



# Impacts of Rising Sea Level: A Santa Barbara Case Study

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## Background

Eleven of the past 12 years were the hottest on record, and global temperatures are predicted to rise 1.8-4.0°C by 2100. Accelerated glacial melting, increased ocean temperatures, and thermal expansion of ocean water have contributed to a 0.2m increase in sea level height since 1900.

Given accelerated climate change scenarios, scientists currently estimate sea level heights will rise between 0.5 to 1.4 m above 1990 levels by 2100, with a maximum physically possible estimate of 2m (Rahmstorf, 2007; Pfeffer et al, 2008).



Elevated cliff erosion rates and permanent inundation are major physical impacts of sea level rise that will be compounded by increased storm intensities and reduced 'hydraulic head' of drainage systems.



**Question:** Given that past research has centered on regions with low coastal relief, what will the local impacts of sea level rise be on the city of Santa Barbara by 2100?

## Objectives

- Model physical impacts of sea level rise in the city of Santa Barbara under .5, 1.4, and 2 meter scenarios.
- Analyze the costs of sea level rise on the Santa Barbara's physical and economic infrastructure using GIS.
- Identify appropriate adaptation and mitigation measures for Santa Barbara city officials to consider.

## Study Area

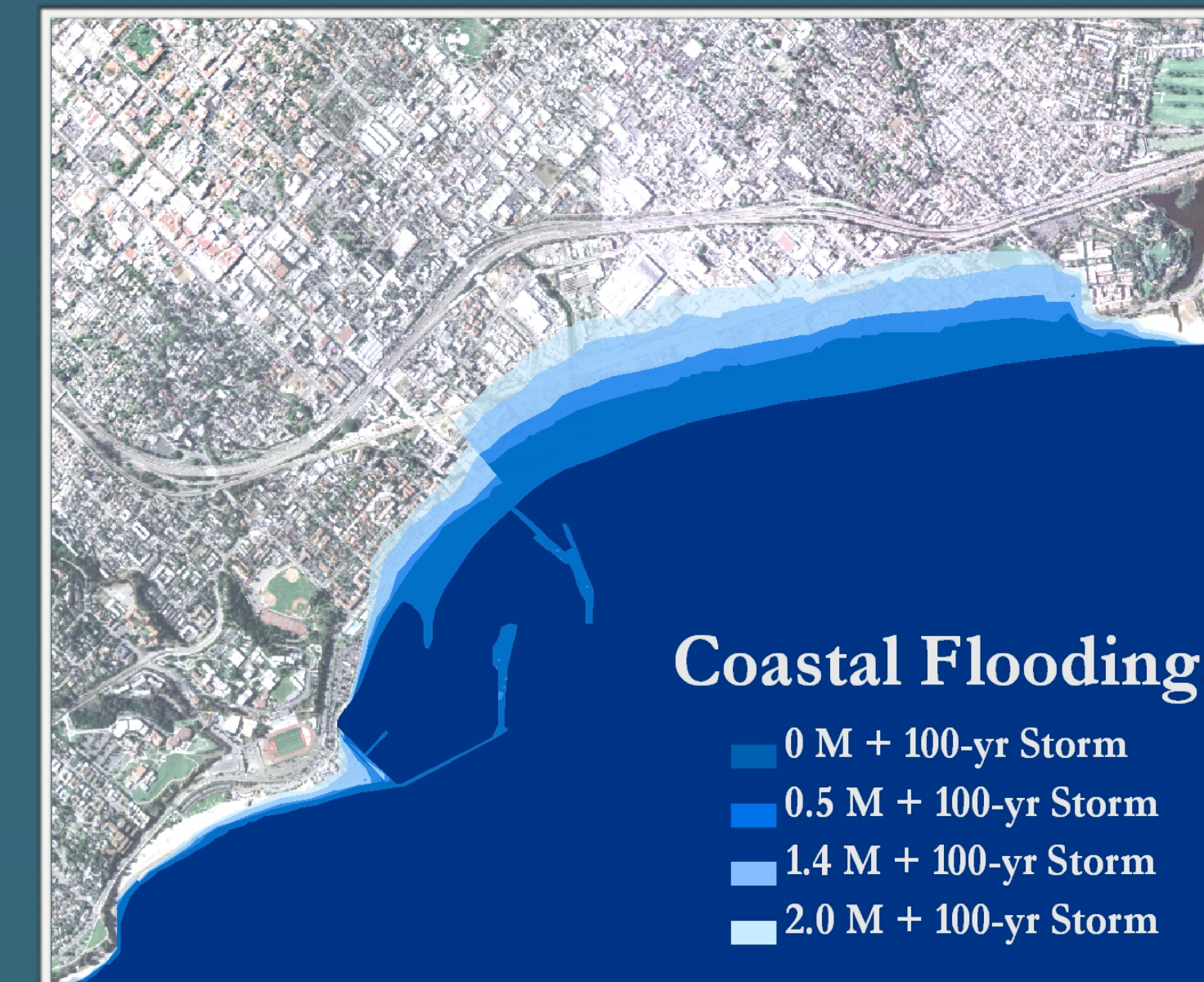
- Population: 81,305. Area: 43.09 mi<sup>2</sup> (21.09 mi<sup>2</sup> = land).
- Key low lying coastal regions: The Santa Barbara Harbor, Downtown, Arroyo Burro, and the Santa Barbara Airport.
- Placement between ocean and mountain ranges causes orographic precipitation events, resulting in flash floods.



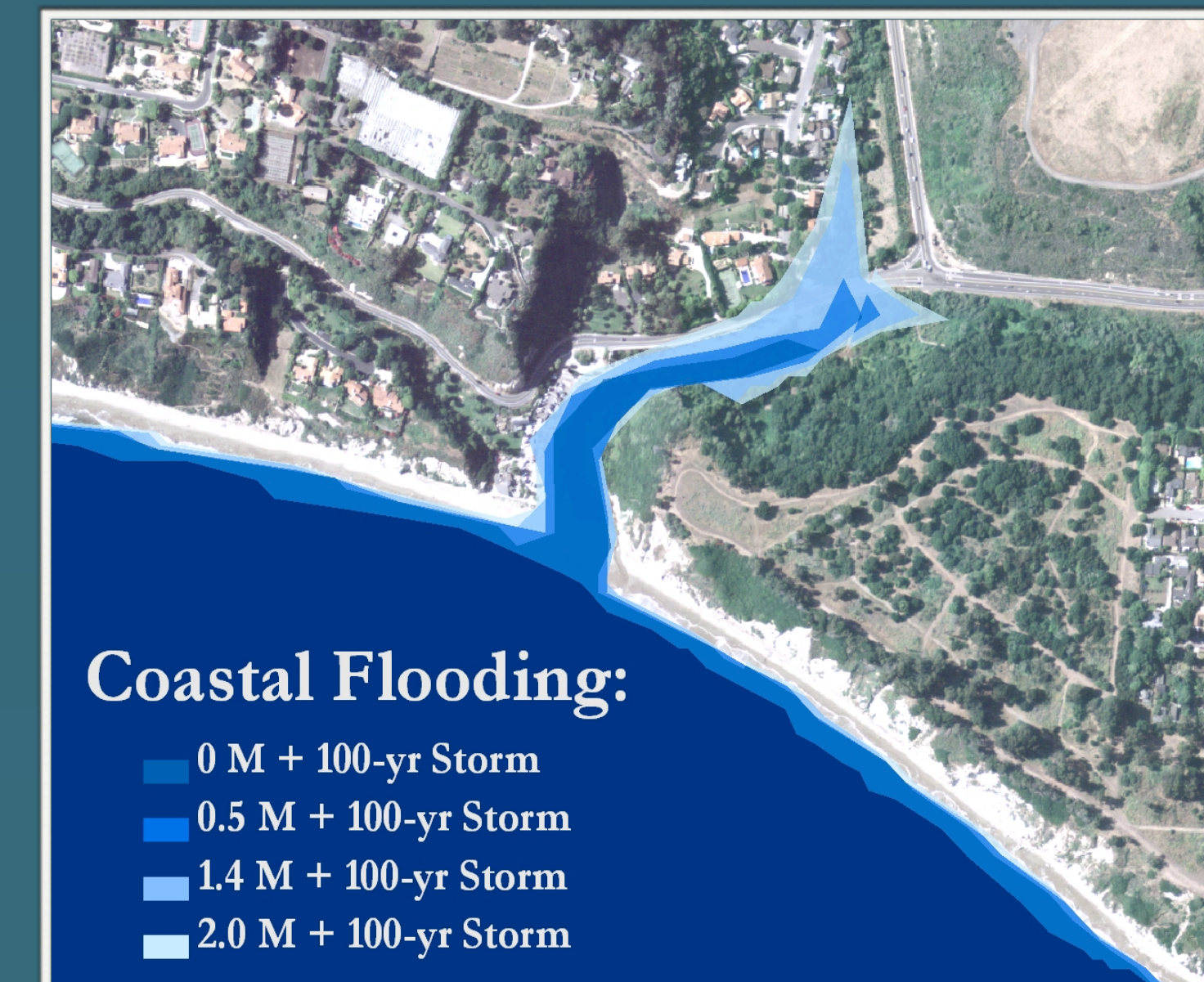
- Sediment transport generally occurs from west to east, and most major swells are blocked by the Channel Islands.
- Winter rainy season with strong storms during El Niño years.

## Sea Level Rise Scenario SLR & Storm Surge

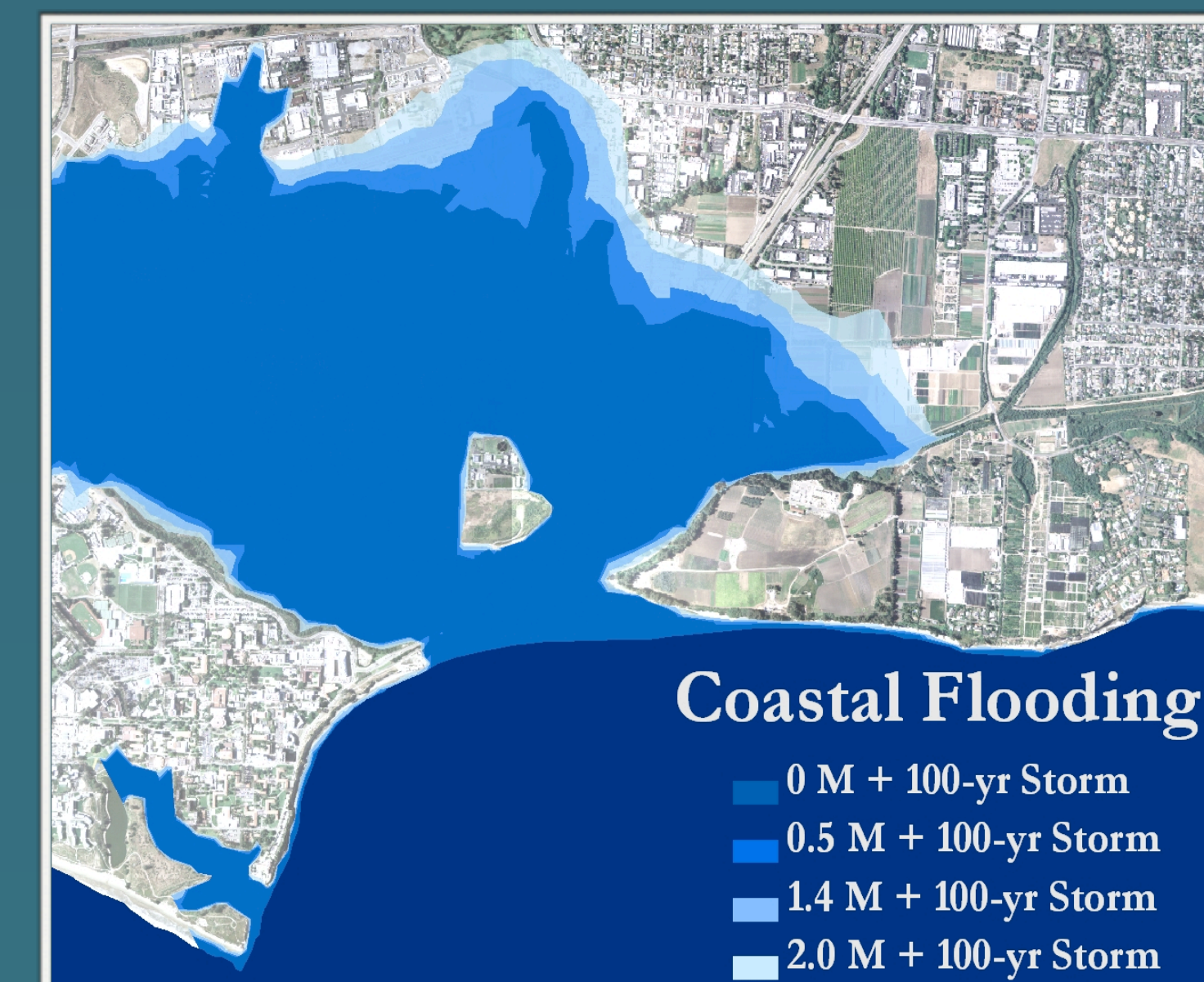
Harbor-Downtown



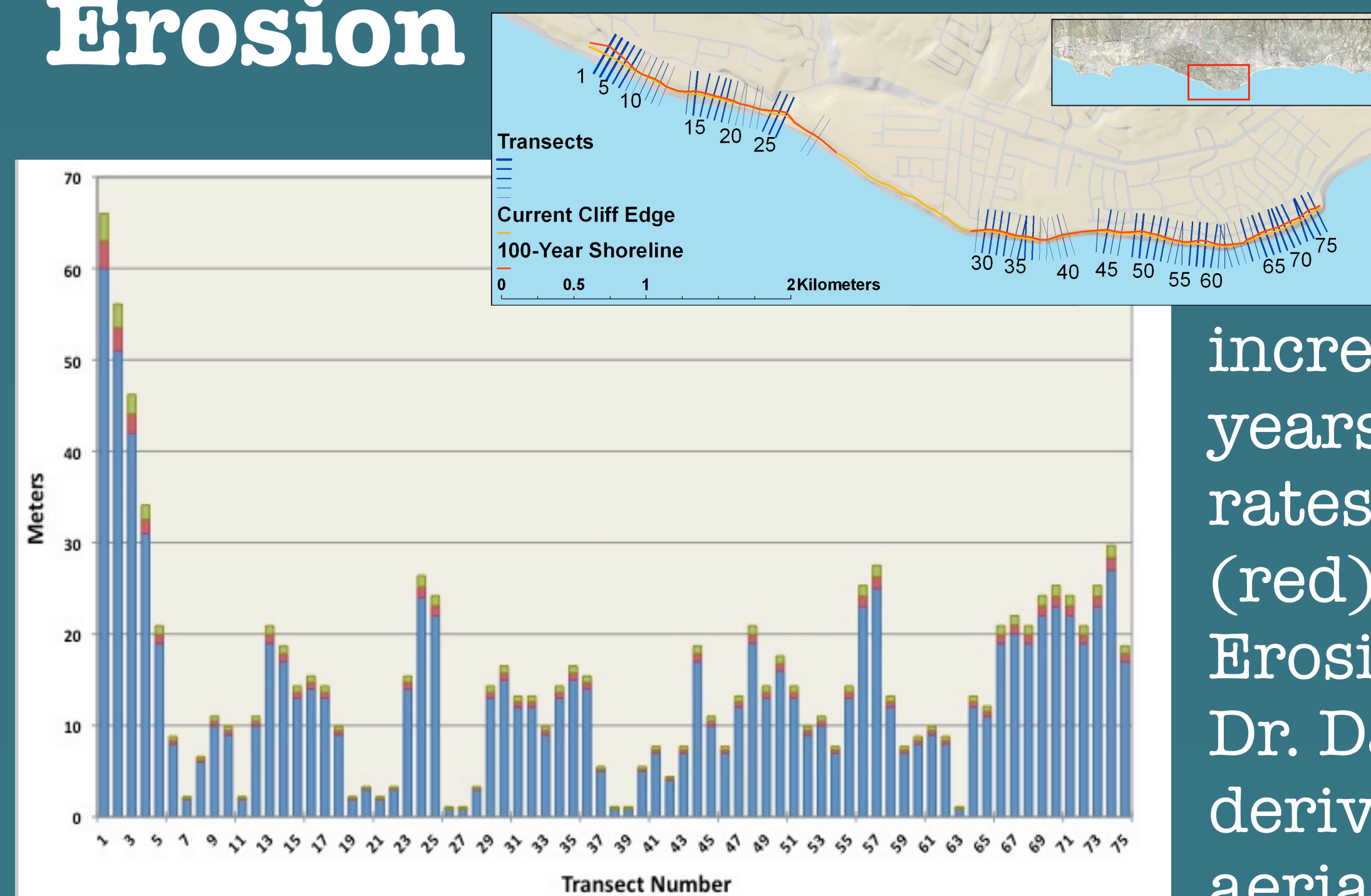
Arroyo Burro



Airport



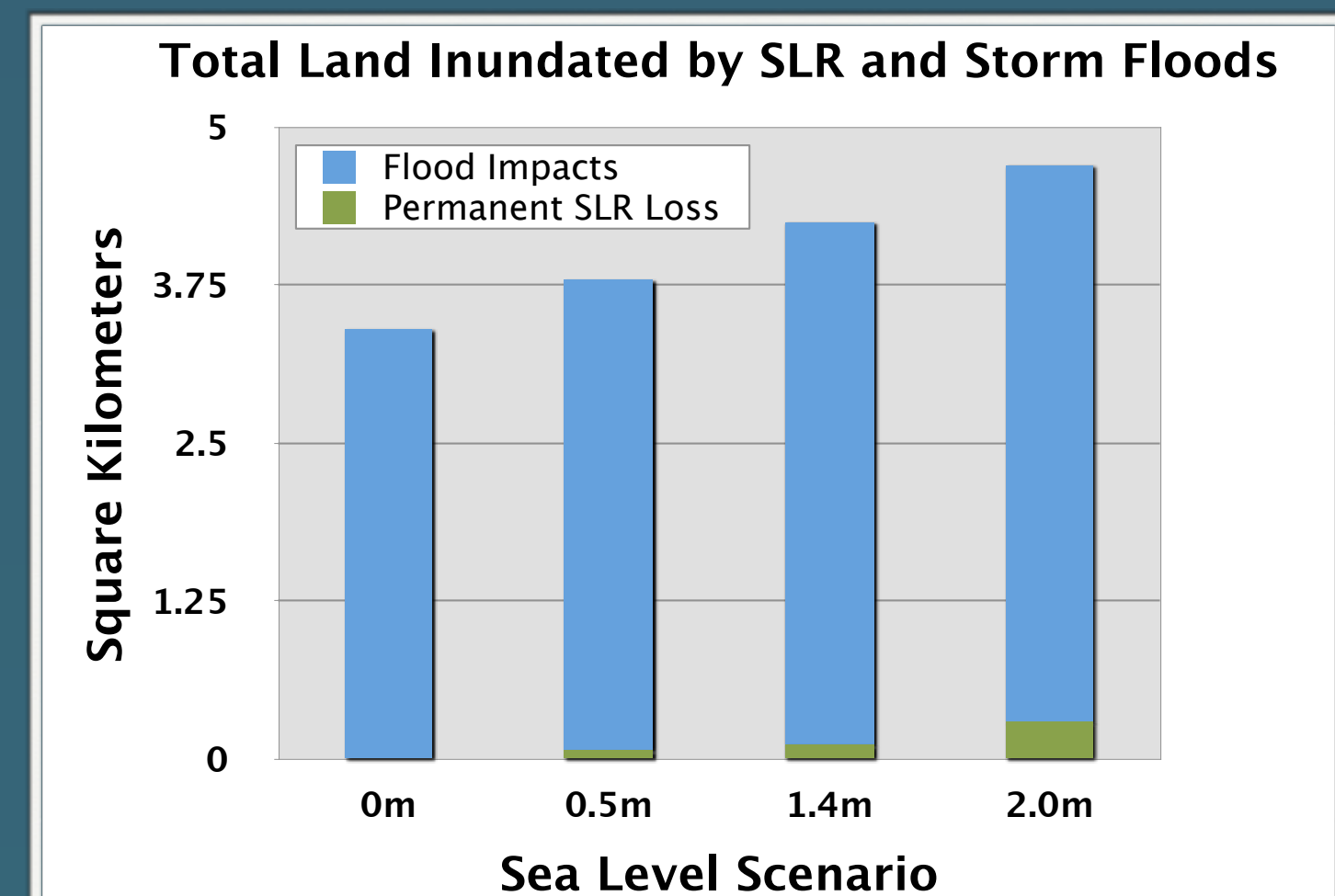
## Erosion



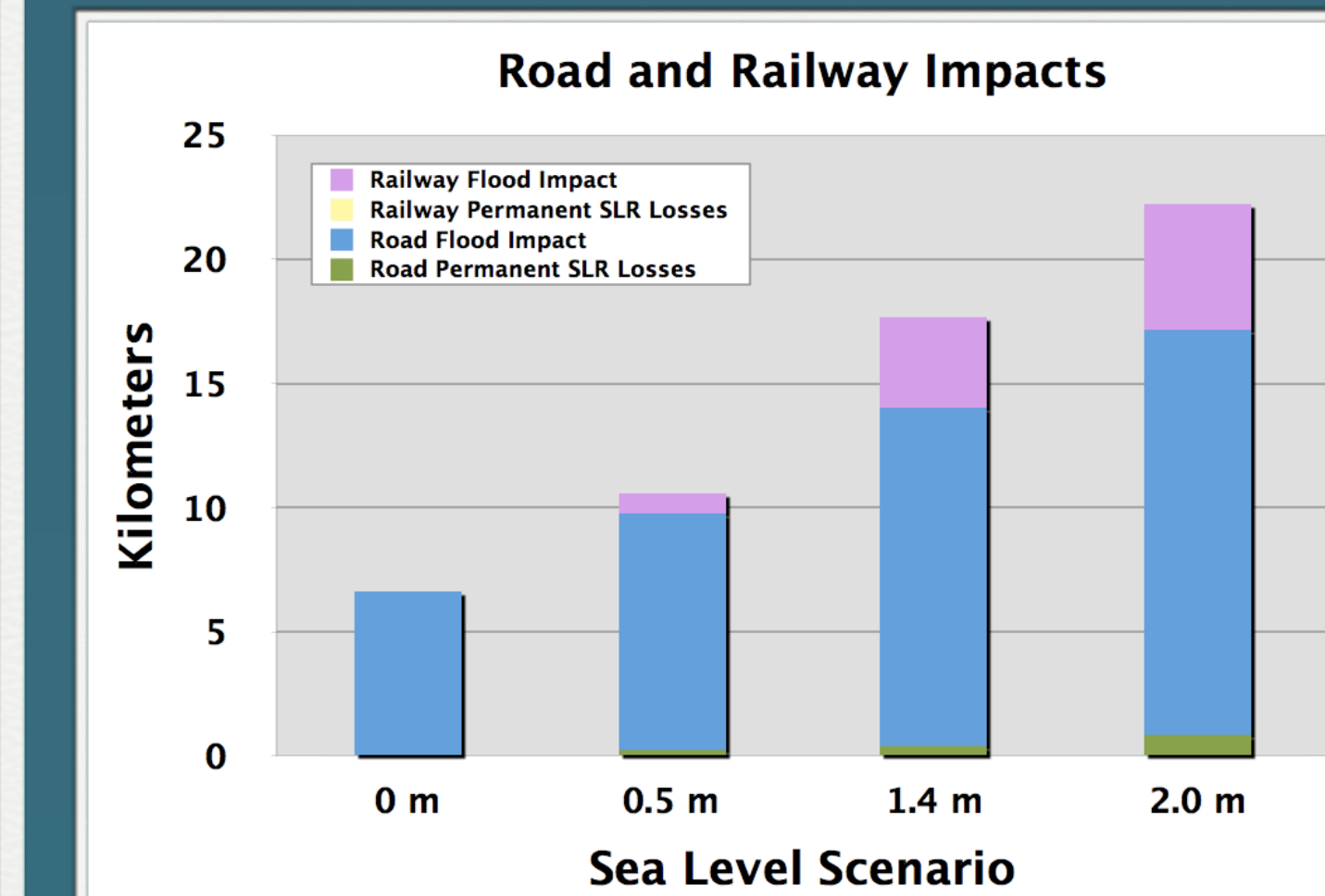
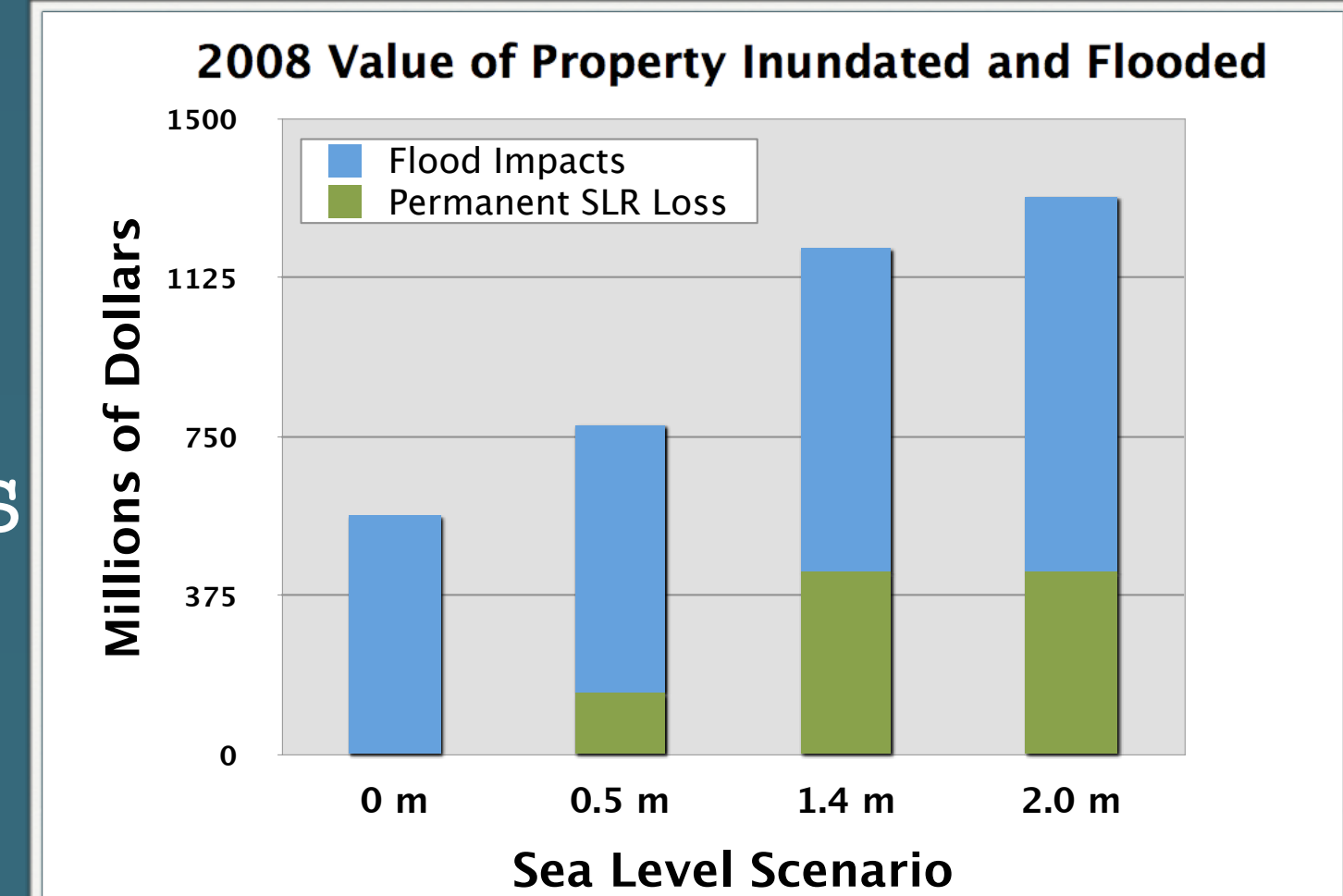
Sea level rise and increased storm intensities will cause cliff erosion rates to increase over the next 90 years. Estimated erosion rates were increased by 5% (red) and 10% (green). Erosion rates, provided by Dr. David Revell, were derived from historical aerial photographs.

## Results

Location	Area Permanently Inundated (km <sup>2</sup> )	Area at Risk for Storm Surge (km <sup>2</sup> )	Value Permanently Inundated	Value at Risk for Storm Surge
Harbor/Downtown				
0 Meters		0.291		\$228,650,476
0.5 Meters	0.069	0.411	\$145,256,984	\$296,627,372
1.4 Meters	0.101	0.670	\$145,949,144	\$412,872,466
2 Meters	0.124	0.839	\$145,949,144	\$527,091,018
Arroyo Burro				
0 Meters		0.013		
0.5 Meters		0.018		
1.4 Meters		0.028		\$4,861,133
2 Meters		0.035		\$6,170,866
Airport				
0 Meters		3.100		\$335,393,903
0.5 Meters		3.298		\$335,690,844
1.4 Meters	0.010	3.439	\$282,631,496	\$340,812,198
2 Meters	0.168	3.533	\$282,631,496	\$340,812,198



The impact of sea level rise will largely be due to damages from temporary flooding during major storm events rather than permanent inundation. Properties flooded during storms will likely maintain some value depending on frequency of flooding.



The combination of sea level rise and more intense storms will cause flooding problems for certain local roads in Santa Barbara. Railways will have no permanent losses, but will be subject to storm flooding under future sea levels rise.

## Recommendations

Area	Response Consideration
Downtown	Adaptation: Beach nourishment, artificial reefs and dunes, and building codes emphasizing flood damage prevention.
Harbor	Protection: Increase breakwater height, continue annual dredging, and consider elevating buildings.
Arroyo Burro	Status Quo: Beach nourishment possible, but no protective barrier due to minimal property value at risk in region.
Airport	Protection: 0.8 mile sea wall with a flood wall or flap sluice barrier and drainage pump system.

- Santa Barbara's Local Coastal Plan should be updated to account for possible sea level rise scenarios up to 2m by 2100.

## Future Research

- Additional data is needed on (1) the value of public and governmental buildings and (2) the tourism and recreation services provided by coastal parks and beaches.
- Future research should model drainage issues that will be compounded by sea level rise and storm flooding.
- City officials should monitor future literature for new estimates of sea level rise and erosion over the next century.

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