

Critical Infrastructure at Risk

Sea Level Rise Planning Guidance for California's Coastal Zone

Final Adopted Guidance
November 17, 2021



California Coastal Commission



Finally, the California [Funding Wizard](#) is a searchable database of grants, rebates, and incentives available to pay for sustainable projects. Funding opportunities can be searched by category such as transportation and water.

Adaptation Costs and Funding Recommendations

Given these cost considerations, the Coastal Commission has the following recommendations:

1. **Encourage increased federal and state funding** for sea level rise adaptation strategies for infrastructure. Such support will protect the health and safety of communities now and in the future and will save money by providing for proactive approaches, rather than waiting for more expensive damage to occur and emergency measures to be needed.
2. **Prioritize funding for adaptation strategies that move infrastructure out of hazardous areas**, such as realignment or relocation and other long term strategies.
3. **Evaluate the costs and benefits of each adaptation alternative over the entire life cycle of the infrastructure** rather than in 20 or 30 year increments, when performing alternatives analyses. All costs and benefits should be considered, including non market and other difficult to quantify values. Equity and environmental justice considerations should also be evaluated, including the benefits and burdens of individual decisions.
4. **Analyze the full life cycle costs of maintaining infrastructure in place**, including costs from damage to facilities, need for upgrades, and loss of recreational areas, habitats, and natural protective features.

NATURE-BASED ADAPTATION STRATEGIES

Nature-based adaptation strategies rely on ecological and physical processes to offer protection to the built, inland, or backshore environment while preserving coastal resources. Unlike hard shoreline protective devices that can exacerbate erosion and contribute to the loss of coastal resources, nature-based adaptation strategies are intended to improve ecological and natural systems while reducing the impacts of coastal flooding and erosion. Coastal habitats that can support nature-based adaptation strategies include wetlands, dunes, sandy beaches, and reefs. Nature-based adaptation strategies include solutions that are composed entirely of natural systems – called “soft strategies” – or natural systems that have been restored or enhanced in combination with constructed features such as marsh sills, buried revetments, and cobble berms – called “hybrid armoring.” Both approaches can help to ensure that ecological value from the natural habitat is maintained or enhanced.

Nature-Based Adaptation Strategies

Unlike hard shoreline protective devices that can exacerbate erosion and contribute to the loss of coastal resources, nature-based adaptation strategies improve ecological systems while reducing the impacts of coastal flooding and erosion.

Nature-based adaptation strategies can provide co-benefits in the form of water quality enhancement, habitats, recreation, flood resiliency, and improved coastal ecosystems. Siting vulnerable infrastructure away from coastal hazards and implementing nature-based adaptation strategies as the first line of defense can also allow for the natural systems to adapt and keep pace with sea level rise.

Recognizing the numerous co-benefits that nature-based adaptation strategies can impart, the State has broadly encouraged the use of these adaptation options. Specifically, [Executive Order B-30-15](#) requires that state agencies prioritize natural infrastructure (OG, 2015) and [Executive Order N-82-20](#) emphasized the need for state agencies to accelerate the use of natural infrastructure. Further, [Safeguarding California](#), the Ocean Protection Council's [State of California Sea-Level Rise Guidance](#), the [California State Hazard Mitigation Plan](#), and the California Coastal Commission's [Sea Level Rise Policy Guidance](#) all encourage the use of living shorelines and other nature-based adaptation strategies. The Coastal Act also includes key policies that encourage this alternative to traditional shoreline protective devices, broadly mandating maintenance, protection, and, where feasible, restoration and enhancement of natural coastal habitats. The California Environmental Quality Act and some Coastal Act policies also require agencies to evaluate alternatives to hard shoreline protection and to approve the least-environmentally damaging feasible alternative. Nature-based adaptation strategies will be an increasingly useful way to proactively address sea level rise impacts in line with these Coastal Act requirements, particularly as part of a phased approach.

While nature-based adaptation strategies may contribute to the resilience of coastal infrastructure, there are a number of important factors that should be considered when implementing these strategies. It can be challenging to construct natural systems where they do not currently exist and ensure that the created habitat provides adequate coastal protection at the same time as ecological, recreational, and other shoreline values. In addition, open coast environments in California are very different than low energy or bay coast environments and may require different strategies to be successful. Factors such as larger tidal ranges, storm surges, and wave action as well as impacts from coastal storms and El Niño events are often exacerbated in open coast environments. Furthermore, areas along the East and Gulf Coasts, where nature-based adaptation strategies have been more extensively implemented, often have different geomorphology and ecology compared to California. Therefore, strategies such as wetland restoration and oyster beds that work for low energy environments in other parts of the country will need to be reevaluated along with other types of nature-based adaptation strategies to account for the



Image 7. Dune restoration at Surfer's Point in Ventura County. Photo by Louis White.

conditions of much of California’s open coast. Nature-based adaptation strategies may also require a larger footprint or a greater upfront cost than more traditional armoring. Finally, the habitats involved in nature-based adaptation strategies are also susceptible to the impacts of climate change and sea level rise themselves, including the impacts caused by “coastal squeeze” when habitats are located adjacent to developed areas. Therefore, careful planning is necessary to balance the goals and needs of implementing a successful nature-based adaptation strategy with the protection of built infrastructure.

Many case studies, guidance documents, and other tools have been developed to better understand the opportunities and constraints for these kinds of strategies. In 2019, the Federal Highway Administration (FHWA) released a resource titled [Nature-Based Solutions for Coastal Highway Resilience: An Implementation Guide](#). The Implementation Guide provides transportation managers with key resources in planning and developing nature-based adaptation strategies to improve transportation infrastructure resilience. In addition, a Technical Report prepared for the Fourth California Climate Change Assessment, [Toward Natural Shoreline Infrastructure to Manage Coastal Change in California](#), provides guidance for planners that is specific to California and that describes how to reduce reliance on coastal armoring and deploy natural shoreline infrastructure solutions (Newkirk *et al.*, 2018). Additionally, NOAA’s Office for Coastal Management provides a [Green Infrastructure Effectiveness Database](#), which contains peer-reviewed articles, gray literature, and online tools regarding various nature-based adaptation strategies that have been implemented across the country. This database may be most helpful as a starting point when planning for a nature-based adaptation strategy to better understand best practices and lessons learned. Several examples of nature-based adaptation strategies are highlighted in [Appendix E](#) and [Appendix F](#).

However, more case studies will be needed to better understand how nature-based adaptation strategies might function on California’s open shoreline areas, and to help facilitate wider use of such strategies. A critical step to understanding and facilitating wider use of nature-based adaptation strategies is to implement on-the-ground projects and monitor their performance. To this end, the Commission is encouraging local governments and asset managers to prioritize nature-based adaptation strategies with measurable environmental benefits over strategies that have adverse coastal resource impacts such as traditional shoreline protective devices. In many instances, partnering with Native American Tribes to incorporate tribal knowledge and tribal science will improve planning and implementation of nature-based adaptation strategies given that many tribes have a long history of using nature-based solutions to restore degraded habitats. These and other approaches can contribute to a growing repository of best practices and guidance documents to share lessons learned and further encourage the use of nature-based adaptation strategies.

Image 8. San Gregorio State Beach in San Mateo County. Photo by the California King Tides Project.



Table 1 is adapted from the aforementioned FHWA’s *Nature-Based Solutions for Coastal Highway Resilience Report* and applied to the coastal contexts found in California, where higher tidal ranges, higher energy wave climates, and geologic diversity make categorizing solutions more difficult. The table highlights the range of potential nature-based adaptation strategies, organized by hazard type and geophysical context. The strategies highlighted in Table 1 are not based on any quantifiable metric and are not comprehensive; rather, it is meant to capture common approaches determined by the typical geophysical and engineering constraints for each hazard and geophysical context specific to California. Projects requiring a Coastal Development Permit (CDP) will still be reviewed for consistency with the Coastal Act and/or LCPs, and the suggested approaches below may or may not be appropriate or consistent with the Coastal Act/LCPs in particular instances. Coastal managers and potential applicants are encouraged to reach out to Coastal Commission staff early in the conceptual planning process to discuss the potential for nature-based adaptation strategies.

Table 1. Hazard and corresponding potential adaptation strategy with nature-based component (See also [Appendix F](#)).

Hazard/Issue	Softer Strategies	Hybrid Armoring Strategies
Erosion (sheltered coast)	<ul style="list-style-type: none"> • Oyster bed • Eelgrass bed • Tidal bench • Wetland restoration • Regional sediment management 	<ul style="list-style-type: none"> • Cobble berm + sand dunes • Marsh sill • Marsh sill + breakwater • Tidal bench + breakwater • Cobble berm + marsh sill • Sand dunes + finger groins
Erosion (beach)	<ul style="list-style-type: none"> • Sand dunes • Sand nourishment • Regional sediment management 	<ul style="list-style-type: none"> • Cobble berm • Buried revetment • Buried seawall • Artificial reef
Erosion (bluff)	<ul style="list-style-type: none"> • Native vegetation stabilization • Drainage improvements • Sand nourishment • Regional sediment management 	<ul style="list-style-type: none"> • Cobble berm • Rock platform + vegetation
Flooding (static water level)	<ul style="list-style-type: none"> • Wetland restoration • Daylighting/widening/ naturalizing creek/ stream drainages • Adding tidegates, enlarging culverts, or replacing culverts with bridges 	<ul style="list-style-type: none"> • Ecotone levee
Flooding (wave overtopping and runup, sheltered coast)	<ul style="list-style-type: none"> • Sand dunes • Eelgrass bed • Tidal bench • Oyster bed • Wetland restoration 	<ul style="list-style-type: none"> • Cobble berm • Marsh sill • Ecotone levee • Sand dune + buried seawall • Artificial reef
Flooding (wave overtopping and runup, open coast)	<ul style="list-style-type: none"> • Sand dunes • Sand berm 	<ul style="list-style-type: none"> • Cobble berm • Sand dunes + buried seawall • Artificial reef

Nature-Based Adaptation Recommendations

The Coastal Commission has the following recommendations related to nature-based adaptation strategies:

- 1. Consider nature-based adaptation strategies in all sea level rise adaptation planning efforts** and prioritize such solutions over proposals for hard shoreline armoring, whenever feasible. Where these strategies are not feasible, pursue opportunities to increase their feasibility in the future.
- 2. Identify existing nature-based shoreline protection** and consider opportunities to maintain, enhance, or expand these existing features.
- 3. Prioritize funding for nature-based adaptation strategies** over traditional hard shoreline armoring methods.
- 4. Encourage partnerships among state agencies to strengthen and accelerate opportunities for using nature-based adaptation strategies** – including the Ocean Protection Council, Coastal Conservancy, State Lands Commission, State Parks, State and Regional Water Quality Control Boards, Department of Fish and Wildlife, and Coastal Commission.
- 5. Continue monitoring the performance of nature-based adaptation strategies and their co-benefits**, and developing case studies, guidance, and best practices to share lessons learned and encourage wider use of nature-based adaptation strategies.

