Card Fronts

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Adaptation Strategy

Rip-Rap Revetment

Rip-rap revetments consist of an armor layer of stone with stone underlayers and/or geotechnical fabric to prevent loss of soil material due to wave action. Revetments are built at 2H:1V or shallower slopes and achieve stability through the armor stone weight and some interlocking between stones. Revetments are flexible and can sustain some damage or adjust to settlement and still retain their function.

2

Adaptation Strategy

Marsh Enhancement

Many tidal marshes cannot build vertically naturally to keep pace with sea level rise due to limited sediment supplies. As sea level rise accelerates, these marshes will drown and disappear. Strategic placement of a thin layer of sediment at regular intervals can enhance marsh resilience to sea level rise.

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Pros

- Maintains wetland flood risk reduction capacity
- Prevents wetland drowning and disappearance
- Maintains habitat quality and biodiversity
- Supports endangered species

Cons

- Requires sediment of quality
- Must be coordinated within seasonal windows to avoid species impacts
- Long-term benefits may be limited if marshes cannot migrate inland

Lifespan

20 years for 3.3 feet of SLR by 2100
10 years for 6.6 feet of SLR by 2100

Costs

$50,000 per acre

1

Pros

- Reduces wave energy and mitigates erosion
- Maintains performance after sustaining damage
- Can provide habitat for mollusks and aquatic vegetation
- Potential for creation of vegetation benches + aquatic habitats to be integrated into design

Cons

- Accelerates erosion of adjacent unprotected shorelines
- Limits maritime access to the shoreline
- Can provide unwanted habitat to rodents or other pests
- Poses hazard to people climbing on the revetment
- Regulations discourage hard armoring

Lifespan

25 years
Requires regular inspections and maintenance

Costs

$2,000 per linear foot for 3.3 feet of SLR

$4,000 per linear foot for 6.6 feet of SLR

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Adaptation Strategy

Seawall

Seawalls harden the shoreline and limit inland flooding and reduce erosion behind the seawall. The slope of the structure is generally vertical or near vertical. The vertical slope of seawalls can increase the potential for wave hazards and wave runup, requiring higher structure heights than a traditional levee.

2

Adaptation Strategy

Beach Nourishment

Beach nourishment is the engineered process of pumping or dumping sand on a beach to replace eroded sand and provide temporary erosion protection of inland areas.

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2

Pros

- Temporarily reduces wave energy and mitigates erosion
- Temporarily maintains the width of an eroding beach
- Improves public access, tourism, and recreation
- Can be coupled with native vegetation establishment to promote longevity and increase habitat diversity

Cons

- Local sand sources can be limited, increasing costs
- Environmental impacts from sourcing sand
- Sand can be lost to offshore canyons

Lifespan

5 years
Can be seriously damaged by wave and storm activity
Requires regular inspections and maintenance

Costs

$1,000 per linear foot for 3.3 feet of SLR
May increase if sand cannot be sourced locally

1

Pros

- Reduces inland erosion
- Reduces inland flooding
- Can protect individual properties or large stretches of shoreline
- Can be accredited by FEMA and reduce flood insurance premiums for inland structures
- Can incorporate living seawall textures or concrete mixtures to attract native species and increase habitat biodiversity

Cons

- May impact inland drainage
- Prevents inland habitat migration
- Increases erosion rates of adjacent shorelines due to wave reflection
- Reduces habitat diversity
- Regulations discourage hard armoring
- Challenging to maintain if property ownership is complex (multiple properties with property-based seawalls)

Lifespan

100 years
Requires regular inspections and maintenance

Costs

$12,000 per linear foot for 3.3 feet of SLR

$24,000 per linear foot for 6.6 feet of SLR

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Adaptation Strategy

Dune Restoration And Management

Dune restoration and management creates or stabilizes dunes to provide erosion and inland flooding protection. It requires rock and sand to build up dunes and native vegetation planting.

Placement of rip-rap armoring under the dunes can extend the lifespan and provide a secondary line of defense.

2

Adaptation Strategy

New Inner Breakwater

Breakwaters protect coastal areas from strong wave hazards. Most used to protect harbors and anchorages, helping to isolate vessels from wave hazards. Breakwaters installed parallel to the shore can minimize wave-induced erosion and beach loss.

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2

Pros

- Reduces wave energy and mitigates erosion
- Low visual impact
- Protects maritime and recreation areas
- May prolong the life of beach nourishment
- Can be designed to provide habitat benefits or shellfish to improve water quality

Cons

- Accelerates erosion of adjacent unprotected shorelines
- Impacts to natural sediment movement within protected areas
- May impact harbor use or boating access

Lifespan

75 years
Requires regular inspections and maintenance
May require more than one increase in height

Costs

$6,000 per linear foot for 3.3 feet of SLR

$12,000 per linear foot for 6.6 feet of SLR

1

Pros

- Reduces wave energy and mitigates erosion
- Reduces inland flooding
- Allows for natural migration of beach sand
- Improves public access
- Enhances habitat biodiversity
- Opportunities for material reuse, including existing rock, cobble, or dredged material

Cons

- Requires substantial fill material
- Challenging to permit due to limited examples or prior projects

Lifespan

10 years
Depends on native vegetation establishment
Can be seriously damaged by wave and storm activity
Requires regular inspections and maintenance

Costs

$3,000 per linear foot for 3.3 feet of SLR

$6,000 per linear foot for 6.6 feet of SLR

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Adaptation Strategy

Traditional Levee

Traditional Levees provide flood risk reduction and reduce shoreline erosion. Levee slopes are typically 3H:1V or 4H:1V, with riprap armoring to reduce wave energy.

2

Adaptation Strategy

Raising Breakwaters

Raising and enhancing existing breakwaters to accommodate future sea level rise and increased wave activity. It can be designed to integrate tide pools for rock dwelling flora and fauna, and/or to integrate shellfish reefs to improve water quality.

Raising the outer breakwater would require a cost-share agreement with the U.S. Army Corps of Engineers, where they would likely pay 65% of the total cost.

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2

Pros

- Reduces wave energy and mitigates erosion
- Low visual impact
- Protects maritime and recreation areas
- Can be designed to provide habitat benefits

Cons

- Accelerates erosion of adjacent unprotected shorelines
- Impacts to natural sediment movement within protected areas

Lifespan

50 years
Requires regular inspections and maintenance
May require more than one increase in height

Costs

For inner breakwater: **$2,000** per linear foot for 3.3 feet of SLR
$4,000 per linear foot for 6.6 feet of SLR

For outer breakwater: **$8,000** per linear foot for 3.3 feet of SLR
$16,000 per linear foot for 6.6 feet of SLR

1

Pros

- Reduces wave energy and mitigates erosion
- Reduces inland flooding
- Can be coupled with public access
- Can be accredited by FEMA and reduce flood insurance premiums for inland structures

Cons

- Requires substantial fill material
- May impact inland drainage
- Limits inland habitat migration
- Limits habitat diversity
- Limits maritime access to the shoreline
- Accelerates erosion of adjacent unprotected shorelines
- Regulations discourage hard armoring

Lifespan

50 years
Requires regular inspections and maintenance

Costs

$5,000 per linear foot for 3.3 feet of SLR

$10,000 per linear foot for 6.6 feet of SLR

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Adaptation Strategy

Elevated Roadway

Elevated roadways (on fill) raise the street above an expected flood elevation. The elevated roadway becomes the levee, providing flood risk reduction for inland assets and infrastructure.

2

Adaptation Strategy

Structure Elevation

For new construction, structure elevation can be achieved by raising the ground with fill material, or elevating structures on piles above a design flood elevation.

For existing structures, structures are physically raised above a design flood elevation through various measures, including elevating on continuous foundation walls; elevating on open foundations, such as piles, piers, posts or columns; elevating on fill; and removing first occupancy and converting the second story.

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2

Pros

- Can enhance compliance with the National Flood Insurance Program
- Can reduce or eliminate flood insurance premiums
- Raising structure can be coupled with seismic retrofits

Cons

- Buildings must be structurally sound and capable of being elevated safely
- New construction built on fill may increase flood risks for non-elevated existing structures
- Limited adaptability
- Access may be impacted during flood events (e.g., flooded roadways)
- Addresses temporary flooding, not permanent sea level rise inundation

Lifespan

50 years
Depends on surrounding area with continued access to utilities and roadways

Costs

$100,000 for 3.3 feet of SLR

$200,000 for 6.6 feet of SLR

1

Pros

- Reduces inland flooding
- Protects transportation assets
- Increased initial capital costs but may reduce long-term costs when coupled with utility improvements
- Can be combined with dune restoration

Cons

- Significant construction impacts
- Disrupts utilities and transit
- May impact inland drainage
- Impacts inland habitat migration
- Liability for flood protection may fall on transportation agency

Lifespan

50 years
Requires regular inspections and maintenance

Costs

$8,000 per linear foot for 3.3 feet of SLR

$16,000 per linear foot for 6.6 feet of SLR

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Adaptation Strategy

2

Adaptation Strategy

Card Backs

2

Pros

Cons

Lifespan

Costs

1

Pros

Cons

Lifespan

Costs

Card Fronts

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Adaptation Strategy

Update Land Use Regulations

Update land use policies to only allow uses that are more compatible with flooding because they either have a high ability to adapt or are less sensitive if flooded. Examples could include commercial and industrial uses built to withstand flooding, or floodable parks and floodable conservation areas. This may also include limiting sensitive uses such as new housing and new critical infrastructure and services (wastewater treatment plants, fire stations, etc.).

This work includes updating the General Plan, the Local Coastal Program, and the Zoning Ordinance. It could also be implemented as part of a Sea Level Rise Overlay Zone.

2

Adaptation Strategy

Acquisition and Buyout Programs

Buyout program can reduce flood risks in existing or future high-risk areas.

For a leaseback program, County could purchase at-risk properties, floodproof them at the County's cost, and rent them out as an interim strategy, including to the same renters to avoid displacement. Most floodproofing can be completed without relocating tenants.

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Pros

- Long term solution
- Could preserve or create new open (or floodable) space
- Reduces future costs of evacuation or structure abandonment

Cons

- Could impact existing community character
- Public opposition
- Potential equity concerns (potential for bias towards less expensive properties which may lead to displacement)

Costs

$1,000,000 per building

1

Pros

- Long-term solution
- Could preserve or create new open space

Cons

- Could change existing community character
- Impacts to existing property owners
- Potential lost tax revenue

Costs

$250,000

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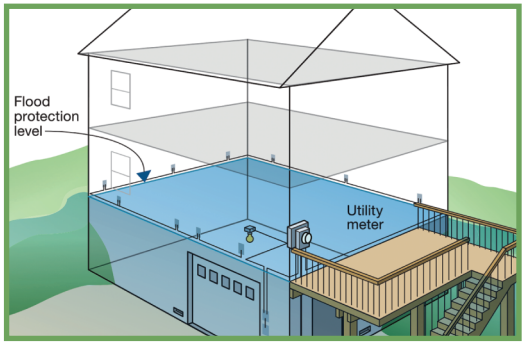
Adaptation Strategy

Structure Floodproofing

Floodproofing includes "any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents" (FEMA 2020).



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Adaptation Strategy

Structure Relocation

Structures can be relocated outside of areas of existing and future flood and erosion risk.

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Pros

- Reduces flood risk
- Increases useful life

Cons

- Identifying receiving location can be challenging
- Potential loss of community

Lifespan

Permanent protection

Costs

$200,000 for typical structure

1

Pros

- Reduces flood risk damage
- Less costly than other interventions

Cons

- Certain additions may need to be actively closed in advance of a flood event (e.g. waterproof flood door) to work properly

Lifespan

15 years

Requires regular inspections and maintenance

Costs

$20,000 for typical residential structure

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Adaptation Strategy

Transfer of Development Rights

The program allows unused development potential from a property at risk to be transferred to another property out of the sea level rise exposure zone to increase the allowable gross floor area of development above what would otherwise be allowed.

2

Adaptation Strategy

Resilient Development Standards

Updating land use policies includes updating land use designations in the General Plan and Local Coastal Program. Changes in land use could include limiting new development in flood-prone or high flood risk areas.

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Pros

- Provides options for new development or redevelopment
- Prolongs the useful life of new and redeveloped buildings
- Reduces flood risk damage
- Reduces costs to recover from a flood

Cons

- Harder to implement for existing development
- High upfront building costs

Costs

$250,000

1

Pros

- Long-term solution
- Could preserve or create new open (or floodable) space

Cons

- Could impact existing community character
- Public opposition

Costs

$100,000