Adapting to Rising Tides

Structural Shorelines Vulnerability and Risk Profile

Structural shorelines protect the built and natural environment, including key infrastructure, parks and natural areas, and the people that live and work along the Bay. In the ART project area, three categories of structural shorelines were identified: (1) engineered flood protection, e.g., levees/floodwalls designed to protect inland areas from a 100-year water level; (2) engineered shoreline protection, e.g., revetments or bulkheads that harden the edge to reduce erosion; and (3) non-engineered berms, e.g., mounds of Bay mud placed to separate managed baylands from the Bay, which can also provide "ad hoc" flood protection.

The shoreline of the northern portion of the ART project area, e.g., Emeryville, Oakland, and Alameda, is urbanized, and engineered flood and shoreline protection predominates. The southern portion of the ART project area, e.g., Hayward, has a less developed shoreline edge, and structures mostly consist of non-engineered berms. Structural shoreline assets are owned, maintained, regulated, and financed by a complex system of local, regional, state, and federal agencies, including Alameda County Flood Control and Water Conservation District, California Department of Transportation (e.g., around the San Francisco-Oakland Bay Bridge), the U.S. Army Corps of Engineers (e.g., around navigable waters), East Bay Regional Parks District, Hayward Area Recreation and Park District (along the Hayward Regional Shoreline), and the California Department of Fish and Wildlife (along Eden Landing Ecological Reserve).

Key Issues

Structural shorelines are vulnerable to sea level rise and storm events that expose them to additional tidal currents, wave energy, runup and overtopping, which can weaken structures and increases their potential for failure. Different types of structural shorelines have differing sensitivities. Specifically, engineered flood protection is vulnerable to levee crest and backside erosion if overtopped, while engineered shoreline protection is vulnerable to mobilization of the armor layer and erosion of the foundation. Non-engineered berms are especially vulnerable to erosive wave and tidal action because they have not been engineered to meet specific design criteria and are often not maintained on a regular basis. The vulnerability of any particular stretch of structural shoreline in the ART project area depends on its location, type, design, and maintenance. Structures that have space to be expanded or improved, have dedicated funding and permit authorizations for maintenance and improvements, and are already included in long-range capital improvement planning are less vulnerable. Realignment of some structures to a new inland position may be necessary in some instances, and a multi-agency approach is required to assess the feasibility and potential effectiveness of these types of projects.

Vulnerabilities

Timing

- Most of the structural shorelines in the ART project area will overtop by mid-century during a 100-year storm event that is coupled with wind waves.
- By the end-of-century, more than one third of the shoreline will overtop at daily high tide, and most of the shoreline will overtop during 100-year storm events.

Physical and Functional Qualities

- Depending on the type and design, structural shorelines have varying sensitivity to tidal action, wave energy, and overtopping which can cause erosion, destabilization and failure. For example, non-engineered berms are highly vulnerable due to limitations in their design and maintenance.
- Engineered flood protection, such as levees, is sensitive to overtopping, which can decrease structural stability and increase the potential for failure.
- Engineered shoreline protection, such as revetments, is sensitive to erosion and overtopping because generally armoring is designed for present wave action, and sea level rise may increase wave heights and velocities.
- Structural shorelines are vulnerable if there are technical, physical or environmental constraints that limit the ability to increase their height, for example if located in an environmentally sensitive area (adding height requires an increase in footprint).

Consequences

Scale

- Asset itself
- Adjoining properties and neighborhoods
- Regional to international depending on the assets protected (e.g., the airport or seaport)

People

- If structural shorelines overtop or fail, the people protected by them, including socially vulnerable communities, will be subjected to flooding.

Economy

- If structural shorelines overtop or fail, infrastructure critical to the region's economy, such as the Bay Bridge, the seaport, or the Oakland International Airport are at risk of significant disruption, with spin-off economic consequences that reach beyond the region or even the state.
- Repairing, maintaining and improving structural shorelines requires significant resources, and can have consequences on the local, subregional and regional economy.

Vulnerabilities

Management Control

- Structural shorelines that lack dedicated funding or permit authorizations for maintenance or improvements, and are not included in long-range capital improvement planning are more vulnerable because shoreline managers cannot easily maintain or make repairs to address sea level rise and storm event impacts.
- Existing inter-agency coordination, governance structures and financing strategies are insufficient for planning and implementing the types of large scale, phased structural shoreline projects that will be needed to address sea level rise and storm event impacts.