where wells are either planned or have been installed. We believe this measure is most relevant for application to areas with low erosion rates and storm erosion amounts where the dewatering pipes are less likely to be damaged or exposed (Table 37).

Table 37 Summary of Evaluation Criteria for Desalination Wells

Evaluation Criteria	
Reduce threat to structures	Potentially by widening beach
Maintain Beach Width	Yes , except in storm / large wave conditions
Economic Costs	Ongoing maintenance and pumping costs, reinstallation following storm impacts
Environmental Impacts	Potentially to sandy beach invertebrates
Recreational	No impacts unless pipes exposed
Safety and Public Access	No impacts unless pipes exposed
Aesthetics	No impacts unless pipes exposed
Regulatory Viability	Uncertain, extensive state and federal permitting and environmental review processes
Adaptability to Future Conditions	Adaptable in short term, questionable in medium to long term without relocating pumps and dewatering pipes
Cumulative Impacts	Potential impacts to sandy beach ecosystem, energy expenditure to run pumps
Certainty of Success	Relatively certain (qualitatively, not quantitatively), except in storm / large wave conditions

Description

Pumping of wells located near the shore to obtain water for desalinization plants at Sand City, Marina and Fort Ord have the potential to lower the ground water-table at the beach resulting in possible erosion mitigation. The Sand City desalinization plant, which went into operation May 2010, pumps a coastal aquifer that is formed by a shallow wedge of quasi-fresh water overlying salt water from the ocean. The aquifer is composed of an approximately 50 feet deep sand layer bounded by an impermeable clay barrier that separates it from the deeper Seaside Basin aquifer. The shallow aquifer ground water system is relatively insensitive to climatic variations owing to recharge by the outflow of Robert’s Lake located 1200 feet from the ocean, which is maintained at an elevation of +9.5 feet. The plant operates two vertical intake wells pumping 320 gpm each located 220 feet from the beach separated by 1635 feet alongshore at Bay Street and Tioga Avenue in Sand City. The concentrate discharge is injected into the saline wedge through a 500 foot long horizontal well, 20 feet below sea level, parallel to the shore 100 feet from the ocean between the two intake wells. The ground water elevation at the Bay Street well is naturally +2.5 feet relative to MSL and the ground water slopes seaward intersecting the beach at +2 feet MSL.

Variations in the ground water elevation at the test well were found correlated with wave height owing to set-up on the beach by waves. Thus, the ground water levels on the beach and the well are connected. Test showed that pumping at 420 gpm lowered the ground water in the test well 1-2 feet (Feeney and Williams, 2002). Assuming the water table draw-down between the well and the ocean is horizontal, the pumping has the potential to lower the beach face ground water level 1-2 feet. Field measurements of other beach drainage systems found that the lowered the ground water table extended at least 300 feet alongshore away from the location of the wells (Vesterby, 1994). Therefore, the two wells have the potential of influencing approximately 1200 feet of shore.

Regulatory Viability

Uncertain, extensive state and federal environmental review and permitting would be required (California Coastal Commission, 2004), and unlikely to occur solely for erosion mitigation.

Ecological Impacts

There is little understanding of the ecological effects of desalination on the sandy beach and dune ecosystem.

Cost and Benefits

As this is a system of opportunity, there are no costs, except for possible monitoring. Benefits are not known due to uncertainty about performance.

4.2.4 Beach Nourishment

Description

Beach Nourishment is the placement of sand to increase existing sand volumes and build beach widths (Figure 32). This strategy is widely utilized along the east coast of the United States with less frequency along the US West coast. The success of the nourishment depends on the volume of nourished material, the grain size, and the proximity or use of sand retention structures (Table 38).

Figure 32 Schematic of Beach Nourishment in Southern Bight

General Applicability
Beach nourishment is potentially applicable to any beach where either barge or vehicular access is possible and sand of appropriate quality and quantity is available.

Specific Applicability
This management alternative is most relevant for application to Subregions 1-4 to address all critical erosion areas in the southern bight (PWA et al., 2008).

Table 38 Summary of Evaluation Criteria for Beach Nourishment

Evaluation Criteria	
Reduce threat to structures	Yes – depends on volume and duration that material remains in place
Maintain Beach Width	Widens
Economic Costs	Potentially high, depends on sediment sources, transportation costs, and placement methods
Environmental Impacts	Short term impacts with the severity depending on placement mechanisms and preexisting conditions
Recreational	Improves – after placement
Safety and Public Access	Depends on sediment characteristics, likely improves but potential short term impact to safety caused by alterations in breaking wave characteristics
Aesthetics	Depends on sediment characteristics
Regulatory Viability	Uncertain, may require Congressional modification of MBNMS Designation Document
Adaptability to Future Conditions	Yes, but periodic nourishments likely to be required
Cumulative Impacts	Depends on volumes, number and mechanisms of placements
Certainty of Success	Certain in immediate term, uncertain in short to long term without sand retention structures

Discussion

Subaerial Placement:

Subaerial placement of sand is the placement of sand on the dry beach (Sub-aerial is "under the air" as opposed to submarine or "under the water".) This method of placement results in an immediately wider beach, but as the waves sort the sand material and work the beach face to relocate sand through the entire beach profile and especially the offshore part of the profile, the beach may rapidly lose width to accommodate this profile adjustment. Normally when sand is placed directly on the beach, there needs to be some local education so the public knows that this rapid loss of beach is a normal process and that it is not an indication that the nourishment project has been a failure.

Nearshore Placement:

Nearshore placement puts sand into the submarine nearshore. The intent is that this sand will buffer offshore waves and at the same time, that onshore wave movement will carry some of this sand inland to create a wider beach. Nearshore placement of sand should result in a wider dry beach, but at a much more gradual rate than if the same volume of sand were placed directly into the dry beach. The option of placement often depends upon the original source of sand and the equipment that is available to move the sand from its source location to the receiver site.

Dredge Sand from Deep or Offshore Deposits:

There are many areas of the offshore that have sand deposits; however, this sand is too far removed from the shore and regular coastal processes to be carried onto the beach by normal processes. This sand can be dredged and placed either on the beach or in the nearshore, where it can become part of the littoral sand supply and nourish beach areas. Dredging sand from deep or offshore deposits is a way to add new sand material to the littoral supply.

Effectiveness – Maintaining beach width vs. protecting upland property

Under the large beach nourishment option as described in the CRSMP, beach nourishment appears to be a moderately successful tool at balancing maintaining beach widths with upland property protection. In general, the beach widths fluctuate dramatically, enlarging after a fill project and then eroding in the following years at an accelerated rate, however as long as the beach width remains wider than the initial beach widths, then it can be assumed that the upland property is not affected by erosion (Figure 33)). For reaches of southern Monterey Bay with erosion rates less than 1.5 ft/year, a 25 year nourishment cycle seems able to limit upland erosion, although the analysis in the CRSMP recommended renourishment very 20 years or more frequently depending on storms. However, for reaches north of Sand city with higher erosion rates, there is indication that upland erosion occurs between nourishments. One solution would be to reduce the time period between nourishments, but that was not analyzed in detail in this report.

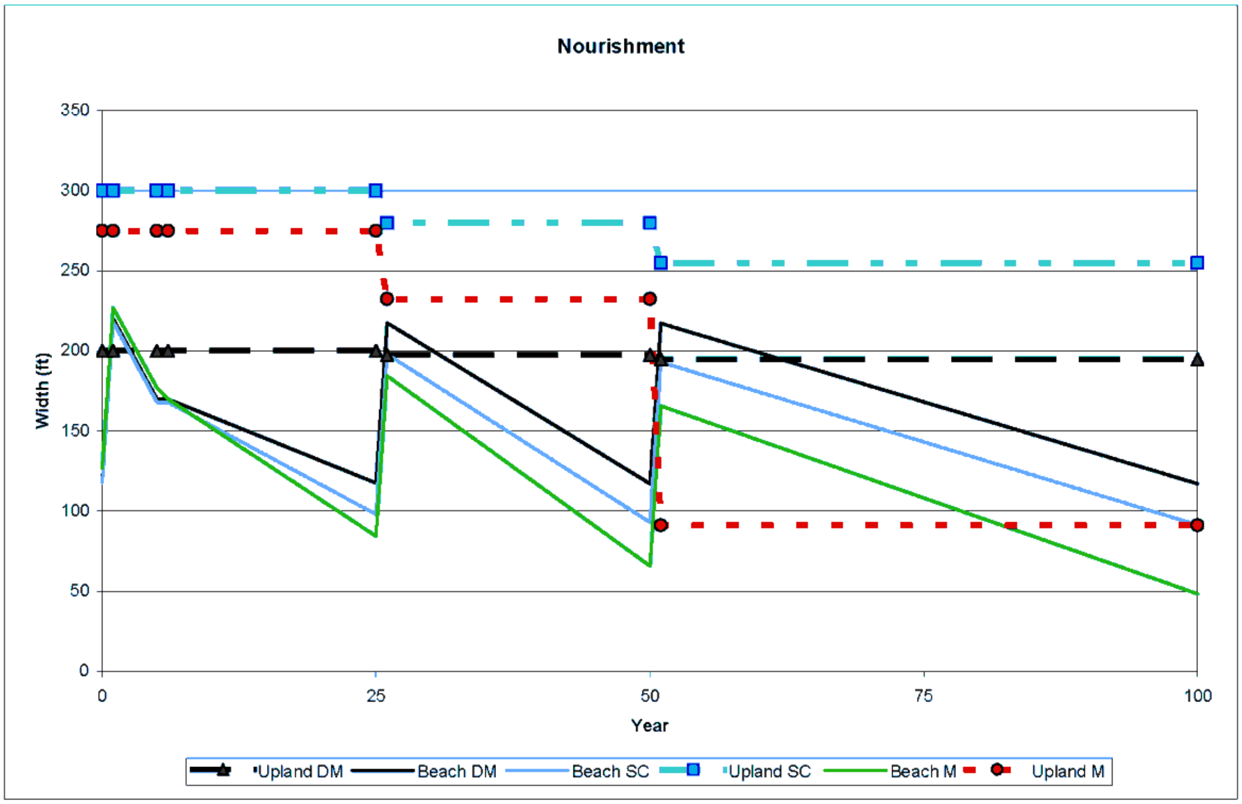

Figure 33 Effectiveness of beach nourishment at maintaining dry sand beach widths and upland property over time assuming 2million cubic yards placed every 25 years

Regulatory Viability

The regulatory viability of beach nourishment is uncertain. At present, this is not likely to be a viable option under existing MBNMS Regulations.

Ecological Impacts
Beach nourishment, as currently practiced, can create significant and lasting impacts to beach ecosystems, although comprehensive studies are limited (National Research Council, 1995; CSMW, 2008). The project size, timing, amount, zone, fill method and sediment match are all important to determining the level of impacts. Immediate impacts occur to both the “borrow” and “receiver” sites. For example, near complete mortality of species living in the intertidal zone, significant declines in shorebird use and physical alterations to the habitat (such as rocky reef or eelgrass beds) may cause lasting impacts to the distribution and abundance of impacted species living within receiver sites (Peterson et al., 2006; Speybroeck et al., 2006). Recovery may be delayed, especially if repeated nourishment occurs in the same area (Dolan et al., 2006). Nourishment impacts to the beach ecosystem can propagate up the beach food web from invertebrates to shorebirds and fish, including endangered species such as snowy plovers. In SANDAG where the beach had been reduced to cobble substrate the sand nourishment did restore some of the shorebird habitat although extensive ecological monitoring of the sandy beach ecosystem was not conducted.

The extent of impacts may be mitigated if timed appropriately. For example, sand crab recruitment occurs primarily in the late winter and spring. If nourishment activities avoid this time frame, potential recovery of at least some young of the year individuals could occur. However for longer-lived species with irregular recruitment, such as Pismo clams, impacts to existing populations could last for many years. Other invertebrates, such as amphipods, isopods and flightless insects, depend on the growth, reproduction and survival of resident populations, including their survival through winter bottlenecks, to recover and to produce any subsequent generations. Impacts to these taxa from beach replenishment projects implemented at any time of year could last for years as well.

Cost and Benefits
Tables 39, 40 and 41 present the benefit and cost analysis for nourishment. See section 3.5.2 for the assumptions used in this measure.

Table 39 Present Value of Benefits and Costs for Nourishment: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 6,264,058	$ 8,683,684	$ 6,467,992	$ 3,336,364	$ 24,752,098
Total Habitat Value above Baseline	$ 2,379,420	$ 3,343,773	$ 3,770,172	$ 1,456,984	$ 10,950,350
Sum Benefits	$ 8,643,478	$ 12,027,458	$ 10,238,163	$ 4,793,348	$ 35,702,448
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ 864,000	$ -	$ -	$ 864,000
Cost of Pubic Property Compensation	$ -	$ 17,415	$ 6,689	$ 2,004	$ 26,108
Construction/Nourishment Cost	$ 12,000,000	$ -	$ 3,543,633	$ 1,355,463	$ 16,899,096
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ (31,200,000)	$ 881,415	$ (9,206,757)	$ (3,522,199)	$ (43,047,541)
Net Benefits	**$ 39,843,478**	**$ 11,146,043**	**$ 19,444,920**	**$ 8,315,547**	**$ 78,749,989**
Benefit/Cost Ratio	**-0.3**	**NA**	**-1.1**	**-1.4**	**-0.8**

Table 40 Present Value of Benefits and Costs for Nourishment: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 13,992,272	$ 19,837,540	$ 8,551,893	$ 3,080,322	$ 45,462,026
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 23,636,352	$ 33,071,961	$ 13,382,444	$ 4,498,989	$ 74,589,747
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Net Benefits	$ 16,496,608	$ 24,645,803	$ 15,664,919	$ 5,181,217	$ 61,988,547
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ 239,846	$ 102,365	$ 34,378	$ 376,589
Cost of Pubic Property Compensation	$ -	$ 216,963	$ 101,199	$ 34,047	$ 352,209
Construction/Nourishment Cost	$ 50,000,000	$ -	$ 14,765,139	$ 5,647,761	$ 70,412,900
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Net Cost	$ (130,000,000)	$ 456,809	$ (38,185,797)	$ (14,615,755)	$ (182,344,742)
Net Benefits	**$ 146,496,608**	**$ 24,188,995**	**$ 53,850,715**	**$ 19,796,972**	**$ 244,333,290**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 41 Present Value of Benefits and Costs for Nourishment: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 13,910,851	$ 19,337,757	$ 7,783,927	$ 2,569,539	$ 43,602,075
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 31,069,085	$ 39,460,633	$ 13,310,839	$ 3,995,526	$ 87,836,083
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 21,758,160	$ 37,633,468	$ 21,094,766	$ 6,565,065	$ 87,051,459
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	0	0	0
Cost of Private Property Compensation	$ -	$ 2,891,074	$ 13,421,057	$ -	$ 16,312,131
Cost of Pubic Property Compensation	$ -	$ 3,501,609	$ 4,121,033	$ 2,004	$ 7,624,645
Construction/Nourishment Cost	$ 69,500,000	$ -	$ 19,546,231	$ 7,850,388	$ 96,896,620
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ (180,700,000)	$ 6,392,683	$ (36,796,432)	$ (20,409,006)	$ (231,512,756)
Net Benefits	**$ 202,458,160**	**$ 31,240,785**	**$ 57,891,199**	**$ 26,974,071**	**$ 318,564,214**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that Nourishment has a net positive cost benefit primarily as a result of avoidance of revetment construction cost, a reduction in private and public costs as well as avoidance of costs associated with the replacement of the MRWPCA infrastructure. The total benefits over the entire study for the 100 year planning horizon total about ~$631 million with that made up of ~$185 million in recreation and ecosystem benefits. Construction costs associated with 100 years of nourishment are estimated at ~$184 million for the entire study area

Nourishment provides substantial benefits over the use of revetments. However, beach nourishment does not protect development and upland property as well as revetments. This means that a more frequent sand placement rate is required than the 25 years assumed based on CSBAT calculations in the CRSMP.

The nourishment benefits are likely overstated, because the degradation of beach ecology associated with nourishment construction was not considered in this analysis. This would mean that the habitat benefits are overstated relative to land use planning measures. . The analysis could be improved by reducing habitat value until re-population could occur. However there have been no long term systematic sandy beach ecological studies on the impacts and recovery time of nourishment in California that could inform this habitat degradation value. Conceptually, though if it took 10 years for the beach ecology to recover, for example, then the ecological value would be reduced significantly since the ecology would be degraded about half of the time.

4.3 REGIONAL EROSION MITIGATION ALTERNATIVES – HARD ENGINEERING APPROACHES

Hard Engineering Approaches refers to structural measures. This follows the coastal engineering and management practice vernacular that shoreline armoring are “hard” structural measures and sand placement is a “soft” non-structural measure. Structural measures include rock revetments (aka rip rap, rock slope protection), seawalls, artificial reefs, groins and breakwaters.

4.3.1 Artificial Reefs/ Submerged Breakwaters/ Low Crested Structures

Description

The artificial reef (submerged breakwater or low crested structure) is a variant of the common shore-parallel emergent breakwater in which the structure crest height is below the still water level (i.e., non-surface piercing) (Figure 34). Artificial reefs installed to act as submerged breakwaters have received increased attention in recent years as a means of shore stabilization and erosion control, primarily due to their low aesthetic impact and enhanced water exchange relative to traditional emergent breakwaters (Vicinanza et al., 2009) and the potential to enhance local surfing conditions (Ranasinghe & Turner, 2006). These structures are designed to be overtopped and to provide partial wave attenuation through greater wave reflection, breaking, and turbulent energy dissipation than a natural beach (Dean & Dalrymple, 2002). Artificial reefs can reduce the amount of wave energy reaching the shore that cause erosion, and can also create an area of relatively calm conditions shoreward of the reef, allowing suspended sand to be deposited and often a salient to build out.

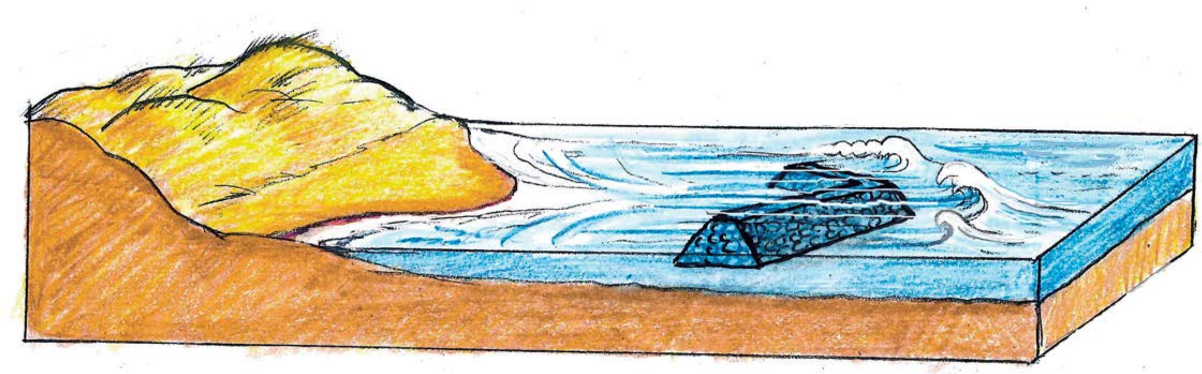

Figure 34 Schematic of an Artificial Reef

Three general types of artificial reefs are recognized in the literature: (1) rubble-mound with trapezoidal cross section, (2) prefabricated modular units, and (3) flexible-membrane units (Harris 1996). Laboratory tests were conducted starting in the mid-1980s to determine the degree of wave attenuation possible with these structures. Ahrens and Fulford showed that properly designed structures could initiate premature wave breaking and greater wave height dissipation than a natural sloping beach, with as much as 17-56% reduction in wave height (Ahrens & Fulford, 1988). Armono and Hall investigated in a laboratory study the effects of different configurations of hollow hemispherical shaped artificial reefs on wave transmission, and found that on average, there was about a 60% reduction in wave energy associated with the structures (Armono & Hall, 2003). Field installations of pre-fabricated reef units began in the 1970s and 1980s along the Atlantic, Great Lakes, Gulf of Mexico, and Hawaii coasts (Goldsmith et al., 1992), although detailed field experiments and monitoring projects did not begin until the late 1980s (summarized in Stauble & Tabar, 2003).

Artificial reefs must be designed to endure the forces of heavy waves and are typically constructed of durable materials such as concrete, rock, or sand-filled geotextile containers. Structures built using geotextile containers have the advantage of improved safety as well as being easily modified or removed. Certain commercially designed components such as the Prefabricated Erosion Prevention ("P.E.P.") reef and Beachsaver breakwater units are manufactured (i.e., pre-fabricated) and sold for this purpose, and some are designed to provide habitat for marine organisms (e.g. ReefBall). The pre-fabricated units are typically modular and fitted together in the field to create a continuous structure. For the modular units above, typical unit dimensions are 5 ft high, 10-25 ft long, and 15 ft wide at the base, with a crest width of 1-2 ft. Units are typically installed using a barge-mounted crane in the nearshore region at a depth shallow enough to influence incoming waves.

The effectiveness of a submerged structure in dissipating wave energy is controlled by the structure dimensions, water depth and distance offshore, local wave conditions, and nearshore bathymetry (Dean et al., 1994; Wamsley et al., 2002). Dattatri et al. identified the relative submerged depth and relative crest width of the structure as being significant factors associated with wave transmission (Dattatri et al., 1978), and Ahrens developed relationships of wave transmission and reflection as a function of relative crest height and relative water depth (Ahrens, 1987). Other design parameters such as structure material and weight, surface area and habitat value, wave and current interaction with the structure, and scour, deposition, and settlement should also be considered (Table 42).

General Applicability

Artificial reefs and low crested breakwaters are potentially applicable to any location with a relatively stable sea bed. Given their function, they are typically constructed in an environment with wave energy.

Specific Applicability

This management alternative is most relevant for application to Subregions 1-4 to address critical erosion areas throughout.

An offshore reef was one of the alternatives considered for the Ocean Harbor House seawall project (Del Monte Beach, CA), however was abandoned due to regulatory considerations, even though it was concluded that this option would "provide long-term protection of the sand dune bluff feature that protects the shallow spread footings of the buildings, the common area, and the sewer system and other utilities".

Table 42 Summary of Evaluation Criteria for Artificial Reefs

Evaluation Criteria	
Reduce threat to structures	Yes
Maintain Beach Width	Yes – potentially widen behind structure
Economic Costs	High – depends on type and source of material, transportation, and placement costs. Ongoing monitoring and maintenance
Environmental Impacts	Potential impacts to offshore bottom species, promotion of non-native species, alters habitat types from sand to rock
Recreational	Potentially improves surfing and fishing
Safety and Public Access	Improves
Aesthetics	Minimal impacts if any below sea surface
Regulatory Viability	Uncertain
Adaptability to Future Conditions	Potentially – depends on rate of climate changes, ability to add material to increase crest of structure elevation
Cumulative Impacts	Conversion of sand bottom habitat to rock reef, increase in non-native species diversity and abundance
Certainty of Success	Mixed results, more certain in short term, uncertain in short to long term without placement of additional material or raising crest elevation

Discussion

The increased popularity of submerged structures is due, in part, to the growing recognition that the structures can be optimized to enhance local surfing conditions. Engineering design and implementation of artificial surfing reefs is still in its infancy, and only six structures have been constructed worldwide in California, UK, Australia, and New Zealand (Scarfe, 2008). Little is known about the shore response to these structures because the concept of multi-functional (i.e., wave dissipation, habitat, and recreation) artificial reefs is relatively new.

The shore response to submerged structures is not well understood and is an area of active research. While the theoretical concept of using a submerged structure to dissipate wave energy (i.e., reduce wave height) is sound (Ahrens, 1987; Ahrens & Fulford, 1988; Armono & Hall, 2003), the implementation of these structures to promote *shore stability* is yet to be proven (Scarfe, 2008). Relatively little is known about the shore response to submerged structures in general, and key environmental and structural parameters governing shore response are yet to be fully resolved (Ranasinghe & Turner, 2006). In a review of shore response to submerged structures, Ranasinghe et al. reported mixed results, and concluded that 70% of documented cases actually resulted in net shore erosion in the lee of the structure (Ranasinghe et al., 2006).

The well-established methods currently used to predict shore response to emergent structures cannot be directly applied to submerged breakwaters because of the fundamentally different interaction of the structure with the nearshore wave and current field (Ranasinghe & Turner, 2006). Dean et al. proposed that the normal seaward return flow of water pumped over the structure by waves is impeded by the presence of the breakwater, resulting in increased currents and scour at the ends of the breakwater (Dean et al., 1994). In a modeling study of the morphologic impacts of submerged breakwaters, Lesser et al.

observed scour holes at the breakwater ends and between breakwater sections for various breakwater-gap configurations (Lesser et al., 2003). Bathymetric monitoring of the artificial surfing reef at Mount Maunganui, NZ documented a scour hole 3 times the size of the structure itself (in the lee of the structure) (Scarfe, 2008).

In addition to modifying local hydrodynamics, localized scour can also act to destabilize the structure. Stauble and Tabar discuss the performance of six installations of modular narrow-crested submerged breakwaters in Florida and New Jersey, all of which experienced scour landward of the breakwater that undermined the base of the structures and contributed to settlement and slumping of the units by 1.5 to 5.0 ft. Since settlement acts to increase the submerged depth of the structure and reduce effectiveness, controlling scour and settlement is a key design issue (Stauble & Tabar, 2003). Recent installations have employed a geotextile fabric base with concrete anchor to minimize scour and settlement (Stauble & Giovannozzi, 2003).

Structure resilience to storms and sea level rise is another important design consideration. Both storm surge and sea level rise act to increase the depth of submergence of the structure, and reduce effectiveness. Over time, settlement of the Vero Beach, FL pre-fabricated modular breakwater units rendered the structures ineffective in terms of wave dissipation due to the increased submergence of the structure (Priest & Harris, 2009). This highlights the major disadvantage of the submerged breakwater – that they become less effective during storms due to storm surge (Dean & Dalrymple, 2002), and over time with sea level rise. Designs which anticipate the gradual increase in submergence with sea level rise and allow for structure modification (e.g., stackable geotextile tubes) in the future will be more resilient to climate change.

While artificial reefs are typically associated as having fewer environmental impacts (e.g., aesthetic and water quality) than other alternatives, they do involve activities that can significantly impact the seafloor environment. However if properly designed and sited, these structures can have the advantage of potential environmental enhancement by providing habitat for marine life as well as recreational enhancement and shore protection. Another important consideration with any submerged offshore structure is the impacts it can cause to recreational and commercial activities that occur in the vicinity, as it can represent a significant hazard.

Effectiveness – Maintaining beach width vs. protecting upland property

Under the artificial reefs that are used in conjunction with a large nourishment project as a retention device, the effect on effectiveness at maintaining beach widths and upland property is shown below (Figure 35). In this case, the beach widths oscillate based on the fill interval with upland property only eroded along reaches of SMB where erosion rates exceed 3 ft/year.

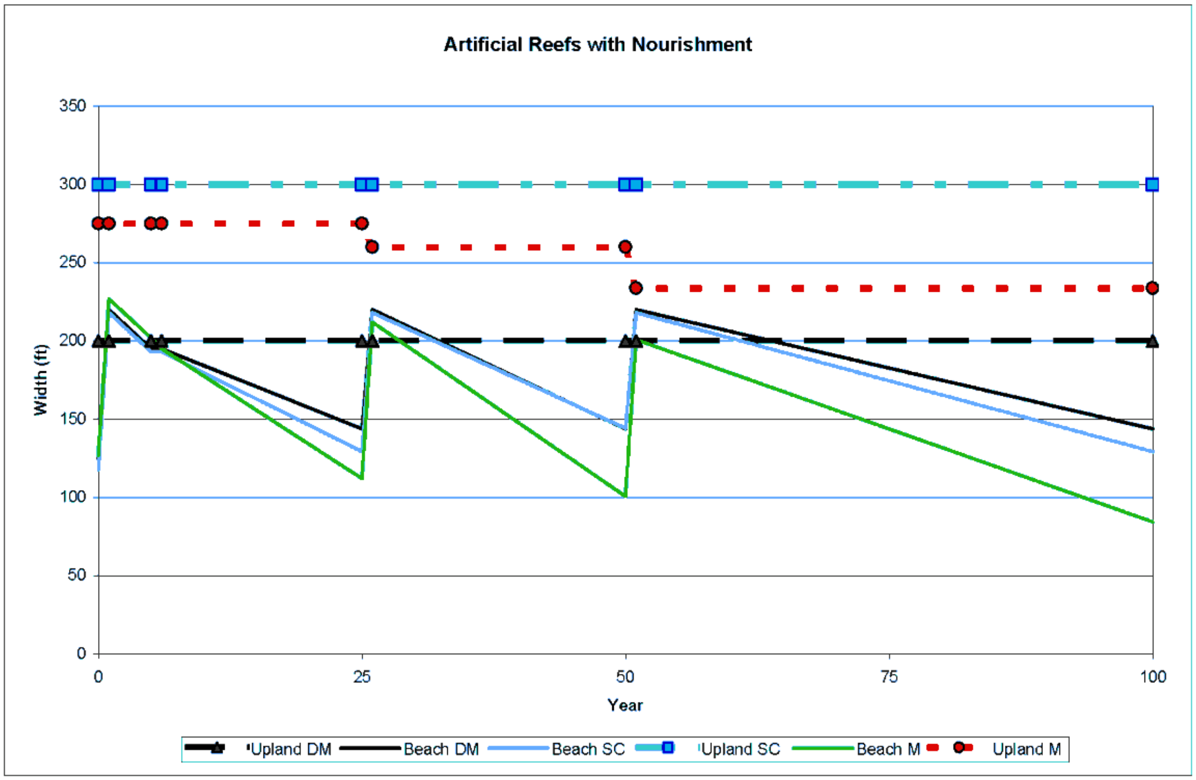

Figure 35 Effectiveness of artificial reefs as a sand retention device used in conjunction with a large beach nourishment at maintaining dry sand beach widths and upland property over time

Regulatory Viability

The regulatory viability of offshore structures is uncertain. Constructing offshore structures in the marine environment within a National Marine Sanctuary would require MBNMS NEPA review and authorization for seabed alteration.

Ecological Impacts

Ecological Impacts are unknown in SMB but expected to be site-specific. The conversion of sandy substrate to rocky reef would be one unavoidable impact. In Narrowneck, Australia, the reef became a favorite spot for recreational fishing since it was the only hard substrate within a large sandy bay. Some initial ecological evaluation results of Low Crested structures in Italy suggest that the hard structures preferentially favor generalist species with high recruitment rates as opposed to more soft substrate dwelling species (Airoldi et al., 2005). The conversion of such of artificial hard substrata in predominately soft sediment ecosystems can provide habitat and stepping stones for sessile species, many of which are invasive or weedy forms.

Costs and Benefits

Tables 43 - 45 present the benefit and cost analysis for artificial reefs. See section 3.5.2 for the assumptions used in this measure.

Table 43 Present Value of Benefits and Costs for Reefs: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 6,263,912	$ 10,455,313	$ 9,735,916	$ 3,661,289	$ 30,116,431
Total Habitat Value above Baseline	$ 2,606,574	$ 4,387,256	$ 4,062,990	$ 1,554,120	$ 12,610,940
Sum Benefits	$ 8,870,486	$ 14,842,569	$ 13,798,906	$ 5,215,409	$ 42,727,371
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 93,600,000	$ -	$ 27,640,339	$ 8,162,269	$ 129,402,608
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ 50,400,000	$ -	$ 14,883,260	$ 3,282,603	$ 68,565,863
Net Benefits	**$ (41,529,514)**	**$ 14,842,569**	**$ (1,084,354)**	**$ 1,932,807**	**$ (25,838,492)**
Benefit/Cost Ratio	**0.18**	**NA**	**0.93**	**1.59**	**0.62**

Table 44 Present Value of Benefits and Costs for Reefs: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 14,581,846	$ 22,753,697	$ 10,014,746	$ 3,734,999	$ 51,085,287
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 24,582,824	$ 38,696,898	$ 17,322,610	$ 6,626,011	$ 87,228,343
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 18,032,654	$ 33,186,897	$ 21,067,938	$ 7,962,916	$ 80,250,404
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 390,000,000	$ -	$ 115,168,081	$ 44,052,539	$ 549,220,620
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ 210,000,000	$ -	$ 62,013,582	$ 23,720,598	$ 295,734,180
Net Benefits	**$ (191,967,346)**	**$ 33,186,897**	**$ (40,945,644)**	**$ (15,757,682)**	**$ (215,483,776)**
Benefit/Cost Ratio	**0.09**	**NA**	**0.34**	**0.34**	**0.27**

Table 45 Present Value of Benefits and Costs for Reefs: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 14,468,120	$ 21,837,871	$ 9,195,297	$ 3,216,681	$ 48,717,969
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 32,384,681	$ 47,230,252	$ 18,859,604	$ 5,972,042	$ 104,446,579
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 23,631,024	$ 47,903,200	$ 28,054,901	$ 9,188,723	$ 108,777,848
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	0	0	0
Cost of Private Property Compensation	$ -	$ 2,186,381	$ 4,949,671	$ -	$ 7,136,051
Cost of Pubic Property Compensation	$ -	$ 2,677,181	$ 2,513,731	$ -	$ 5,190,912
Construction/Nourishment Cost	$ 542,100,000	$ -	$ 152,460,602	$ 61,233,030	$ 755,793,632
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ 291,900,000	$ 4,863,562	$ 86,039,250	$ 32,971,631	$ 415,774,444
Net Benefits	**$ (268,268,976)**	**$ 43,039,637**	**$ (57,984,349)**	**$ (23,782,908)**	**$ (306,996,595)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that the Artificial Reefs with Nourishment measure show a net negative cost benefit primarily as a result of high construction cost. Construction costs associated with 100 years of reefs with nourishment are estimated at ~$1.18 billion. Some positives are the benefits from reduction in private and public costs as well as avoidance of costs associated with the replacement of the MRWPCA infrastructure. The total costs (negative net benefits) over the entire study for the 100 year planning horizon total about ~$547 million with that made up of ~$232 million in recreation and ecosystem benefits.

In all three reaches the benefits of using reefs as a policy alternative do not outweigh the costs. Indeed, in many cases the net benefits are negative, implying that reefs, even though they cost more than the baseline strategy of revetment, actually lower overall benefits. The most striking differences are in the 0-5 year planning horizon, where the costs are ten to twenty times the benefits in Del Monte and Sand City respectively. Net benefits are only positive for the 6-25 year planning horizon. However that is misleading because our model assumes that reefs are replaced every 25 years and the 5-25 year horizon does not include those costs. As the 100-year planning horizon indicates, the overall benefit cost ratio is far less than one in all instances, indicating that artificial reefs are not likely to be cost-effective. However, they do maintain a beach, protect inland property and could potentially mitigate some of the adverse effects of beach nourishment (less frequent sand placement, new subtidal habitat) and recreational effects (surfing and fishing benefits).

4.3.2 Groins

Description

Groins are structures built to extend out from the beach with the objective of capturing or retaining sand. Sand capture occurs as sand is transported alongshore by the waves and alongshore current (Figure 36). When the sediment being transported alongshore encounter the groin, the currents and sediment are diverted offshore into deeper water where the currents slow down depositing much of their sediment load. Alternative groin designs include weir groins and partially transparent groins that slow down the alongshore current transport the sediment so that the sediments are deposited at the groin. Groins work best where there is a dominant wave direction that drives currents and sediment alongshore. Groins are also used to retain a nourished beach at its end, again in a location where there is a dominant transport towards the groin (Table 46).

Traditionally groins have been built out of rock, concrete or sheetpile. There are some innovative designs that use geotextile bags or tubes, filled with gravel, stone, sand, or other material, instead of the more traditional materials. The geotextile groins can be built entirely of filled geotextile bags or tubes, or could be filled with more traditional rock as an outer armor layer. Any groin project would need to be designed for the local wave and current regime and the local forces may limit the use of various materials

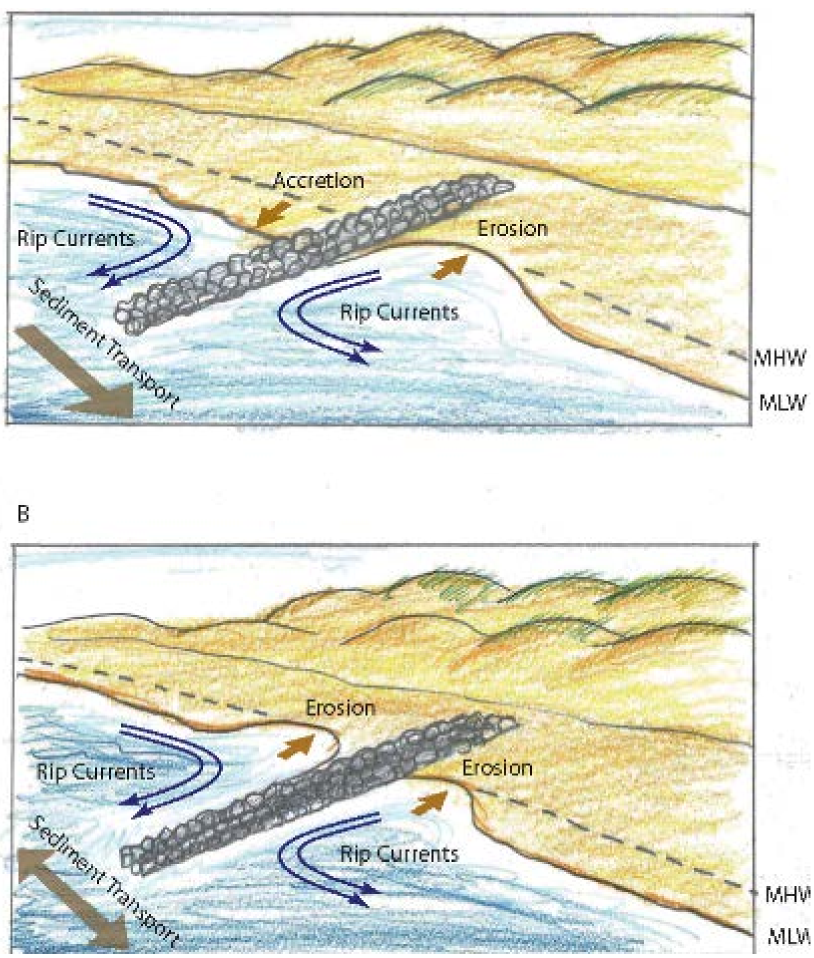

Figure 36 Examples of Groins

General Applicability

Groins are generally considered along stretches of coast with high net longshore sediment transport. The authors posit that the most applicable location for groins is in an area of increased longshore transport rate between slower transport rate areas: This situation would allow for a finite length of groin field and limited downstream erosion effects. These conditions do not exist along the sandy shores in southern Monterey Bay.

Specific Applicability

This mitigation measure is most relevant for application to Subregions 1-4 to be used possibly for sand retention in conjunction with beach nourishment.

Table 46 Summary of Evaluation Criteria for Groins

Evaluation Criteria	
Reduce threat to structures	Yes generally in areas updrift of structure
Maintain Beach Width	Potentially improves updrift narrows downdrift
Economic Costs	High
Environmental Impacts	Yes
Recreational	Potential benefits to beach width and surfing
Safety and Public Access	Impacts from rip current generation, and lateral access
Aesthetics	Impacts
Regulatory Viability	Uncertain
Adaptability to Future Conditions	Depends on rates of climate change, likely not in medium/long term
Cumulative Impacts	Likely downcoast erosion impacts. One groin usually leads to fields of groins, a reasonable expectation of long term buildout of groin field
Certainty of Success	For areas with mainly uni-directional transport, and with pre-filling of the accretion fillet: Certain in short term, less certain in medium/long term

Discussion

Well-defined rip channels and associated rip currents are the dominant morphologic feature in southern Monterey Bay owing to the near-normal wave incidence year-round (Reniers et al., 2007). The near-normal wave incidence results in weak alongshore currents. Placing a groin in a rip field acts as a perturbation on the morphology that will result in a rip current at the groin. The strong off-going current will most likely create a scour hole off the end of the groin. Instead of capturing sand, the groin may act to enhance erosion locally.

Effectiveness – Maintaining beach width vs. protecting upland property

Under this mitigation measure groins would be used in conjunction with a large nourishment project as a retention device, the affect on effectiveness at maintaining beach widths and upland property is shown below (Figure 37). In this case, the beach widths oscillate based on the fill interval with upland property only eroded along reaches of SMB where erosion rates near 4.5 ft/year.

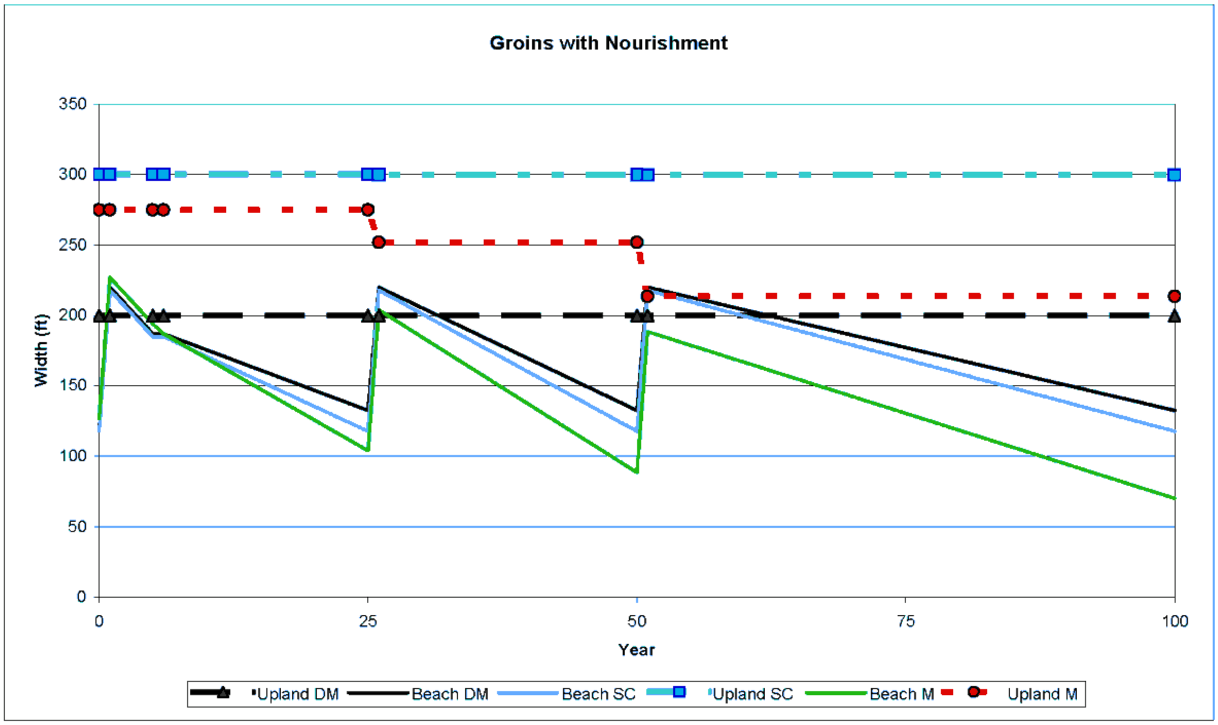

Figure 37 Effectiveness of groins as retention structures plus beach nourishment at maintaining dry sand beach widths and upland property over time

Regulatory Viability

Uncertain, constructing offshore structures in the marine environment within a National Marine Sanctuary would require MBNMS NEPA review and authorization for seabed alteration.

Ecological Impacts

Unknown in SMB. Likely to be site specific, although the conversion of sandy substrate to rocky reef would be one unavoidable impact. The conversion of such artificial hard substrata in predominately soft sediment ecosystems can provide habitat and stepping stones for generalist sessile species, many of which are invasive or weedy forms.

Costs and Benefits

Tables 47 through 49 present the benefit and cost analysis for groins. See Section 3.5.2 for the assumptions used in the cost benefit analysis for this measure.

Table 47 Present Value of Benefits and Costs for Groins plus Nourishment: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 6,661,144	$ 10,345,791	$ 7,164,437	$ 14,467	$ 24,185,838
Total Habitat Value above Baseline	$ 2,533,885	$ 3,997,035	$ 3,839,422	$ 1,503,315	$ 11,873,657
Sum Benefits	$ 9,195,028	$ 14,342,825	$ 11,003,859	$ 1,517,782	$ 36,059,495
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 62,400,000	$ -	$ 18,426,893	$ 7,048,406	$ 87,875,299
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ 19,200,000	$ -	$ 5,669,813	$ 2,168,740	$ 27,038,554
Net Benefits	**$ (10,004,972)**	**$ 14,342,825**	**$ 5,334,046**	**$ (650,958)**	**$ 9,020,942**
Benefit/Cost Ratio	**0.48**	**NA**	**1.94**	**0.70**	**1.33**

Table 48 Present Value of Benefits and Costs for Groins plus Nourishment: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 14,394,505	$ 21,724,339	$ 9,599,581	$ 3,545,590	$ 49,264,015
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 24,279,953	$ 37,098,009	$ 16,773,088	$ 6,415,042	$ 84,566,092
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 17,542,442	$ 30,558,650	$ 20,103,251	$ 7,562,538	$ 75,766,881
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ 1,319	$ 653	$ 231	$ 2,203
Cost of Pubic Property Compensation	$ -	$ 1,163	$ 575	$ 204	$ 1,942
Construction/Nourishment Cost	$ 260,000,000	$ -	$ 76,778,721	$ 29,368,360	$ 366,147,080
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ 80,000,000	$ 2,482	$ 23,625,449	$ 9,036,853	$ 112,664,785
Net Benefits	**$ (62,457,558)**	**$ 30,556,168**	**$ (3,522,198)**	**$ (1,474,315)**	**$ (36,897,903)**
Benefit/Cost Ratio	**0.22**	**NA**	**0.85**	**0.84**	**0.67**

Table 49 Present Value of Benefits and Costs for Groins plus Nourishment: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 14,291,003	$ 21,113,157	$ 8,733,001	$ 2,984,682	$ 47,121,843
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 31,963,690	$ 44,948,329	$ 16,757,471	$ 5,044,221	$ 98,713,711
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 23,032,917	$ 44,896,563	$ 25,490,472	$ 8,028,903	$ 101,448,855
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	0	0	0
Cost of Private Property Compensation	$ -	$ 2,391,383	$ 5,056,063	$ -	$ 7,447,445
Cost of Pubic Property Compensation	$ -	$ 1,894,988	$ 1,080,516	$ -	$ 2,975,504
Construction/Nourishment Cost	$ 361,400,000	$ -	$ 101,640,402	$ 40,822,020	$ 503,862,421
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ 111,200,000	$ 4,286,371	$ 33,892,227	$ 12,560,621	$ 161,939,219
Net Benefits	**$ (88,167,083)**	**$ 40,610,192**	**$ (8,401,755)**	**$ (4,531,718)**	**$ (60,490,364)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that the Groins with Nourishment measure has a net negative cost benefit primarily as a result of high construction cost. Construction costs associated with 100 years of groins with nourishment for the entire study area are estimated at ~$957 million. Some positives are the benefits from reduction in private and public costs as well as avoidance of costs associated with the replacement of the MRWPCA infrastructure. The total costs (negative net benefits) over the entire study including cost savings from not building a revetment (baseline scenario) for the 100 year planning horizon total about ~$89 million with that made up of ~$213 million in recreation and ecosystem benefits. It should be noted that in the Del Monte Reach groins with nourishment have a net positive of $9 million over the 100-year time horizon

4.3.3 Emergent – Offshore Breakwaters

Description

Breakwaters are structures constructed offshore with the intended purpose of reducing the wave energy inland of the structure (Figure 38). Emergent or surface penetrating breakwaters are relatively common in California and have been constructed in Venice (for beach retention), Santa Monica (to create an anchorage, but has mainly been for beach retention), Ventura (as part of the harbor), and other locations.

Breakwaters hold sand by reducing the wave energy inland of the structure. As the wave energy decreases, there is less energy for sand transport and sand is deposited inland of the structure. In some situations, the salient of sand inland of the structure can become large enough to act itself as a barrier to sand transport; this has happened in Santa Monica where the upcoast sand retention is a factor of both the breakwater and the salient (Table 50).

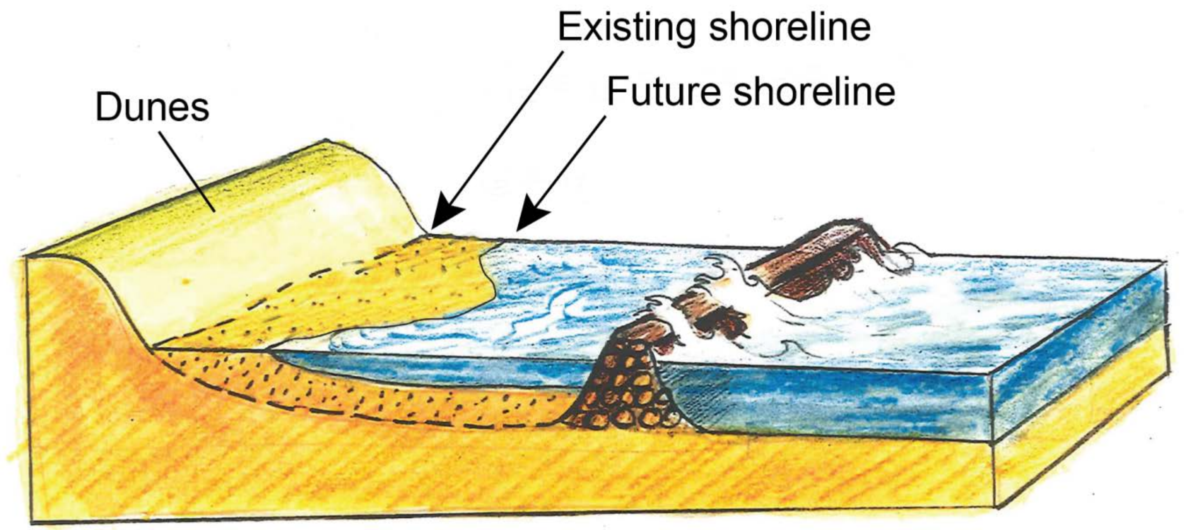

Figure 38 Schematic of Emergent Offshore Breakwaters with Beach Nourishment

General Applicability

Offshore breakwaters and beach nourishment are generally applicable where there is a firm seabed and the need to create a calm area free from wave energy.

Specific Applicability

This management measure is potentially applicable to all Subregions but is most likely to be appropriate in Subregions 1-4 where the conditions are calmer and there is more coastal development.

Table 50 Summary of Evaluation Criteria for Breakwaters

Evaluation Criteria	
Reduce threat to structures	Yes
Maintain Beach Width	Yes to improves
Economic Costs	High
Environmental Impacts	Yes – sand to rock habitat, potential to become a sink of sediment until equilibrium is reached
Recreational	Benefits to beach recreation and potentially swimming and fishing, impacts to surfing and boating
Safety and Public Access	Reduces wave energy, promotes calmer waters
Aesthetics	Impacts
Regulatory Viability	Uncertain
Adaptability to Future Conditions	Eventually become submerged breakwater
Cumulative Impacts	Depends on scale of breakwater, a breakwater may also lead to additional structures
Certainty of Success	Certain

Discussion
Offshore breakwaters have been constructed in California at Long Beach, Santa Monica, Oxnard-Ventura and Half Moon Bay.

At Long Beach, there are studies to remove a portion of the offshore breakwater to improve water quality and beach quality, and to restore surfing. Of interest, the Long Beach is very wide and stable, but is not considered to be adequate by those that want the breakwater removed. This is an important consideration before embarking on extensive coastal engineering works – part of the allure of a beach is apparently its natural character.

At Santa Monica, the beach widening has been relatively successful and seems to serves the human-centric design objectives.

At Oxnard – Ventura, offshore breakwaters are mostly associated with harbors and sand trapping / bypassing operations. These projects indicate the need to consider carefully the operational costs of coastal engineering works and the potential need to mechanically move sand to maintain the engineered shore in a configuration well removed from its natural condition.

At Pillar Point Harbor, the offshore breakwater provides a more sheltered area for boat mooring. Of interest, there have been ongoing erosion problems within this harbor area (Griggs et al.2005). There is also increased erosion just south of the harbor breakwaters, with the erosion attributed to the breakwaters focusing wave energy. This indicates that a reduction of wave climate alone does not prevent erosion: It is the resulting gradient of wave energy and sand transport that affects erosion and accretion.

We are not aware of any offshore breakwaters constructed on California's Pacific coast since the 1980s and most are much older. Offshore breakwaters proposed for Imperial Beach (San Diego County) have been strongly opposed for years, and may never be constructed despite continuing studies.

Effectiveness – Maintaining beach width vs. protecting upland property
Under the offshore or emergent breakwater mitigation measure used in conjunction with a large nourishment project as a retention device, the effectiveness at maintaining beach widths and upland property is shown below (Figure 39). This erosion mitigation measure is the most effective at balancing beach widths with upland erosion protection. In this case, the beach widths oscillate based on the fill interval with upland property only eroded along reaches of SMB where erosion rates exceed 4.5 ft/year for 25 years or greater. This finding however, does not identify the high costs, ecological impacts and changes to recreational and aesthetic values.

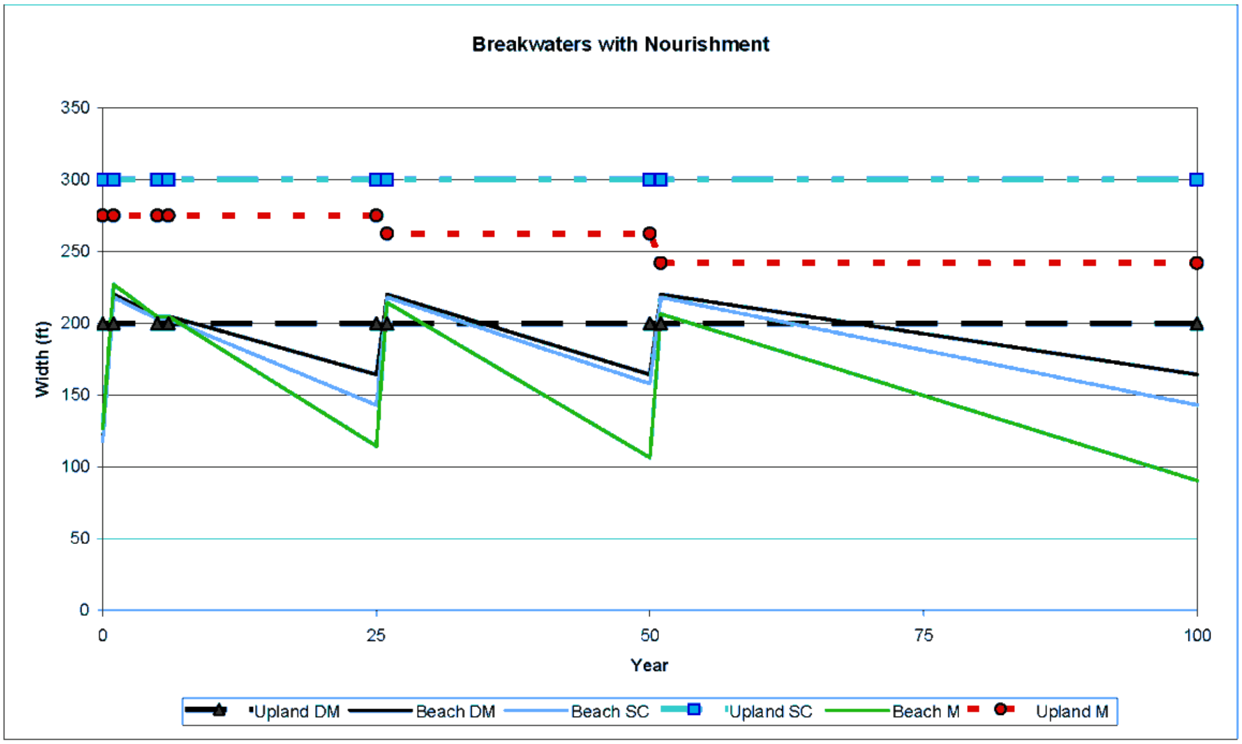

Figure 39 Effectiveness of offshore breakswaters as a sand retention device used in conjunction with a large beach nourishment at maintaining dry sand beach widths and upland property over time

Regulatory Viability

Regulatory viability is dubious at best. Constructing offshore structures in the marine environment within a National Marine Sanctuary would require MBNMS NEPA review and authorization for seabed alteration.

Ecological Impacts

The ecological impacts in SMB are not known but are likely to be potentially significant. The conversion of sandy substrate to rocky reef would be one unavoidable impact. The conversion of such artificial hard substrata in predominately soft sediment ecosystems can provide habitat and stepping stones for generalist sessile species, many of which are invasive or weedy forms.

Costs and Benefits

Tables 51 through 53 present the benefit and cost analysis for offshore breakwaters plus nourishment. See Section 3.5.2 for the assumptions used in the cost benefit analysis for this measure.

Table 51 Present Value of Benefits and Costs for Breakwater plus Nourishment: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 6,484,360	$ 7,722,888	$ 7,722,888	$ 3,909,409	$ 25,839,546
Total Habitat Value above Baseline	$ 2,697,435	$ 4,996,483	$ 4,174,134	$ 1,579,931	$ 13,447,984
Sum Benefits	$ 9,181,795	$ 12,719,372	$ 11,897,022	$ 5,489,341	$ 39,287,530
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 93,600,000	0	$ 27,640,339	$ 10,572,609	$ 131,812,949
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ 50,400,000	$ -	$ 14,883,260	$ 5,692,944	$ 70,976,203
Net Benefits	**$ (41,218,205)**	**$ 12,719,372**	**$ (2,986,237)**	**$ (203,603)**	**$ (31,688,674)**
Benefit/Cost Ratio	**0.18**	**NA**	**0.80**	**0.96**	**0.55**

Table 52 Present Value of Benefits and Costs for Breakwater plus Nourishment: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 14,814,425	$ 23,984,649	$ 10,496,953	$ 3,949,235	$ 53,245,263
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 24,961,413	$ 40,638,966	$ 17,987,709	$ 6,880,415	$ 90,468,503
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 18,643,822	$ 36,359,917	$ 22,215,244	$ 8,431,557	$ 85,650,541
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 390,000,000	$ -	$ 115,168,081	$ 44,052,539	$ 549,220,620
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ 210,000,000	$ -	$ 62,013,582	$ 23,720,598	$ 295,734,180
Net Benefits	**$ (191,356,178)**	**$ 36,359,917**	**$ (39,798,338)**	**$ (15,289,041)**	**$ (210,083,639)**
Benefit/Cost Ratio	**0.09**	**NA**	**0.36**	**0.36**	**0.29**

Table 53 Present Value of Benefits and Costs for Breakwater plus Nourishment: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 14,523,252	$ 22,062,550	$ 9,399,010	$ 3,315,971	$ 49,300,782
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 32,516,240	$ 47,943,352	$ 19,723,817	$ 6,423,572	$ 106,606,981
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 23,817,716	$ 48,840,979	$ 29,122,827	$ 9,739,542	$ 111,521,064
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	0	0	0
Cost of Private Property Compensation	$ -	$ 2,122,318	$ 4,899,362	$ -	$ 7,021,679
Cost of Pubic Property Compensation	$ -	$ 1,029,885	$ 576,688	$ -	$ 1,606,573
Construction/Nourishment Cost	$ 542,100,000	$ -	$ 152,460,602	$ 61,233,030	$ 755,793,632
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ 291,900,000	$ 3,152,203	$ 84,051,899	$ 32,971,631	$ 412,075,733
Net Benefits	**$ (268,082,284)**	**$ 45,688,777**	**$ (54,929,072)**	**$ (23,232,089)**	**$ (300,554,668)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that the Offshore Breakwaters with Nourishment measure has a net negative cost benefit primarily as a result of high construction cost. Construction costs associated with 100 years of offshore breakwaters with nourishment for the entire study area are estimated at ~$1.44 billion. Some positives are the benefits from reduction in private and public costs as well as avoidance of costs associated with the replacement of the MRWPCA infrastructure. The total costs over the entire study including cost savings from not building a revetment (baseline scenario) for the 100 year planning horizon total about ~$541 million with that made up of ~$236 million in recreation and ecosystem benefits.

In all three reaches the benefits of using breakwaters as an erosion mitigation measure do not outweigh the costs. Indeed, in most cases the net benefits are negative, implying that groins/nourishment, even though they cost more than the baseline strategy of revetment, actually lower overall benefits. As the 100-year planning horizon indicates, the overall benefit cost ratio is less than one in all instances, indicating that breakwaters/nourishment is not a viable or cost-effective option.

4.3.4 Perched Beaches

Description

Perched beaches are formed by constructing a sill at the seaward edge of the proposed beach and either allowing sand to collect landward of the sill or intentionally placing sand landward of the sill to build a beach (Figure 40). The perched beach is a special case of the submerged breakwater in which the sill's primary function is to retain sand in a perched (i.e., elevated) profile as opposed to reducing incident wave energy (Moreno, 2003). The sill acts to raise the natural beach profile, resulting in a wider beach at the shore. The width of shore advance can be predicted using equilibrium profile theory (Gonzalez, 1999). The dry beach area inland of the sill will provide the access and recreation functions of a naturally wide beach, as well as many of the same storm protection functions (Table 54).

Along armored shores, an extreme example of a perched beach would be to terrace the structure and import some sand so that there would be a flat terrace above impacts of the waves that could provide some recreational utility.

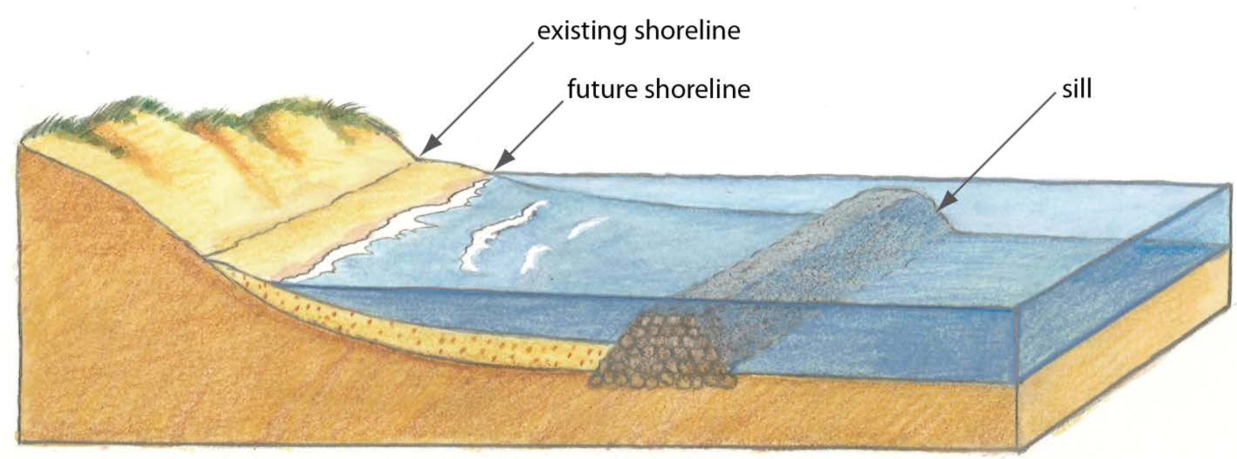

Figure 40 Schematic of a Perched Beach using a submerge sill

The perched beach method is typically proposed in conjunction with beach nourishment behind a constructed sill. A perched beach requires less sand than would be needed to nourish the full offshore portion of a natural beach because the sill effectively truncates the length of the active profile and limits offshore movement of sand (Dean & Dalrymple, 2002). Therefore, an offshore sill along a segment of the coast may be more economical than full profile nourishment. This is especially true for steep eroded profiles in which establishment of the full equilibrium profile through nourishment would not be economically feasible (Raudkivi & Dette, 2002), or where sand is readily lost offshore.

A variety of construction methods can be employed to construct the offshore sill, many of which are similar to the submerged breakwater. Rubble mound structures constructed of quarrystone are traditionally the most common type of coastal structure used worldwide (USACE 1992). Armor size is selected based on design wave conditions and water depth. Offshore sills for perched beaches could also be constructed using geotextile sand bags, grout-filled bags, sheet-piles, or bulkheads, although the sill need not be a “structure” at all, and could be constructed by placing a rock ridge or gravel/cobble mound to retain sand (Raudkivi & Dette, 2002). Stauble and Giovannozzi describe installation of a linear, prefabricated concrete sill at Cape May, NJ using modular units typically used for parking garage decks (Double-T structures) (Stauble & Giovannozzi, 2003). The units were placed end-to-end in an inverted position with vertical legs extending approximately 2.5 ft above the bed. Modular units are typically placed using a barge-mounted crane.

As with many structures in the nearshore, wave and current velocities are often increased in the vicinity of the structure, which can lead to scour and undermining of the foundation (Sumer et al., 2001). The stability of the perched beach will depend upon the stability of the sill and its ability to withstand scour and wave forces. The sill foundation is often the critical design feature for these structures, and may require installation of filter cloth to prevent winnowing of fine sediment and undermining of the structure. In addition, some regular nourishment may be needed for the beach itself if there are not sufficient onshore transport mechanisms to keep the entire beach area filled.

Perched beaches are not likely to be stable during high swell and large storm events. Under these conditions, the large volumes of water transported onto the shore and returning seaward will likely overwhelm the sill structure and scour the beach. By perching the profile landward of the sill, an abrupt drop off on the seaward side of the structure may exist that can alter some of the available aquatic recreational opportunities for the area and create potentially difficult water access. Safety may be compromised if beach goers are pulled seaward past the sill. For these reasons, perched beaches are considered primarily for sheltered areas.

General Applicability

Perched beaches are conceptually applicable to any parcel threatened with erosion with relatively low wave energy. The California ocean shore is exposed to long period swell which tends to have large dynamic setup pulses. The authors posit that such conditions are likely to scour sand from behind sills and therefore question the applicability to southern Monterey Bay. Examples of application in California have not been found.

Specific Applicability

Perched beaches would be mostly likely viable in the Southern Bight where wave exposure is typically limited. Therefore, we concluded that this management alternative is most relevant for application to Subregions 1 and 2 to address critical all erosion areas in these Subregions.

Table 54 Summary of Evaluation Criteria for Perched Beaches

Evaluation Criteria	
Reduce threat to structures	Yes behind toe structure, potential flanking erosion on adjacent parcels
Maintain Beach Width	Yes potentially widens
Economic Costs	High initial cost, ongoing maintenance
Environmental Impacts	Conversion of sand bottom to rocky reef
Recreational	Improves to maintains
Safety and Public Access	Improves lateral access, potential safety issue by alterations of breaking wave characteristics and deepwater offshore of toe structure
Aesthetics	Minimal impacts if any below sea surface
Regulatory Viability	Uncertain
Adaptability to Future Conditions	Adaptable until depth over sill increases and stops dissipating wave energy
Cumulative Impacts	Conversion of sand bottom habitats to rock reef
Certainty of Success	Low Wave Exposure: Somewhat certain in short term, less certain in medium/long term without improvement/repairs to sill structure High Wave Exposure: Uncertain.

Discussion

The theory of perched beaches is often presented in the literature as an alternative to traditional shore armoring approaches (Dean & Dalrymple, 2002; USACE, 1992), but few documented cases of implementation exist. In general, there is little engineering guidance available as to the morphodynamic response of a beach to a sill structure, which has likely reduced the number of successful applications. For example, construction of a perched beach was considered for beach protection at Adelaide, Australia, but was eliminated due to uncertainties associated with their performance (South Australia EPA, 1999).

The concept of a perched beach is based on several assumptions that require careful consideration when implementing the method: (1) no loss of material over sill, (2) no alongshore losses, and (3) equilibrium beach profile applies. Laboratory tests conducted by various researchers show contradictory evidence of onshore/offshore transport from a perched beach (Sorenson & Beil, 1988; Dette et al., 1997), and a specific submerged sill may have either a beneficial or undesirable shore response depending on the incident wave conditions and structure geometry (Moreno, 2003; Raudkivi & Dette, 2002).

Numerical modeling studies for a proposed perched beach at the Port of Rotterdam found that the magnitude of offshore losses was dependent on structure distance offshore, with greater losses for structures closer to shore (Eversdijk, 2005). Since greater offshore losses result in increased frequency of nourishment, the cross-shore location of the sill is a cost optimization problem (i.e., placing the structure close to shore saves initial nourishment costs but may result in increased cumulative offshore losses over time). This is especially pertinent to perched beaches because, unlike a natural beach where offshore transport is a reversible process (e.g., onshore transport during long-period swell events), offshore movement of sand from a perched beach is permanent.

In areas of significant wave energy, alongshore transport out of the project area will be an important design consideration, especially as it relates to frequency of re-nourishment. The problem of coast-wise continuity of a project can be solved using solid or permeable groins to limit alongshore transport (Raudkivi & Dette, 2002). Some installations tie in to existing structures or headlands at lateral boundaries. An installation near Venice used solid groins with the seaward half submerged to allow some alongshore transport. Physical model tests of that installation showed negligible loss of sediment from the perched beach compartment bounded by the groins (Raudkivi & Dette, 2002).

Much of the engineering literature on beach nourishment and beach profile evolution relies on the “equilibrium profile” concept, which suggests that under constant wave and water levels, the shoreface will attain an equilibrium form that dissipates wave energy without significant change in shape or net sand transport (Larson and Kraus 1989). There is a well-documented debate on the validity of the equilibrium profile in the literature (e.g., Dean, 1977; Dean, 1991; Pilkey et al., 1993); nonetheless, its application to coastal engineering problems is widespread. Gonzalez (1999) provides a theoretical description of the equilibrium profile for a perched beach that predicts shore advance and profile shape. Results compared well with laboratory data. Gonzalez concluded that the most important factor in determining the shape of the profile (and the resulting shore advance) is the degree of wave reflection at the submerged sill, which depends on the sill geometry, location, and incident wave conditions. Not surprisingly, maximum shore advance is predicted to occur as the crest of the sill approaches the water surface; however, the equilibrium profile concept does not account for the effect of the sill on nearshore hydrodynamics which may act to modify the profile through transport and scour of sediment. As a result, conceptual models of equilibrium profiles for perched beaches may have limited applicability to actual projects in the field.

Regulatory Viability

The regulatory viability of perched beaches is uncertain. Constructing offshore structures in the marine environment within a National Marine Sanctuary would require MBNMS NEPA review and authorization for seabed alteration.

Ecological Impacts

The ecological affects of perched beaches is unknown in SMB. Effects are likely to be potentially significant but site specific. The conversion of sandy substrate to rocky reef would be one unavoidable impact. The conversion of such artificial hard substrata in predominately soft sediment ecosystems can provide habitat and stepping stones for generalist sessile species, many of which are invasive or weedy forms.

4.3.5 Seawalls/Revetments

Description

Seawalls are vertical structures along a beach or bluff, used to protect structures from wave action as a course of last resort (Figure 41). A seawall works by absorbing or dissipating wave energy. They may be either gravity- or pile-supported structures. Seawalls can have a variety of face shapes. Seawalls and bulkheads are normally constructed of stone or concrete, however other materials can be used. Current seawall projects usually require design elements that allow the structure to resemble the natural environment in that area, in order to blend in with the existing geologic conditions. Currently in the Southern Monterey Bay Region seawall projects have been built for the Ocean Harbor House and the Monterey Beach Resort.

Revetments provide protection to existing slopes affronting a threatened structure, and are constructed of a sturdy material such as stone. Similar in purpose to a seawall, revetments work by absorbing or dissipating wave energy. They are made up of: an *armor layer*--either stone or concrete rubble piled up or a carefully placed assortment of interlocking material which forms a geometric pattern, a *filter layer* --which provides for drainage, and retains the soil that lies beneath, and a *toe*--which adds stability at the bottom of the structure. Revetments are the most common coastal protection structure along the shore of the southern Monterey Bay, currently protecting several structures such as the Del Monte Lake storm drain outfall. In comparison to seawalls, revetments tend to have greater visual impacts and require a larger footprint, which leads to a larger placement loss and impacts to public access (Table 55).

Figure 41 Example of a seawall, Ocean Harbor House, Monterey, CA (Photo Gary Griggs)

Geotextile revetment constructed of geotextile bags or tubes have most of the same constraints as any other revetment; however, the geotextile option allows the use of smaller aggregate for construction, where normally the design conditions would require larger material. In theory, the geotextiles, while not as stable as rock, have the advantage of relative easy removal.

General Applicability
Seawalls are potentially applicable to any oceanfront parcel that can be established as existing development under the Coastal Act.

Specific Applicability
This management alternative is most relevant for application to Subregions 1-4 and 6 to address critical erosion problems where there are existing structures on the coast.

Table 55 Summary of Evaluation Criteria for Seawalls / Revetments

Evaluation Criteria	
Reduce threat to structures	Yes in short to medium term
Maintain Beach Width	No – loss due to structure footprint and narrowing due to passive erosion
Economic Costs	High ($3,500-$10,000 per lineal foot of shore)
Environmental Impacts	Impacts to sandy beach habitats, shorebirds, potential flanking erosion to adjacent unprotected parcels
Recreational	Reduces beach widths over time
Safety and Public Access	Reduces
Aesthetics	Impact but partially mitigable with concrete contouring, texturing
Regulatory Viability	Probably, case-by-case analysis required
Adaptability to Future Conditions	No
Cumulative Impacts	Large cumulative impacts to recreation, and beach habitats
Certainty of Success	Certain in short term, less certain in medium/long term

Discussion
There are a number of environmental impacts associated with seawalls including short-term construction impacts as well as long-term cumulative impacts. The most commonly recognized impacts include: visual and aesthetic effects, encroachment onto beach due to placement loss, restriction of vertical and lateral public access, prevention of historic sand supply from hardening of eroding cliffs, passive and active erosion, and potential biological impacts. These impacts vary significantly depending on the design of the structure, the magnitude of the project, and the specific geologic, biologic, and oceanographic conditions in the area, and must be evaluated on a case-by-case basis.

The southern Monterey Bay shore is a highly erosive shore and seawalls contribute to passive erosion. Passive erosion occurs on erosive shores where the shore erodes landward of a hardened structure such as a seawall that then projects into the ocean. This peninsula effect blocks lateral access of the shore. Examples in southern Monterey Bay of where lateral access is blocked are the rip-rap seawall fronting Stillwell Hall in Fort Ord (since removed) and the rip-rap at the end of Tioga Avenue in Sand City. In addition, the shore access is presently blocked at high tide at the Monterey Beach Hotel and the Ocean Harbor House Condominiums seawalls during the winter when the beach is cut back. This situation is expected to become worse with time until the seawalls project into the ocean completely blocking shore lateral access, unless other mitigation measures such as beach nourishment are instituted.

Effectiveness – Maintaining beach width vs. protecting upland property

Seawalls and Revetments protect upland property by fixing the backshore in place which leads to a loss of beach width (Figure 8). The primary difference between the revetment and seawall is the footprint of the structure that occupies the beach (placement loss). On the eroding shores of Southern Monterey Bay, both the seawall and the revetment options lead to a loss of beaches between 25 and 50years into the future (Figure 42 and 43).

Figure 42 Effectiveness of seawalls at maintaining dry sand beach widths and upland property over time

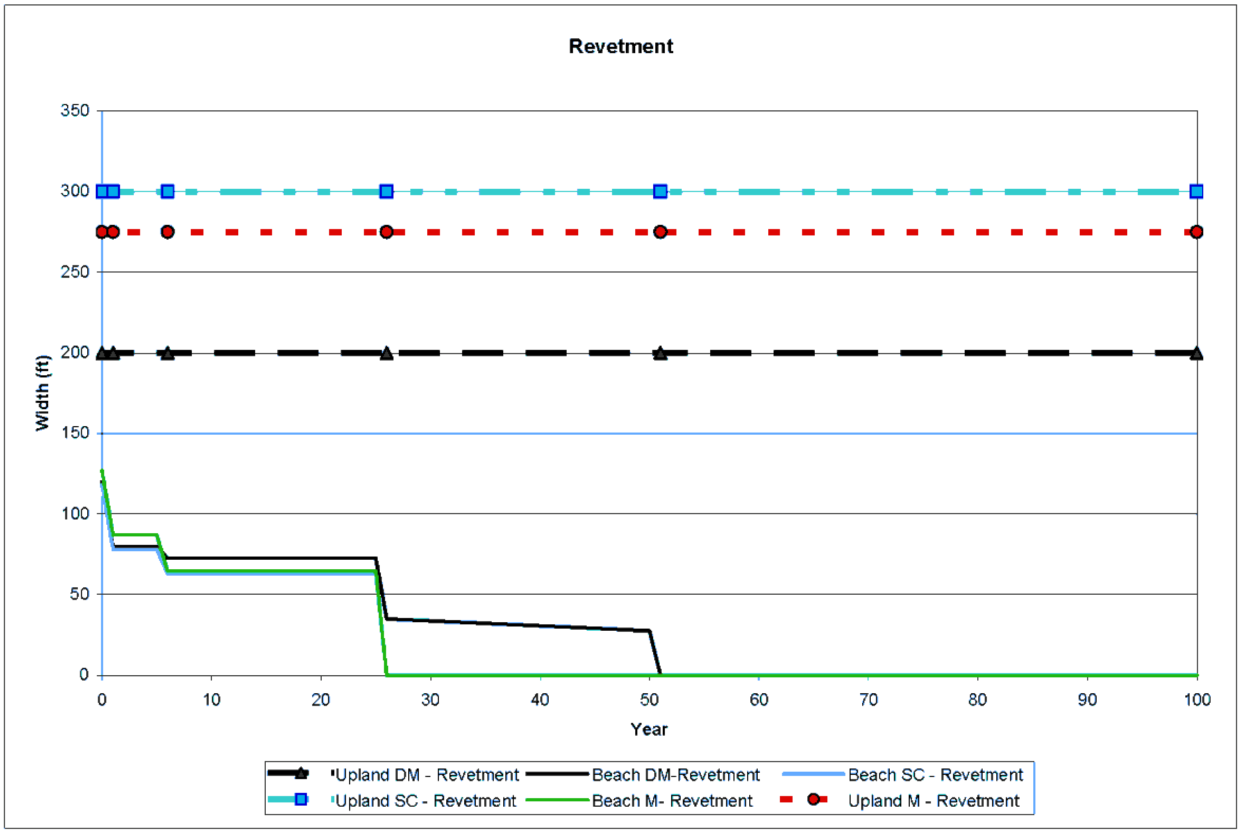

Figure 43 Effectiveness of revetments at maintaining dry sand beach widths and upland property over time

Regulatory Viability

Seawalls and revetments are controversial due to adverse effects on shores but are generally approved by the Coastal Commission and other regulatory agencies with significant conditions to help mitigate for recreation and sand supply. Probably, case-by-case analysis is required.

Ecological Impacts

Despite widespread use of coastal armoring on coastlines around the world for thousands of years, numerous studies of their physical effects, costs and efficacy and a very active debate on the geomorphic impacts of these structures on both open and sheltered coasts, the ecological impacts of these structures have only just begun to be addressed or considered (NRC 2007, Dugan et al 2010). Results of recent studies suggest that coastal armoring, including seawalls and revetments, causes a number of significant ecological impacts to open coast beach ecosystems (Dugan and Hubbard 2006, Dugan et al 2008, Dugan et al in press). Many of these impacts are associated with the loss of beach habitat with strongest effects evident on the upper shore. Shore-parallel armoring also disrupts vital connections between the marine and terrestrial realms, eliminating key exchanges (detritus, sediments, nutrients, prey, propagules) and functions (nutrient remineralization and cycling, water filtration) for coastal ecosystems (Dugan et al. 2011, in press).

The placement of and subsequent beach erosion and narrowing associated with an armoring structure cause the reduction and eventual loss of upper to middle habitat zones of the beach, including the vegetated coastal strand, the dry sand and the driftline zones. In California, these higher shore zones support unique biodiversity (~40% of intertidal invertebrate species, Dugan et al., 2003) and ecological functions (Dugan and Hubbard 2010, Dugan et al 2011, in press), which are not replicated in the lower damp and saturated sand zones that may persist. As the upper intertidal zone, including the driftline, shifts from the beach to the armoring structure, strong ecological consequences including reduced biodiversity, invertebrate abundance and prey resources for shorebirds and fish are realized. Rich, three-dimensional infaunal beds of the driftline are eliminated and replaced by the steep artificial habitat of the armoring which may support a low diversity of some rocky shore species (e.g. Chapman, 2003; Chapman & Bulleri, 2003) but has little or no resource value for shorebirds. This reduction and alteration of beach habitat from coastal armoring was associated with significant 2 to 36-fold impacts to beach zone widths, driftwood and wrack accumulation, upper shore macroinvertebrates, abundance and diversity of foraging shorebirds and of roosting gulls and seabirds for intertidal seawalls on open coast beaches in California (Dugan et al., 2008; Dugan & Hubbard, 2006). In those studies, the reductions in abundance of shorebirds and of gulls, seabirds and other birds associated with coastal armoring (>3-fold and >4-fold respectively) exceeded that predicted by the overall loss of beach habitat area from armoring (2-fold) suggesting that avifauna are responding to other impacts of armoring, including prey abundance and the availability of high tide feeding and roosting habitat and refuges. The greatly reduced retention and accumulation of macrophyte wrack seaward of armoring structures strongly affects beach food webs via impacts to intertidal biodiversity and abundance that are key prey resources for shorebirds, including snowy plovers (see Dugan et al., 2003). Furthermore, preliminary studies suggest that the distribution, abundance, and survival of important macroinvertebrates of the mid to lower shore (e.g. bivalves, isopods and hippid crabs) are reduced by the loss of habitat, changes in habitat quality, and restrictions on tidal migration, as well as by the decreased availability of alternative sandy habitats or refuges during high surf conditions imposed by armoring (Jaramillo et al., unpublished). The uppermost zones of the beach ecosystem most affected by armoring structures also provide critical wildlife support, which includes habitat for nesting snowy plovers and grunion spawning (Dugan et al., in press).

Along with the physical effects as predicted by Weigel (Weigel, 2002a; Weigel 2002b; Weigel, 2002c), the ecological impacts of any armoring structure are expected to increase as the amount of interaction between the structure and waves and tides increases, whether this is due to initial placement or subsequent erosion of the beach. Hence, the lower a structure is located on the beach profile, the stronger ecological impacts are expected to be.

Costs and Benefits

Tables 56 through 58 present the benefits and costs analysis for revetments. See Section 3.5.2 for assumptions used in this measure. Since the baseline scenario includes the use of a revetment we present the net benefits and costs.

Table 56 Present Value of Benefits and Costs for Revetment: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value Above Baseline	$ -	$ -	$ -	$ -	$ -
Total Habitat Value Above Baseline	$ -	$ -	$ -	$ -	$ -
Sum Benefits	$ -	$ -	$ -	$ -	$ -
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 43,200,000	$ -	$ 12,757,080	$ 4,879,666	$ 60,836,746
Total Cost	$ 43,200,000	$ -	$ 12,757,080	$ 4,879,666	$ 60,836,746
Net Benefits	**$ (43,200,000)**	**0**	**$ (12,757,080)**	**$ (4,879,666)**	**$ (60,836,746)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 57 Present Value of Benefits and Costs for Revetment: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 21,132,016	$ 28,263,698	$ 6,269,418	$ 2,398,093	$ 58,063,225
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ 112,670	$ 112,670
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ 109,517	$ 109,517
Construction/Nourishment Cost	$ 180,000,000	0	$ 53,154,499	$ 20,331,941	$ 253,486,440
Total Cost	$ 180,000,000	$ -	$ 53,154,499	$ 20,554,128	$ 253,708,627
Net Benefits	**$ (158,867,984)**	**$ 28,263,698**	**$ (46,885,081)**	**$ (18,156,034)**	**$ (195,645,401)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 58 Present Value of Benefits and Costs for Revetment: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Sum Benefits	$ 23,221,776	$ 21,164,923	$ -	$ -	$ 44,386,699
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 250,200,000	0	$ 73,884,753	$ 28,261,398	$ 352,346,152
Total Cost	$ 250,200,000	$ -	$ 73,884,753	$ 28,261,398	$ 352,346,152
Net Benefits	**$ (226,978,224)**	**$ 21,164,923**	**$ (73,884,753)**	**$ (28,261,398)**	**$ (307,959,453)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Benefit Cost Results

The results of the cost benefit analysis shows that the Revetment and Seawall measures have a negative net benefit primarily as a result of high construction cost. Construction costs associated with 100 years of revetment for the entire study area are estimated at ~$ 667 million. Seawall construction is estimated at ~$1.22 billion for the entire study area. Some positives are the benefits from reduction in private and public cost associated with erosion damages as well as avoidance of costs associated with the replacement of the MRWPCA infrastructure. The net cost over the entire study for a revetment (baseline scenario) for the 100 year planning horizon total about ~$667 million with no additional recreation and ecosystem benefits (because the revetment is the baseline). The net cost over the entire study for a seawall for the 100 year planning horizon total about ~$461 million with that made up of ~$94 million in recreation and ecosystem benefits.

In every case the B/C ratio is less than one indicating that the costs exceed the benefits. In other words, the loss in recreational and habitat value is greater than the costs of building a revetment (and the net benefits are negative).

Tables 59 through 61 present essentially the same tables for a seawall. The only difference is that a seawall is about twice as expensive as a revetment and yields similar benefits, thus the B/C ratio is even lower.

Table 59 Present Value of Benefits and Costs for Seawall: Del Monte

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value above Baseline	$ 1,891,463	$ 3,751,875	$ 2,078,659	$ 973,121	$ 8,695,117
Total Habitat Value above Baseline	$ 578,022	$ -	$ -	$ -	$ 578,022
Sum Benefits	$ 2,469,485	$ 3,751,875	$ 2,078,659	$ 973,121	$ 9,273,139
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 79,200,000	0	$ 23,387,980	$ 8,946,054	$ 111,534,034
Revetment Cost	$ (43,200,000)	$ -	$ (12,757,080)	$ (4,879,666)	$ (60,836,746)
Total Cost	$ 36,000,000	$ -	$ 10,630,900	$ 4,066,388	$ 50,697,288
Net Benefits	**$ (33,530,515)**	**$ 3,751,875**	**$ (8,552,240)**	**$ (3,093,268)**	**$ (41,424,149)**
Benefit/Cost Ratio	**0.07**	**NA**	**0.20**	**0.24**	**0.18**

Table 60 Present Value of Benefits and Costs for Seawall: Sand City

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 9,356,974	$ 12,204,183	$ 1,748,297	$ -	$ 23,309,454
Baseline	$ 7,409,916	$ 8,413,408	$ -	$ -	$ 15,823,324
Total Habitat Value	$ 16,130,525	$ 23,477,205	$ 6,922,872	$ 2,398,093	$ 48,928,696
Baseline	$ 13,722,100	$ 19,850,290	$ 6,269,418	$ 2,398,093	$ 42,239,901
Sum Benefits	$ 4,355,482	$ 7,417,691	$ 2,401,751	$ -	$ 14,174,925
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -
Cost of Private Property Compensation	$0	$0	$0	$112,670	$112,670
Cost of Pubic Property Compensation	$0	$0	$0	$109,517	$109,517
Construction/Nourishment Cost	$ 330,000,000	$ -	$ 97,449,915	$ 37,275,226	$ 464,725,140
Revetment Cost	$ (180,000,000)	$ -	$ (53,154,499)	$ (20,331,941)	$ (253,486,440)
Total Cost	$ 150,000,000	$ -	$ 44,295,416	$ 17,165,471	$ 211,460,887
Net Benefits	**$ (145,644,518)**	**$ 7,417,691**	**$ (41,893,664)**	**$ (17,165,471)**	**$ (197,285,962)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

Table 61 Present Value of Benefits and Costs for Seawall: Marina

Planning Horizon (Years)	0 to 5	6 to 25	26 to 50	51 to 100	0 to 100
Total Recreational Value	$ 9,336,491	$ 10,575,941	$ 6,937	$ 2,654	$ 19,922,022
Baseline	$ 7,512,217	$ 8,275,750	$ -	$ -	$ 15,787,968
Total Habitat Value	$ 19,057,268	$ 16,292,382	$ -	$ -	$ 35,349,651
Baseline	$ 15,709,559	$ 12,889,172	$ -	$ -	$ 28,598,731
Net Benefits	$ 5,171,983	$ 5,703,400	$ 6,937	$ 2,654	$ 10,884,974
Structural Adjustment Costs	0	0	0	0	0
MRWPCA	0	0	0	0	0
Cost of Private Property Compensation	$ -	$ -	$ -	$ -	$ -
Cost of Pubic Property Compensation	$ -	$ -	$ -	$ -	$ -
Construction/Nourishment Cost	$ 458,700,000	$ -	$ 135,455,381	$ 51,812,564	$ 645,967,945
Revetment Cost	$ (250,200,000)	$ -	$ (73,884,753)	$ (28,261,398)	$ (352,346,152)
Net Cost	$ 208,500,000	$ -	$ 61,570,628	$ 23,551,165	$ 293,621,793
Net Benefits	**$ (203,328,017)**	**$ 5,703,400**	**$ (61,563,690)**	**$ (23,548,512)**	**$ (282,736,819)**
Benefit/Cost Ratio	**NA**	**NA**	**NA**	**NA**	**NA**

The results indicate that shore armoring is not cost effective in terms of multiple objectives including recreation and ecology (ecosystem services). However, we believe the extensive construction of shore armoring indicates that there is at least a perception of a favorable net benefit. We speculate that this apparent dichotomy is logically derived from a different accounting of costs and benefits, as follows:

- Shore armoring projects do not consider ecosystem services except as forced in the regulatory process. On eroding shores, beaches are lost over time in front of shore armoring with most of the costs borne by others than those that armor.
- Property owners and infrastructure managers have great incentive to protect their property and infrastructure, but are not directly accountable for the consequences of their decisions at the future time when concerns of loss of beach may arise.

5. DISCUSSION OF REGULATORY RISK

5.1 INTRODUCTION

The purpose of this section of the report is to estimate the regulatory risk associated with four different land use planning tools as applied to hypothetical categories of development in southern Monterey Bay[12](Figure 44).

This study considers several land use alternatives for coping with coastal erosion. One perception of local governments who may implement some of these land use planning measures is that they may face takings challenges from private property owners. Under the so-called "Takings Clause" of the Fifth Amendment to the U.S. Constitution, the federal or a state government may not "take" private property for public use without providing the landowner with just compensation.

When agencies act to impair recognized property rights without providing compensation, they may encounter Fifth Amendment challenges from property owners. Such challenges are analyzed under one of four legal frameworks, depending on the sort of regulation at issue:

1. A regulation that leads to an involuntary, permanent, and physical occupation of property, no matter how small, is an automatic (or "per se") taking that must be compensated.[13]
2. A regulation that deprives the property owner of all economically beneficial use of the property is a taking that must be compensated, unless the agency can show that the regulation merely codifies an already existing limitation on the owner's use of her property.[14]
3. A regulation that results in a partial diminution in property value is analyzed under a loose, three-factor test that balances: (a) the economic impact of the regulation, (b) the reasonable investment-backed expectations of the owner, and (c) the character of the regulation (e.g., whether the regulation restricts harmful activity across the community versus targeting specific property owners).[15]
4. Exactions or dedications (e.g., conditions imposed by an agency for approval of a coastal development permit) may constitute an unlawful taking unless they are both logically related to and roughly proportional to the impact of the individual project.[16]

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[12] Note: nothing in this document should be construed as conveying legal advice. This document provides INFORMATION ABOUT THE LAW as it relates to hypothetical fact situations, and is solely for academic and informational purposes. Legal information is not the same as legal advice, which applies the law to specific circumstances. Nothing in this document purports to apply law to specific situations or to provide a comprehensive picture of the law. We make no claims, assurances, or guarantees as to the accuracy or completeness of the information in this document. One should consult a lawyer for up-to-date information about the law or legal advice.

[13] *Loretto v. Teleprompter Manhattan CATV Corp.*, 458 U.S. 419 (1982).

[14] *Lucas v. South Carolina Coastal Council*, 505 U.S. 1003, 1022-23.

[15] *Penn Central Transp. Co. v. New York City*, 438 U.S. 104 (1978).

[16] *Nollan v. California Coastal Comm'n*, 483 U.S. 825 (1987); *Dolan v. City of Tigard*, 512 U.S. 374 (1994).

5.2 POTENTIAL TAKINGS ANALYSIS USING HYPOTHETICAL SITUATIONS

KEY: ■ = Possible High Risk ■ = Likely Medium Risk ■ = Likely Low Risk

HYPOTHETICAL LAND USE TOOL	HYPOTHETICAL PROPERTY TYPE		
	Undeveloped property with proposed development	**Developed property with "no future armoring" permit condition in place**	**Residential development *predating* the Coastal Act**
Transfer of development rights (TDR) credits	No Development Allowed; Partial Diminution in Property Value —1	N/A, although TDRs can be used in combination with easements and setbacks to reduce regulatory risk.	N/A, although TDRs can be used in combination with easements and setbacks to reduce regulatory risk.
Lateral conservation easement condition to CDP	Exactions or Dedications—2	Exactions or Dedications—3	Exactions or Dedications—4
Rolling easement ("no future armoring") condition to CDP	Exactions or Dedication—5	N/A, although TDRs can be used in combination with easements and setbacks to reduce regulatory risk.	Exactions or Dedication—6
Rolling easement regulation	Partial Diminution in Property Value—7	Partial Diminution in Property Value—8	Partial Diminution in Property Value—9
Setback condition to CDP	Exactions or Dedications—10	Exactions or Dedications—11	Exactions or Dedications—12
Setback regulation	Denial of All Economically Beneficial Use; Partial Diminution in Property Value—13	Denial of All Economically Beneficial Use; Partial Diminution in Property Value—14	Denial of All Economically Beneficial Use; Partial Diminution in Property Value—15

Figure 44 Comparison matrix of hypothetical land use tools and property types

5.2.1 <u>Transfer of Development Rights (TDR) Credits</u>

1. **Undeveloped property with proposed development:** If no development is allowed and compensation is not provided, a court might find a regulatory taking because the regulation may deny the owner all economically beneficial use of her property.[17] However, with a well-designed TDR program, a court is more likely to find that the transfer of development rights credits amounts to sufficient compensation for the taking. In particular, a court would be more likely to rule in favor of the local government if the local government guaranteed a ready market for TDR credits, ensuring that the property owner could sell credits at a predictable and fair price.[18]

[17] *See Suitum v. Tahoe Reg'l Planning Agency*, 520 U.S. 725, 747-50 (1997) (Scalia, J., concurring).

[18] *See Suitum*, 520 U.S. 725.

If some minimal amount of development is allowed, and so long as some economic value remains, a court applying the partial diminution in value analysis may not find a taking.[19] Under the first prong of analysis, the economic impact of the regulation is offset by the TDR credits, and under the third prong, the character of the regulation is to protect public resources.

5.2.2 Lateral Conservation Easement Condition to CDP

1. **Undeveloped property with proposed development:** As a condition to a Coastal Development Permit, a court may find that a lateral conservation easement is logically related to and roughly proportional to the impact of developing the property, because the development will be subject to sea-level rise and inevitable future interference with public tidelands.
2. **Developed property with "no new seawalls" condition:** As a condition to a Coastal Development Permit for redevelopment of the property, a court may find that a lateral easement is logically related to and roughly proportional to the impact of redevelopment if the remodeling extends the life of the property, thereby subjecting it to sea-level rise and inevitable future interference with public tidelands. However, an argument incorporating sea-level rise and the public trust doctrine has not yet been tested in court. Additionally, in the past, the U.S. Supreme Court has not looked favorably upon lateral conservation easements as conditions to redevelopment permits where adequate nexus findings were not made.[20]
3. **Residential development predating the Coastal Act:** As a condition to a Coastal Development Permit for *coastal armoring*, a court may find that a lateral conservation easement is logically related to and roughly proportional to the impact of the shoreline armoring, if, for example, the regulator can demonstrate with quantified studies that seawalls accelerate beach erosion and hinder public access to tidelands.[21]

As a condition to a Coastal Development Permit for *redevelopment of the property*, a court may find that a lateral easement is logically related to and roughly proportional to the impact of redevelopment if the remodeling extends the life of the property, thereby subjecting it to sea-level rise and the inevitable need for future coastal armoring or future interference with public tidelands. However, an argument incorporating sea-level rise and the public trust doctrine has not yet been tested in court. Additionally, in the past, the U.S. Supreme Court has not looked favorably upon lateral conservation easements as conditions to redevelopment permits where adequate nexus findings were not made.[22]

5.2.3 Rolling easement condition to CDP

1. **Undeveloped property with proposed development:** As a condition to a Coastal Development Permit for development of a property, a court may find a "no future armoring" condition to be logically related and roughly proportional to the impact of developing the property because the

[19] *Penn Central*, 438 U.S. 104.

[20] *See Nollan*, 483 U.S. 825.

[21] *See Dolan*, 512 U.S. 374.

[22] *See Nollan*, 483 U.S. 825.

development would be subject to sea-level rise and inevitable future interference with public tidelands. Of course, proper findings must be made. Such a condition operationalizes Coastal Act provisions that prevent the Coastal Commission from approving new development (a) contributing to erosion,[23] (b) requiring the construction of armoring devices,[24] or (c) interfering with the public's right of access to the shore.[25]

2. **Residential development predating the Coastal Act:** The Coastal Act is generally interpreted to grant owners of structures predating the Act the privilege to armor if specified conditions are met.[26] In cases of redevelopment where the pre-Coastal Act structure is removed, the court should treat the property as undeveloped property with proposed development.

5.2.4 Rolling easement regulation

1. **Undeveloped property with proposed development:** A rolling easement should not result in a partial diminution in property value. It is difficult to predict with certainty how a court will apply the subjective three-part balancing test; but, under the first prong, the rolling easement would reduce the value of the property so slowly that a court is unlikely to find a "taking." Under the second prong, it is possible a court will find that the owners can have no investment-backed expectation of interfering with the "public trust," the land seaward of the mean high tide line that is held in trust for the public by the state. Indeed, a rolling easement regulation would merely codify preexisting limits on development that are found in the public trust doctrine. Finally, the third prong of the balancing test should be persuasive to the court, as the character of the regulation is to prevent private property owners from interfering with the public trust.
2. **Developed property with "no new seawalls" condition:** A rolling easement is easiest to defend against a takings claim in this case because, under the second prong of the subjective balancing test applied by the court, the owner has no reasonable expectation of armoring the property. A court should also be persuaded by the third prong of the test that the character of the regulation is to protect private property owners from interfering with the public trust doctrine, which holds that the land below the mean high tide line is held in trust for the public by the state.
3. **Residential development predating the Coastal Act:** In this case, a rolling easement may result in a partial diminution in property value. It is difficult to predict with certainty how a court will apply the subjective three-part balancing test; but, under the second prong, it is possible a court will find that the owners have already enjoyed beneficial use of the residential structure(s) and should have no continued expectation to armor the property. The third prong should be most persuasive to the court, as the character of the regulation is to protect private property owners from interfering with the public trust resources and tidelands. The public trust doctrine holds that land below the mean high tide line is held in trust for the public by the state.

[23] CAL. PUB. RES. CODE § 30253(b).
[24] *Id.*
[25] CAL. PUB. RES. CODE §§ 30211, 30252.
[26] *See* CAL. PUB. RES. CODE § 30235.

Furthermore, even if the rolling easement, at the time it is asserted, would result in a loss of all economically beneficial use of the property, a court could find that the denial is not a "taking" because it merely codifies preexisting limits on development grounded in the public trust doctrine.

5.2.5 Setback condition to CDP

1. **Undeveloped property with proposed development:** As a condition of a coastal development permit for developing the property, a court may find that a setback is logically related to and roughly proportional to the impact of developing the property because the development would be subject to sea-level rise.
2. **Developed property with "no new seawalls" condition:** As a condition to a Coastal Development Permit for redevelopment of the property, a court may find that a setback requirement is logically related to and roughly proportional to the impact of redevelopment if the remodeling extends the life of the property, thereby subjecting it to sea-level rise and the inevitable future interference with public tidelands.
3. **Residential development predating the Coastal Act:** As a condition to a Coastal Development Permit for redevelopment of the property, a court likely should find that a setback requirement is logically related to and roughly proportional to the impact of redevelopment if the remodeling extends the life of the property, thereby subjecting it to sea-level rise and the inevitable need for future coastal armoring or future interference with public tidelands.

5.2.6 Setback Regulation

1. **Undeveloped property with proposed development:** A court may find regulatory setbacks to be a regulatory taking[27] if the use of a meaningful erosion rate over an appropriate time period will result in a setback that denies the property owner any economically beneficial use of her property. Such could be the case if there were not enough space left on the property to reconstruct the development behind the setback line. In practice, however, the local government could exercise its authority to grant a variance from the setback regulation in extreme situations, thus avoiding a takings claim.

If there is still room to construct development behind the setback line, a court applying the partial diminution in value balancing test is less likely to rule against an owner who purchased the property under a different understanding of land use restrictions. However, if the property owner purchased the property with knowledge of the regulation, a court applying the subjective balancing test might be persuaded by the fact that the character of the regulation is to protect the public trust, and the owner had no reasonable investment-backed expectations of developing the property in interference with public trust lands.

[27] *See Lucas*, 505 U.S. at 1022-23.

2. **Developed property with "no new seawalls" condition:** A court could find regulated setbacks to be a regulatory taking[28] if the use of any meaningful erosion rate over an appropriate time period would result in a setback that denied the property owner any economically beneficial use of her property. Such might be the case if there were not enough space left on the property to reconstruct development behind the setback line. In practice, however, the local government could exercise its authority to grant a variance from the setback regulation in situations where the regulated setback would deny the property owner any economically beneficial use of her property, thus avoiding a takings claim.

Even if there still is room to reconstruct development behind the setback line, a court applying the partial diminution in value balancing test may be unlikely to rule against an owner who developed the property under a different understanding of land use restrictions.

3. **Residential development predating the Coastal Act:** A court may find regulated setbacks to be a regulatory taking[29] if the use of a meaningful erosion rate over an appropriate time period results in a setback that denies the property owner any economically beneficial use of her property. Such would be the case if there were not enough space left on the property to reconstruct development behind the setback line. In practice, however, the local government could exercise its authority to grant a variance from the setback regulation in extreme situations, thus avoiding a takings claim.

Even if there still is room to reconstruct the development behind the setback line, a court applying the partial diminution in value balancing test may be unlikely to rule against an owner who developed the property under a different understanding of land use restrictions.

[28] *See id.*
[29] *See id.*

6. RESULTS

6.1 COST /BENEFITS RESULTS

The value of the properties located within the coastal erosion hazard zones is shown in Table 62. This shows that there are substantial properties at risk (>$400 million) within the coastal hazard zones for the entire region (identified as the planning horizon multiplied by the historic erosion rates).

Table 62 Existing Fair Market Value of Properties within Hazard Zones

Planning Regio	Assessor Value	Estimated Market Value
Del Monte	**$20**	**$45**
0-5	$	$1
6-25	$2	$3
26-50	$6	$13
51-100	$11	$28
Marina	**$121**	**$236**
0-5	$38	$38
6-25	$6	$6
26-50	$36	$85
51-100	$40	$107
Sand City	**$84**	**$125**
0-5	$33	$32
6-25	$15	$24
26-50	$15	$30
51-100	$21	$39
Grand Total	**$225**	**$406**

$ Damages Rounded in Millions

Table 62 shows existing value if the damages to the property occurred today. However, the modeling considered when in the future the damages would occur. The damages were discounted to present value using a 5% discount rate and are shown in Table 63. This demonstrates the importance of the timing of the damages when compared to implementing the erosion mitigation measures. There were not any adjustments to account for changes in perceived market value (e.g. due to threat of erosion or high protection costs) at future dates.

Table 63 Net Present Value of Properties within Hazard Zones Discounted at 5%

Planning Region	Assessor Value	Estimated Market Value
Del Monte	**$5**	**$10**
0-5	$	$1
6-25	$2	$3
26-50	$2	$4
51-100	$1	$2
Marina	**$58**	**$78**
0-5	$38	$38
6-25	$5	$5
26-50	$11	$25
51-100	$3	$9
Sand City	**$52**	**$65**
0-5	$33	$32
6-25	$13	$21
26-50	$4	$9
51-100	$2	$3
Grand Total	**$115**	**$153**

$ Damages Rounded in Millions

In order to summarize the benefit/cost analysis, the tables below (Tables 64 - 66) present a comparative examination between each of the erosion mitigation measures. To simplify, we only look at the complete planning horizon of 0-100 years. However, since we have discounted future costs and benefits it is appropriate to sum all of these planning horizons. Indeed, this is how a typical benefit/costs analysis would be performed (e.g. for the USACE).

To aid in the analysis, we also present the summarized benefit/cost analysis where the baseline scenario is construction of a revetment. All benefits and costs were discounted by 5% during the relevant time period over the 100-year time horizon. We assumed that all benefits and costs are in real 2010 dollars and the figures should be interpreted accordingly. As discussed in section 3.5, all benefits and costs presented in Section 4 were measured relative to the baseline of shore armoring with a revetment. For example, if adding 50 feet of beach width increases recreational value, the incremental (or marginal) increase in recreational value from this increased beach width was measured (not the total value of the recreation). Similarly, losses in land, infrastructure or residences were measured compared to the losses that would incur in the baseline scenario construction of a revetment. In some cases the biggest benefit of the measure is the savings associated with not building the revetment.

6.1.1 Del Monte Reach

Table 64 below summarizes all of the data presented previously in this paper over the 100 years.

Table 64 Summary of Benefits and Costs for all Alternatives: Del Monte

	Baseline:Rock Revetment	Nourishment	Nourishment with Groins	Nourishment with Reefs	Nourishment with Breakwaters	Seawall	Cease Sand Mining	Setbacks	Conservation Easement	Fee Simple	Rolling Easements
Total Recreational Value Above Baseline	$0	$24,752,098	$24,185,838	$30,116,431	$25,839,546	$ 8,695,117	$ 17,335,903	$ 14,293,851	$ 18,613,794	$ 18,613,794	$ 18,613,794
Total Habitat Value Above Baseline	$0	$10,950,350	$11,873,657	$12,610,940	$13,447,984	$ 578,022	$ 6,625,102	$ 3,602,699	$ 5,734,853	$ 5,734,853	$ 5,734,853
Total Government Property Value (PV) above Baseline	$ 534,259	-$31,317	$0	$0	$0	$0	$ (211,916)	$ (534,259)	$ (534,259)	$ (534,259)	$ (534,259)
Total Private Property Value (PV) above Baseline	$ 191,636	$0	$0	$0	$0	$0	$ -	$ (191,636)	$ (191,636)	$ (191,636)	$ (191,636)
Total Property Value (PV) above Baseline	$ 725,894	$694,577	$725,894	$725,894	$725,894	$ 725,894	$ 513,979	$ 77,398			
MRWPCA above baseline	$ 10,277,227	$0	$0	$0	$0	$0	-$3,186,638	-$10,277,227	-$10,277,227	-$10,277,227	-$10,277,227
Structural Adjustment Benefits above Baseline	$ -	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sum Benefits	$0	$35,702,448	$36,059,495	$42,727,371	$39,287,530	$9,273,139	$23,961,005	$17,896,550	$24,348,648	$24,348,648	$24,348,648
Structural Adjustment Costs	$ -	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
MRWPCA	$ -	$0	$0	$0	$0	$0	$3,186,638	$10,277,227	$10,277,227	$10,277,227	$10,277,227
Cost of Private Property Compensation	$ -	$864,000	$0	$0	$0	$0	$ 2,339,000	$ 5,015,845	$ 4,627,000	$ 9,254,000	
Cost of Pubic Property Compensation	$ -	$26,108	$0	$0	$0	$0	$164,502	$ 191,636	$ 211,425	$ 422,850	
Construction/Nourishment Cost	$ 60,836,746	$16,899,096	$87,875,299	$129,402,608	$131,812,949	$111,534,034	$0	$ 4,879,666	$ -	$ -	$ -
Revetment Cost	$ 60,836,746	$60,836,746	$60,836,746	$60,836,746	$60,836,746	$60,836,746	$60,836,746	$60,836,746	$60,836,746	$60,836,746	$60,836,746
Cost over Baseline	$ -	$ (43,047,541)	$ 27,038,554	$ 68,565,863	$ 70,976,203	$ 50,697,288	$ (55,146,605)	$ (40,472,372)	$ (45,721,094)	$ (40,882,669)	$ (50,559,519)
Net Benefits over Baseline	**$0**	**$ 78,749,989**	**$ 9,020,942**	**$ (25,838,492)**	**$ (31,688,674)**	**$ (41,424,149)**	**$ 79,107,610**	**$ 58,368,923**	**$ 70,069,742**	**$ 65,231,317**	**$ 74,908,166**
Benefit/Cost Ratio		**NA**	**1.3**	**0.6**	**0.6**	**0.2**	**NA**	**NA**	**NA**	**NA**	**NA**

Cessation of sand mining and beach nourishment measures provide the highest long term net benefits. The two measures reduce the risk of erosion impacts to infrastructure but do not completely prevent damages. In addition, several of the land use planning measures including Rolling Easements, Conservation Easements, and Fee Simple Acquisition provide similar levels of net benefits. However, it is important to note that these measures do not prevent damages to property and infrastructure but rather purchase or regulate the ability of the coast to erode and simply provides more benefits than the cost. It is our interpretation that the costs of all these measures may be under estimated as described in Section 4. Also, the benefits of beach nourishment to beach ecology are probably overstated relative to a natural beach without construction impacts. Hence, we expect the actual net benefits and benefit cost ratio of the nourishment measure to be less than presented herein. All of the land use planning measures (e.g. managed shore retreat and realignment) yielded over $70 million in benefits which is slightly lower than nourishment or ceasing sand mining, but still substantially higher than armoring the coast or setbacks which is the current policy practice As described above, it is likely that a better accounting of construction costs and ecological benefits would increase the viability of the land use planning measures above beach nourishment. Moreover, had the habitat analysis properly accounted for loss in habitat value, the nourishment option would likely have a lower value, though ceasing sand mining would then be the superior alternative. Also noteworthy is that the groin with nourishment option remains a net positive long-term benefit in the Del Monte Reach, although the high construction costs and difficult regulatory viability make this measure questionable.

Table 65 shows the ranking (1 = best to 11= worst) of each of the erosion mitigation measures for the various time horizons for Del Monte.

Table 65 Ranking of Erosion Mitigation Strategies For Each Time Horizon: Del Monte

Ranking	Immediate	Short	Medium	Long
1	Rolling Easements	Rolling Easements	Sand Mining	Sand Mining
2	Setbacks	Cons. Easements	Nourishment	Nourishment
3	Cons. Easements	Sand Mining	Rolling Easements	Rolling Easements
4	Fee Simple	Fee Simple	Cons. Easements	Cons. Easements
5	Sand Mining	Setbacks	Fee Simple	Fee Simple
6	Nourishment	Nourishment	Setbacks	Setbacks
7	Revetment	Groins	Groins	Groins
8	Groins	Revetment	Revetment	Revetment
9	Seawalls	Reefs	Seawalls	Reefs
10	Breakwaters	Breakwaters	Breakwaters	Breakwaters
11	Reefs	Seawalls	Seawalls	Seawalls

From the table above it appears that ceasing sand mining has the highest net benefits of all of the other measures. While nourishment comes ranked #2 in the long term it seems unwise to consider a costly large scale nourishment while sand mining continues in SMB. The high ranking of the land use planning tools especially in the shorter time frames provides support that they should be implemented immediately to provide the longest and highest net benefits. This supports taking short-term action to enact appropriate policies and regulations. It is also apparent that structural alternatives make little sense in the long term although groins do have positive net benefits and appear to make the most sense of the structural alternatives in the long term. The low ranking of seawalls and revetments result from the lack of benefits and relatively high cost associated with these measures. Seawalls as modeled show higher benefits as a result of less placement loss initially.

6.1.2 Sand City Reach

Table 66 presents the same analysis for the Sand City reach. The results are similar to those for Del Monte with the land use planning within 10% of the nourishment and cease sand mining alternative. With the higher erosion rates, however the groins cease to be net positive in the long term but still remain as the highest net benefits of any of the structural measures.

Table 66 Summary of Benefits and Costs for all Alternatives: Sand City

	Baseline:Rock Revetment	Nourishment	Nourishment with Groins	Nourishment with Reefs	Nourishment with Breakwaters	Seawall	Cease Sand Mining	Setbacks	Conservation Easement	Fee Simple	Rolling Easement
Total Recreational Value Above Baseline	$ -	$29,638,702	$33,440,691	$35,261,963	$37,421,939	$ 7,486,130.27	$ 18,754,661	$ 10,441,369.80	$ 24,592,108.45	$ 24,592,108.45	$ 24,592,108.45
Total Habitat Value Above Baseline	$ -	$32,349,846	$42,326,191	$44,988,441	$48,228,602	$ 6,688,794.32	$ 15,916,615	$ 10,297,740.90	$ 11,203,976.59	$ 11,203,976.59	$ 11,203,976.59
Sum Benefits	$ -	$ 61,988,547	$ 75,766,881	$ 80,250,404	$ 85,650,541	$ 14,174,925	$ 34,671,276	$ 20,739,111	$ 35,796,085	$ 35,796,085	$ 35,796,085
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ 23,642,591	$ 23,642,591	$ 23,642,591	$ 23,642,591	$ 23,642,591
MRWPCA	$ -	$ -	$ -	$ -	$ -	$ -	$ 11,309,061	$ 25,970,041	$ 25,970,041	$ 25,970,041	$ 25,970,041
Cost of Private Property Compensation		$ 376,589	$ 2,203	$ -	$ -	$ 112,670	$ 665,723	$ 2,424,907	$ 1,747,023	$ 3,494,046	
Cost of Pubic Property Compensation		$ 352,209	$ 1,942	$ -	$ -	$ 109,517	$ 543,436	$ 1,436,205	$ 718,103	$ 1,436,205	
Construction/Nourishment Cost	$ (253,486,440)	$ 70,412,900	$ 366,147,080	$ 549,220,620	$ 549,220,620	$ 464,725,140	$ -	$ 20,331,941	$ -	$ -	$ -
Revetment Cost	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)	$ (253,486,440)
Cost over Baseline	0	$ (182,344,742)	$ 112,664,785	$ 295,734,180	$ 295,734,180	$ 211,460,887	$ (217,325,630)	$ (179,680,755)	$ (201,408,682)	$ (198,943,557)	$ (203,873,808)
Net Benefits	**$0**	**$ 244,333,290**	**$ (36,897,903)**	**$ (215,483,776)**	**$ (210,083,639)**	**$ (197,285,962)**	**$ 251,996,905**	**$ 200,419,865**	**$ 237,204,767**	**$ 234,739,642**	**$ 239,669,893**
Benefit/Cost Ratio		**NA**	**0.67**	**0.27**	**0.29**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 67 shows the ranking (1 = best to 11= worst) of each of the erosion mitigation measures for the various time horizons for Sand City.

Table 67 Ranking of Erosion Mitigation Strategies For Each Time Horizon: Sand City

Ranking	Immediate	Short	Medium	Long
1	Rolling Easements	Rolling Easements	Sand Mining	Sand Mining
2	Sand Mining	Sand Mining	Rolling Easements	Nourishment
3	Cons. Easements	Fee Simple	Cons. Easements	Rolling Easements
4	Fee Simple	Cons. Easements	Fee Simple	Cons. Easements
5	Setbacks	Nourishment	Setbacks	Fee Simple
6	Nourishment	Setbacks	Nourishment	Setbacks
7	Groins	Groins	Revetment	Revetment
8	Seawalls	Revetment	Groins	Groins
9	Revetment	Seawalls	Seawalls	Seawalls
10	Breakwaters	Breakwaters	Breakwaters	Breakwaters
11	Reefs	Reefs	Reefs	Reefs

The table above for Sand City is similar to the findings for the Del Monte reach and it appears that ceasing sand mining has the highest net benefits of all of the other measures. While nourishment comes ranked #2 in the long term it seems unwise to consider large scale nourishment while sand mining continues in SMB. The high ranking of the land use planning tools especially in the shorter time frames provides support that they should be implemented immediately to provide the longest and highest net benefits. This supports taking short-term action to enact appropriate policies and regulations. It is also apparent that structural alternatives make little sense in the long-term although groins do seem to be the most beneficial over the long-term. The low ranking of the breakwaters and reefs result from the extremely high costs associated with construction dwarfing the recreational and ecological benefits.

6.1.3 Marina Reach

Table 68 summarizes the results for the Marina reach which differ from the other two reaches. In this reach, the land use planning options of Rolling Easements and Conservation Easements have the highest long-term net benefits followed by Ceasing of Sand Mining and Fee Simple Acquisition (all within ~10%) All of these options maintain the sand supply caused by Dune erosion and are critical to supporting the sediment budget in the rest of the littoral cell. We assume that these results reflect on the lack of development in this reach and relative lack of critical infrastructure costs. Even with the generous assumptions used in the Nourishment alternative it begins to become clearer that nourishment while still beneficial does not have as many long-term benefits. Of all of the hard structural alternatives groins still seems to make the most sense, but the potential to exacerbate or stabilize erosion hotspots (see Section 4.3.2) may negate this relative benefit compared to other alternatives.

Table 68 Summary of Benefits and Costs for all Alternatives: Marina

	Baseline:Rock Revetment	Nourishment	Nourishment with Groins	Nourishment with Reefs	Nourishment with Breakwaters	Seawall	Cease Sand Mining	Setbacks	Conservation Easement	Fee Simple	Rolling Easements
Total Recreational Value Above Baseline	$ -	$ 27,814,107	$ 31,333,875	$ 32,930,001	$ 33,512,815	$ 4,134,055	$ 16,129,511	$ 6,599,710	$ 25,075,525	$ 25,075,525	$ 25,075,525
Total Habitat Value Above Baseline	$ -	$ 59,237,351	$ 70,114,980	$ 75,847,847	$ 78,008,250	$ 6,750,920	$ 41,226,163	$ 10,320,890	$ 39,054,708	$ 39,054,708	$ 39,054,708
Sum Benefits	$0	$ 87,051,459	$ 101,448,855	$ 108,777,848	$ 111,521,064	$ 10,884,974	$ 57,355,674	$ 16,920,600	$ 64,130,233	$ 64,130,233	$ 64,130,233
Structural Adjustment Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
MRWPCA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,525,340	$ 2,525,340	$ 2,525,340	$ 2,525,340
Cost of Private Property Compensation	$ -	$ 16,312,131	$ 7,447,445	$ 7,136,051	$ 7,021,679	$ -	$ 9,428,979	$ 14,429,497	$ 18,846,962	$ 37,693,923	
Cost of Pubic Property Compensation	$ -	$ 7,624,645	$ 2,975,504	$ 5,190,912	$ -	$ -	$ 5,113,949	$ 13,007,229	$ 6,522,145	$ 13,044,289	
Construction/Nourishment Cost	$ 352,346,152	$ 96,896,620	$ 503,862,421	$ 755,793,632	$ 755,793,632	$ 645,967,945	$ -	$ 102,146,152	$ -	$ -	$ -
Total Cost (PV)	$ 352,346,152	$ 120,833,396	$ 514,285,371	$ 768,120,596	$ 762,815,312	$ 645,967,945	$ 14,542,928	$ 132,108,218	$ 27,894,446	$ 53,263,553	$ 2,525,340
Revetment Cost	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152	$ 352,346,152
Cost over Baseline	$ -	$ (231,512,756)	$ 161,939,219	$ 415,774,444	$ 410,469,160	$ 293,621,793	$ (337,803,224)	$ (220,237,934)	$ (324,451,706)	$ (299,082,599)	$ (349,820,812)
Net Benefits	**$0**	**$ 318,564,214**	**$ (60,490,364)**	**$ (306,996,595)**	**$ (298,948,096)**	**$ (282,736,819)**	**$ 395,158,898**	**$ 237,158,534**	**$ 388,581,939**	**$ 363,212,833**	**$ 413,951,045**
Benefit/Cost Ratio	**NA**	**NA**	**0.63**	**0.26**	**0.27**	**0.04**	**NA**	**NA**	**NA**	**NA**	**NA**

Table 69 shows the ranking (1 = best to 11= worst) of each of the erosion mitigation measures for the various time horizons for Sand City.

Table 69 Ranking of Erosion Mitigation Strategies for Each Time Horizon: Marina

Ranking	Immediate	Short	Medium	Long
1	Rolling Easements	Rolling Easements	Rolling Easements	Rolling Easements
2	Cons. Easements	Sand Mining	Sand Mining	Sand Mining
3	Sand Mining	Cons. Easements	Cons. Easements	Cons. Easements
4	Setbacks	Fee Simple	Fee Simple	Fee Simple
5	Fee Simple	Setbacks	Nourishment	Nourishment
6	Nourishment	Nourishment	Setbacks	Setbacks
7	Groins	Groins	Revetment	Revetment
8	Seawalls	Seawalls	Groins	Groins
9	Revetment	Revetment	Seawalls	Seawalls
10	Breakwaters	Breakwaters	Breakwaters	Breakwaters
11	Reefs	Reefs	Reefs	Reefs

The table above for Marina shows the high ranking of the land use planning tools throughout the 100 year long-term time frame. This analysis provides support that they should be implemented immediately to provide the longest and highest net benefits. This supports taking short-term action to enact appropriate policies and regulations. It is also interesting to note that nourishment, the #2 ranking alternative in Del Monte and Sand City drops below Fee Simple Acquisition by nearly $45M over the long time period. This is associated with the low levels of development and extremely high erosion rates in this reach of the study area.

6.1.4 Economic Impacts

Policy makers typically like to know the economic and fiscal (revenue) impacts of these programs in addition to looking at the benefits and costs associated with them. The analysis below only includes options which enhance beach width, leading to increased recreation (in particular attendance) and thus more economic impact and taxes. As part of the analysis, we looked at spending related to beach and other forms of coastal recreation that would be (negatively) impacted by coastal erosion. A more detailed analysis of the methodology we used is contained in Section 3.5. Briefly, we estimated spending per visitor and lower attendance implies lower spending. Similarly, we estimated taxes generated by coastal recreation spending applying figures from the California Statistical Abstract. Our analysis does not include losses in property tax revenues due to property erosion losses or storm damage losses. In the case of the Marina stretch, our analysis indicates that these losses would be substantial (in the millions of dollars); in the other two reaches they would be very small (in the thousands of dollars). Local spending impacts are lower because not all spending related to recreation occurs locally (e.g., someone buys gas at home and drives to the region).

As one can see in the tables below (Tables 70 – 72) present the economic impacts of these policies (above the baseline) are quite substantial generating tens of millions in spending and millions in State taxes. Tax revenues at the local level would rise also, but less substantially, on the order of several hundred thousand dollars per reach.

Table 70 Economic Impacts of Management Options: Del Monte

	Baseline:Rock Revetment	Nourishment	Nourishment with Groins	Nourishment with Reefs	Nourishment with Breakwaters	Seawall	Cease Sand Mining	Setbacks	Conservation Easement	Fee Simple	Rolling Easements
Direct Local Spending Above Baseline	$ 85,040,537	$106,723,526	$116,293,991	$113,518,524	$121,187,939	$ 56,865,659	$ 79,306,581	$ 67,894,917	$ 67,894,917	$ 67,894,917	$ 67,894,917
Direct State Spending Above Baseline	$ 106,300,671	$133,404,408	$145,367,488	$141,898,156	$151,484,924	$ 71,082,074	$ 99,133,227	$ 84,868,646	$ 84,868,646	$ 84,868,646	$ 84,868,646
	$ -										
Direct Local Taxes Above Baseline	$ 2,126,013	$2,668,088	$2,907,350	$2,837,963	$3,029,698	$ 1,421,641	$ 1,982,665	$ 1,697,373	$ 1,697,373	$ 1,697,373	$ 1,697,373
Direct State Taxes Above Baseline	$ 9,236,299	$5,594,886	$6,182,569	$5,875,115	$6,309,209	$ 2,383,329	$ 3,456,048	$ 3,101,952	$ 3,101,952	$ 3,101,952	$ 3,101,952

Table 71 Economic Impacts of Management Options: Sand City

	Baseline:Rock Revetment	Nourishment	Nourishment with Groins	Nourishment with Reefs	Nourishment with Breakwaters	Seawall	Cease Sand Mining	Setbacks	Conservation Easement	Fee Simple	Rolling Easement
Direct Local Spending Above Baseline	$ 77,644,208	$ 110,366,004	$ 122,201,650	$ 127,895,078	$ 134,440,139	$ 34,627,675	$ 79,601,951	$ 45,580,194	$ 45,580,194	$ 45,580,194	$ 45,580,194
Direct State Spending Above Baseline	$ 97,055,260	$ 137,957,505	$ 152,752,063	$ 159,868,848	$ 168,050,174	$ 43,284,594	$ 99,502,439	$ 56,975,242	$ 56,975,242	$ 56,975,242	$ 56,975,242
Direct Local Taxes Above Baseline	$ 1,389,920	$ 1,171,621	$ 1,287,267	$ 1,344,145	$ 1,410,749	$ 416,936	$ 758,121	$ 568,330	$ 568,330	$ 568,330	$ 568,330
Direct State Taxes Above Baseline	$ 7,992,041	$ 6,736,821	$ 7,401,785	$ 7,728,831	$ 8,111,806	$ 2,397,380	$ 4,359,196	$ 3,267,897	$ 3,267,897	$ 3,267,897	$ 3,267,897

Table 72 Economic Impacts of Management Options: Marina

	Baseline:Rock Revetment	Nourishment	Nourishment with Groins	Nourishment with Reefs	Nourishment with Breakwaters	Seawall	Cease Sand Mining	Setbacks	Conservation Easement	Fee Simple	Rolling Easements
Change to Direct Local Spending (PV)		$95,980,918	$276,505,716	$112,201,976	$283,210,098	$ 17,774,773	$ 61,463,990	$ 20,246,776	$ 20,246,776	$ 20,246,776	$ 20,246,776
Change to Direct State Spending (PV)		$119,976,148	$345,632,145	$140,252,470	$354,012,622	$ 22,218,466	$ 76,829,988	$ 25,308,470	$ 25,308,470	$ 25,308,470	$ 25,308,470
		$0	$0	$0	$0	$ -	$ -	$ -	$ -	$ -	$ -
Change to Direct Local Taxes (PV)		$397,144	$4,737,367	$552,439	$4,798,237	$ 444,369	$ 1,536,600	$ 506,169	$ 506,169	$ 506,169	$ 506,169
Change to Direct State Taxes (PV)		$6,335,331	$23,188,111	$7,228,274	$23,538,113	$ 1,664,029	$ 3,682,951	$ 2,244,713	$ 2,244,713	$ 2,244,713	$ 2,244,713

6.1.5 Sensitivity Analysis and Robustness

In addition to the analysis above, we checked to see how sensitive our results are to the various cost and benefit assumptions used. In particular, we ran a high cost and low cost scenario for nourishment and armoring measures. Under the low cost scenario, the B/C ratio for nourishment is somewhat higher, indicating that it is even more desirable as an alternative. The B/C ratios for the hard engineering mitigation measures are also somewhat higher but still well below one. In sum, the high cost and low cost scenarios yield slightly different estimates but the policy conclusions are exactly the same, which lends credence to our conclusions.

The habitat valuation estimate used is also subject to some uncertainty. To check for robustness, we also examined how varying the estimate of habitat valuation effected our conclusions. Higher habitat valuations tended to strengthen our results further. Lower habitat valuations weakened the conclusion but even at values much lower (half) than the assumption we used, most of our conclusions still stand. However, it should be noted that our habitat analysis is quite crude and does not take into the account the impacts that the options might play in altering the quality of the habitat. In particular, armoring the coast may lower habitat values by even more than we have estimated. On the other hand, nourishment programs have construction impacts and can also devalue ecosystems. Any analysis of beach nourishment needs to carefully consider in more detail the true ecological impacts over time.

7. CONCLUSIONS

7.1 GENERAL FINDINGS

- Ceasing Sand Mining is the most important erosion mitigation strategy in Southern Monterey Bay
- Beach recreation and habitat values have higher long term values than private property
- The benefits of sand placement (both nourishment and opportunistic sand placement) to the beach ecology are believed to be overstated in this analysis, due to a notable lack of data on the impact and duration of nourishment activities on the sandy beach ecosystem.
- Different planning horizons support use of different tools
- Public trust is an important legal component to land use planning measures however the land use planning measure most likely to trigger a takings claim is a setback regulation.
- Land use tools require a significant amount of time and effort to implement
- Most all tools require substantial funding, start saving now
- This new economic analysis approach which includes traditional storm damages as well as ecosystem services and recreational benefits supports evaluation of future scenarios
- Need to develop a standardized beach monitoring program for the region
- Results of these analyses would likely differ if climate change and sea level rise were factored into this report
- Need to continue to monitor current research on innovative erosion mitigation measures
- Pending identification of preferred measures, more detailed regulatory analysis will be required to implement each measure or the overall Subregional strategies.

7.2 LAND USE PLANNING MEASURES

- Analysis completed in this study shows that Rolling Easements are likely to be the least costly land use planning option.
- Land Use planning tools have the highest net benefits over the long term when compared to all other erosion mitigation measures.
- Managed retreat is more cost effective with higher net benefits over the long term than most of the traditional erosion mitigation strategies. Rolling easement, conservation easement and fee simple are all superior to armoring over these entire reaches.
- Inclusion of ecological and recreational benefits along with traditional property damages due to erosion shows status quo coastal management approaches of revetments or setbacks is not cost effective over the long term
- Setback policies differ across the region, with varying methods of calculating the distance
- Setbacks policies (as interpreted) do not maintain beaches after 25-50 years

7.3 SOFT ENGINEERING MEASURES

- Ceasing Sand Mining is the most important erosion mitigation strategy in SMB because it has the highest benefits and addresses the root cause of the high erosion rates in the region.

- The overall recreational and ecosystem service benefits to the communities in the region by the ceasing of sand mining from the beach is estimated to have a present value equal to $116 million in 2010 dollars.
- The overall benefits from ceasing sand mining including avoided construction costs are $718 million in 2010 dollars.

- Nourishment could be effective as a medium term solution but erosion of upland would occur within 25 year timeframe between nourishment cycles under existing erosion rates. The Sand City and Marina reaches are likely not suitable for nourishment given the high erosion rates.
- Nourishment likely need to be implemented more frequently than 25 years
- Opportunistic sand placement (SCOUP) has high benefit cost ratios (>5) but does not resolve long term erosion nor protect property because the rate and amounts of sand placed are low. Moreover the rate of sand placement considered exceeds identified resources.
- SCOUP appears moderately successful under lower erosion rates (-1.5ft/yr)
- Passive dewatering uncertain but low cost may make it a worthwhile experiment with monitoring

7.4 HARD ENGINEERING MEASURES

- Shoreline Armoring (Revetments and Seawalls) result in loss of beaches within ~5-50 year planning horizon
- Groins appear to be the most effective of the retention structures over the long term when net benefits are considered
- Retention structures (groins, reefs and breakwaters) increase the effectiveness of beach nourishment but are not cost effective (high costs to maintain with eroding region), except possibly in Del Monte location. We anticipate that a more detailed consideration of reefs and nourishment would increase the benefits but that the costs would still be greater than the land use and nourishment measures.
- Most retention structures options still show signs of upland erosion under high erosion rates at year 100

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APPENDICES

APPENDIX 1

COMPLETE LIST OF ALL EROSION MITIGATION MEASURES

1. Fee Simple Acquisition:
2. Conservation Easements:
3. Present Use Tax:
4. Transfer of Development Credit
5. Rolling Easements
6. Removal/Relocation Managed Retreat
7. Structural or Habitat Adaption
8. Bluff top Development (setback)
9. Beach Level Development (setback)
10. Controlling Surface Run-off
11. Controlling Groundwater
12. Reservoir and Debris Basin
13. Sand Mining
14. Harbor By-Passing
15. Back-Passing
16. Subaerial Placement
17. Artificial Seaweed
18. Native Plants
19. Geotextile Core
20. Nearshore Placement
21. Dredge Sand from Deep or Offshore Deposits
22. Added Courser Sand than Native
23. Opportunistic Sand
24. SCOUP Efforts
25. Canyon Interception
26. Rip-Current Interruption
27. Inter-littoral Cell Transfers
28. Berms/Beach Scraping
29. Perched Beaches
30. Groins
31. Breakwaters
32. Dune Nourishment
33. Delta Enhancement
34. Headland Enhancement
35. Geotextile Groins
36. Branch Box Breakwaters
37. Floating Breakwaters
38. Coir Logs
39. Submerged Breakwaters
40. Kelp Forest Restoration
41. Beach Dewatering
42. Pressure Equalizing Modules
43. Seawalls
44. Revetments
45. Cave Fills
46. Gabions
47. Mixed Structures
48. Cobble Nourishment
49. Dynamic Revetments
50. Geotextile Revetment
51. Floating Reefs
52. Rubber Dams
53. Visually Treated Walls or Revetments
54. Cessation of Sand Mining
55. Sand Fencing/Dune Guard Fencing

APPENDIX 2

1. MONITORING PLAN

The purpose of this monitoring section is to provide recommendations on several types of monitoring that could be used to inform the overall evaluation of the success of each of these erosion mitigation measures. These include a variety of standard and more innovative techniques to understand how these alternatives are working scientifically, examine environmental impacts and measure how effective they are at mitigating erosion and maintaining beach width.

The monitoring techniques discussed include:

- Survey Methods
- Lidar
- Bluff Edge Monitoring
- Sand Tracers
- Time Lapse Video
- Photographic Documentation
- Groundwater Monitoring
- Biological Monitoring

All of these monitoring techniques would benefit from the establishment of a common system of geodetic control. For example, the state of Florida -Department of Environmental Protection, has established a system of benchmarked monuments from which all beach profiles and survey work is collected forming a basis for long-term standardized data collection.

1.1. Survey Methods

Beach, dune, bluff, and offshore surveying are recommended as a monitoring method for nearly all of the measures. Nearshore Placement, Beach and Dune Nourishment, Dredging Sand From Deep or Offshore Deposits, PEM's and Beach Dewatering, Inter-Littoral cell Transfers, Native Plant Re-Vegetation, Sand Fencing/Dune Guard Fencing, Berms/Beach Scraping, and Sand Mining Cessation all should be monitored in some way to ensure effectiveness and identify impacts, and all could benefit from some form of annual/biannual surveying technique.

1.1.1. Topographic Survey – Beach Profiling

PWA recommends that beach profiling be done twice a year for five years in order to monitor long-term beach change within the potentially impacted zones. Topographic changes will be evaluated primarily though the reoccupation of cross-sections established in the year zero survey of baseline conditions. Beach profiling is a cost effective way to monitor changes accurately, while ensuring that critical morphological changes are not missed. Another advantage of a total station survey is the ability to extend the survey into the tidal zone without worry of LIDAR rays bouncing off of the water surface. A limitation of this, however, is that the survey crew can only proceed into waters that are safely navigable by small boat and not deep enough to affect accuracy limits.

This method would be applicable on different levels for virtually all of the implemented measures, and is recommended to be used in conjunction with other survey methods in order to ground truth the varying sources of data.

1.1.2. Flown LIDAR

An alternative to beach profiling would be a biannual LIDAR flight along the affected zone. While LIDAR flights are fast and relatively cheap, they do not provide ideal accuracy limits, and key components of the survey can theoretically be obstructed by vegetation and structures. LIDAR flights are also limited to land-only measurements, as the beams bounce off of water. For this reason a flown LIDAR survey would be great for dune and bluff edge surveys, but would need to be accompanied by a hydrographic survey if employed along reaches where beach nourishment methods were being monitored.

This method of surveying would be useful for monitoring the effectiveness of Inter-Littoral Cell Transfers within the Southern Monterey Bay sandshed. An annual survey flown across the littoral cell from the submarine canyon to the Monterey rocks would give a big-picture idea of the longshore transport rates and educate for future transfers.

1.1.3. Terrestrial LIDAR

The most thorough of the land survey techniques, terrestrial LIDAR is very effective in beach environments due to minimal obstructions. The main hindrance to terrestrial LIDAR is its inability to survey through or around obstructions. These can be trees, buildings, bushes, or other tall immovable objects. Terrestrial LIDAR is accurate and fast, but expensive.

1.1.4. Hydrographic Survey

Bathymetric survey data would be essential for a majority of the measures, and it is recommended that a full scan of the coastline be done annually to ensure the progress of Beach Nourishment, Beach Level Setback, Placement of Dredged Material, Nearshore Placement, and Inter-Littoral Cell Transfer.

1.1.5. Vessel Mounted LIDAR

The CSUMB Seafloor Mapping Laboratory's (SFML) vessel-based topographic LIDAR system consists of a Riegl LMS-Z420i terrestrial laser scanner coupled with an Applanix Position and Orientation system for Marine Vessels (POS/MV), in a package that can be mounted on all SFML survey launches (12-34 ft) and vehicles. The LMS-Z420i has a range of 1km, a vertical accuracy of 10mm, a vertical scan swath angle of 80°, and measurement rates of up to 11,000 points/second. The POS/MV data from its inertial motion unit (IMU) and dual GPS receivers are post-processed in Applanix POSPAC software using Virtual Reference Station technology to generate a Smoothed Best Estimated Trajectory (SBET) that is a tightly coupled intertial/GPS solution for the geometric center of the Riegl sensor. This SBET consists of positioning (± 2cm) and attitude measurements (pitch, roll, and yaw, ± 0.02°) at 200hz, all tied directly to the ellipsoid. Riegl software is used to merge the SBET and laser data to generate a topographic point cloud in real-world coordinates and free of motion artifacts.

The LMS-Z420i is mounted atop the survey vessel in a fixed orientation (i.e. not rotating scan mode), and set to the system's highest scan rate. This allows continuous scanning of coastal features while the vessel travels parallel to shore or around offshore rocks and pinnacles. Vessel speed and range to the coastline are the two determining factors of final data resolution. Typically, at a range of 500-700m and an average vessel survey speed of 4 knots, the SFML's point cloud data have spatial densities higher than 1 point every 50 square centimeters. Due to the low, horizontal view point of this technique, vessel-based LIDAR, unlike aerial LIDAR, can miss flat terrain above the level of the sensor, and topographic lows behind berms and dunes. This limitation precludes the ability to measure second order dunes, but is an ideal tool for direct measurement of complex vertical and overhanging sea cliff faces where data density can be sparse or missing due to the downward looking viewpoint of aerial LIDAR. The flexible, rapidly mobilized vessel-based LiDAR system produces high-resolution terrain data, in a relatively cost effective manner compared to traditional airborne LiDAR surveys; for which high cost is one of the biggest limiting factors for repeat aerial LiDAR surveys. As a result, we have found vessel-mounted LiDAR to be an efficient and effective method for the detection and quantification of annual sea cliff geomorphic change, highly useful for coastal planning and monitoring.

1.2. Bluff Edge Monitoring

PWA recommends monitoring of the bluff edge to evaluate long-term changes and implications for the future. It is recommended that the bluff edge be delineated by field methods instead of interpretation of scanned data in order to minimize the possibility of misinterpretation. This can be effectively done using a handheld GPS unit on tracking mode. If this method is not preferred, digitizing an ortho-rectified aerial photo in GIS would be an acceptable alternative. PWA can perform both techniques effectively.

1.3. Sand Tracer

Sand tracer is essentially colored sand that is placed along with larger placements for purposes of tracing the direction and rate of sediment transport. While some consider it an ugly addition to a beach, it is the most effective method of telling whether or not the sand you place is going where you want it to go. Sand tracer would be a very cheap and effective monitoring method for use with Nearshore Placement and Inter-Littoral Cell Transfers.

1.4. Time-Lapse Video

Short term monitoring of beach change can be monitored by means of video imagery collected by shore-located cameras. The Naval Postgraduate School has been conducting this type of analysis in the past so continuation of this data collection has the ability to provide a historic data set. The main benefit of this option is the ability to track changes caused by large-scale storm events on a real-time scale. Time-lapse video would supplement beach profiling in a few beneficial ways. As opposed to biennial or yearly surveys, year-round video capture allows for more accurate diagnosis of the erosional or depositional events associated with beach change. Video capture of wave breaking patterns can help to further understand beach dynamics of localized regions, allowing for quicker and better response to failing alternatives.

Time-Lapse video would be an effective supplemental way to monitor the effectiveness and/or failure of submerged breakwaters, perched beaches, groins, emergent breakwaters, and seawalls.

In addition, new research and development has developed automated detection algorithms to analyze video imagery to count the number of users on the beach. This may be a way to improve the estimates of attendance and to better understand the patterns of human usage along the beaches of Southern Monterey Bay.

1.5. Photographic Documentation

A cheaper alternative to time-lapse video would be photographic documentation. Photographic documentation techniques are based on the principals of re-photography, also known as repeat photography. It is a technique of landscape study where scenes are re-photographed at specified time intervals to determine the nature of long-term and short-term change. Photos are taken at a preset angle and orientation from photographic benchmarks established during year zero post-construction monitoring. PWA has a long history of extensive re-photography associated with monitoring efforts conducted for past and current projects.

1.6. Groundwater Monitoring

It is recommended that monitoring of the groundwater level be done seasonally to understand the natural groundwater dynamics of the area. This monitoring can be done with piezometer installations around the site to evaluate where the water table sits both seasonally and spatially. PWA has experience installing and maintaining piezometers, and has the necessary instrumentation in-house available to rent.

This will be beneficial to both monitor the effectiveness of applied alternatives as well as educate future applications of PEMs, dewatering, and desalinization wells.

1.7. Biological Monitoring

1.7.1. Terrestrial

Terrestrial surveys should focus primarily on locations of sensitive and endangered species including the distribution of sensitive dune vegetation and habitats supporting endangered species such as the dune glubose beetle, and legless lizard.

1.7.2. Intertidal

Intertidal monitoring should entail quadrant surveys along specified transect locations to assess the sandy beach ecosystem including invertebrates and wrack deposition. Additionally, shorebird counts of individual species during foraging activities and nesting locations should be included in this monitoring.

1.7.3. Subtidal

Subtidal field surveys should include diver surveys for biological monitoring of distribution of kelp, eelgrass, and rocky substrate.

APPENDIX 3

MRWPCA Costs

Summary of Cost Estimates for replacement of stretches of MRWPCA based on conversation with Jennifer Gonzalez 3/24/2010

Salinas study estimated roughly $4.5M/ mile to relocate pipe infrastructure. This is through farm fields and soil, so estimate of $5-7M per mile is more appropriate for relocating oceanfront pipes to under Del Monte Ave.

Interceptor Pipeline from South to North (Estimated subtotal - $15M to $21M)

- Wharf II to Monterey Pump Station (~1 mile) **$5-10M**
- Monterey Pump Station to Tide Ave (~900' – private properties) **$1-2M**
- Tide Ave (Ocean Harbor House) to Monterey Bay Beach Hotel (~3600') **$5M**
- Monterey Bay Beach Hotel to Seaside Pump Station (~2900') **$4M**
- To North, interceptor on seaward side of Highway 1 use **$5M/mile (likely OK for awhile)**

Pump Stations ($55M each)

- Monterey Pump Station (no estimate) not in 2004 report
- Reeside Pump Station (no estimate – outside study area)
- Seaside Pump Station cost estimate to relocate and rebuild **$55M** (2004 dollars)
  - Note: Not on timeline at present. 2004 report suggested planning occur in 5 years, and rebuild in 10 years. However currently in Capital Improvement Plan for 10+ year time frame

Failures

- Minor – roughly 2 weeks to repair – fines are **$3,000 /day**
- Catastrophic – Double cost estimates for emergency repairs

TOTAL ESTIMATE FOR REPLACEMENT RELOCATION - ~$130M