



City of Santa Barbara Sea Level Rise Vulnerability Assessment

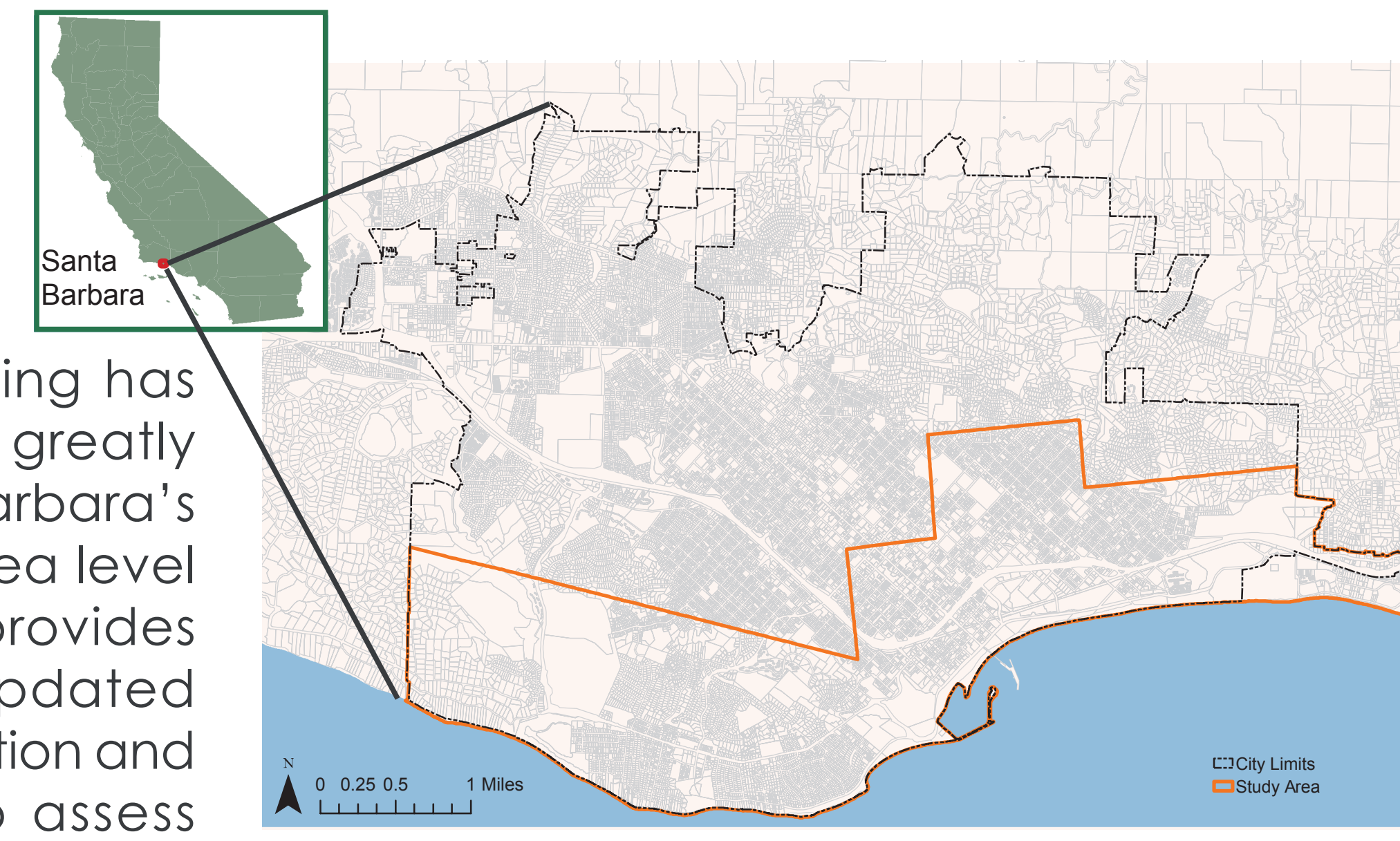
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Prepared for the City of Santa Barbara



Introduction

The anthropogenic release of greenhouse gases into the earth's atmosphere has "locked in" a level of global warming that will cause sea levels to rise over the next few hundred years. Sea level rise will impact communities by increasing the risk of coastal hazards. The city of Santa Barbara is one such community at risk of:

- Intensified damage from coastal storms
- Inundation of low-lying coastal areas
- Increasing rates of coastal bluff erosion



Map of the Santa Barbara city limits and our study area.

Proactive planning has the potential to greatly reduce Santa Barbara's vulnerability to sea level rise. Our study provides the City with updated scientific information and a framework to assess future vulnerability.



A wave crashes up onto Cabrillo Boulevard in 1914 during a large storm before the Harbor was constructed. Photo: Neal Graffy Collection.



High wave event, August 2014. While Cabrillo Boulevard may still be flooded during a very large storm, the Harbor and Breakwater now protect much of the urban waterfront. Photo: Laura Nicholson.

Project Objectives:

1. Conduct a sea level rise vulnerability assessment that addresses:
 - Human populations
 - Critical infrastructure
 - Recreation & public access
 - Ecological resources
2. Identify preliminary adaptation strategies for the City to consider for its Local Coastal Program update.

Methods

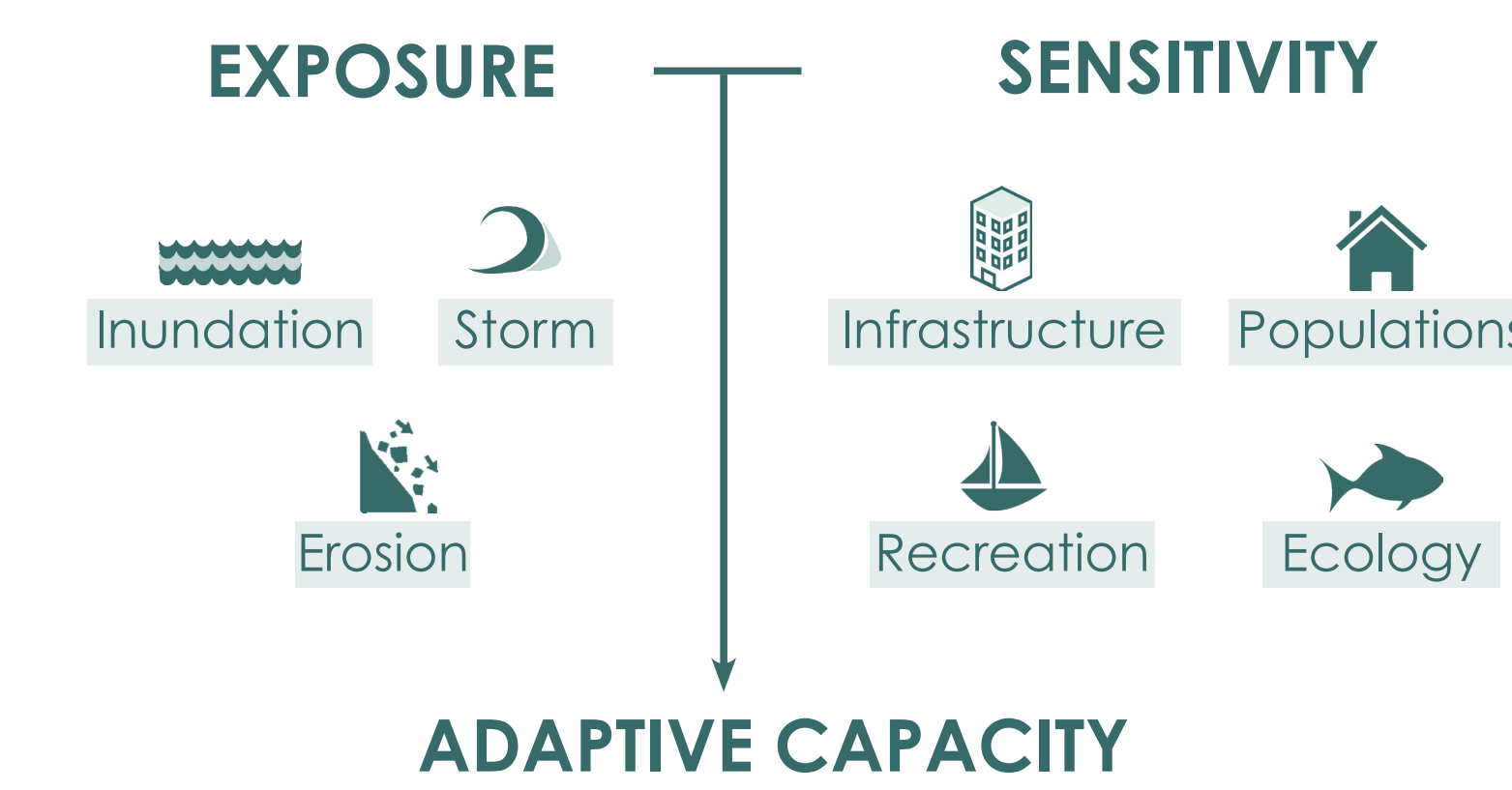
What is a vulnerability assessment?

A vulnerability assessment measures the degree to which a system (in this case, the city of Santa Barbara) is exposed to, susceptible to, and/or unable to cope with the effects from a hazard. They are often organized into three parts to identify overall vulnerability of the system: exposure, sensitivity, and adaptive capacity.

- 1) **Exposure:** the projected spatial extent of a hazard on the land surface.
- 2) **Sensitivity:** a measure of the factors that may increase a feature's susceptibility to a hazard.
- 3) **Adaptive Capacity:** the ability of a resource to maintain its function after being exposed to a hazard.

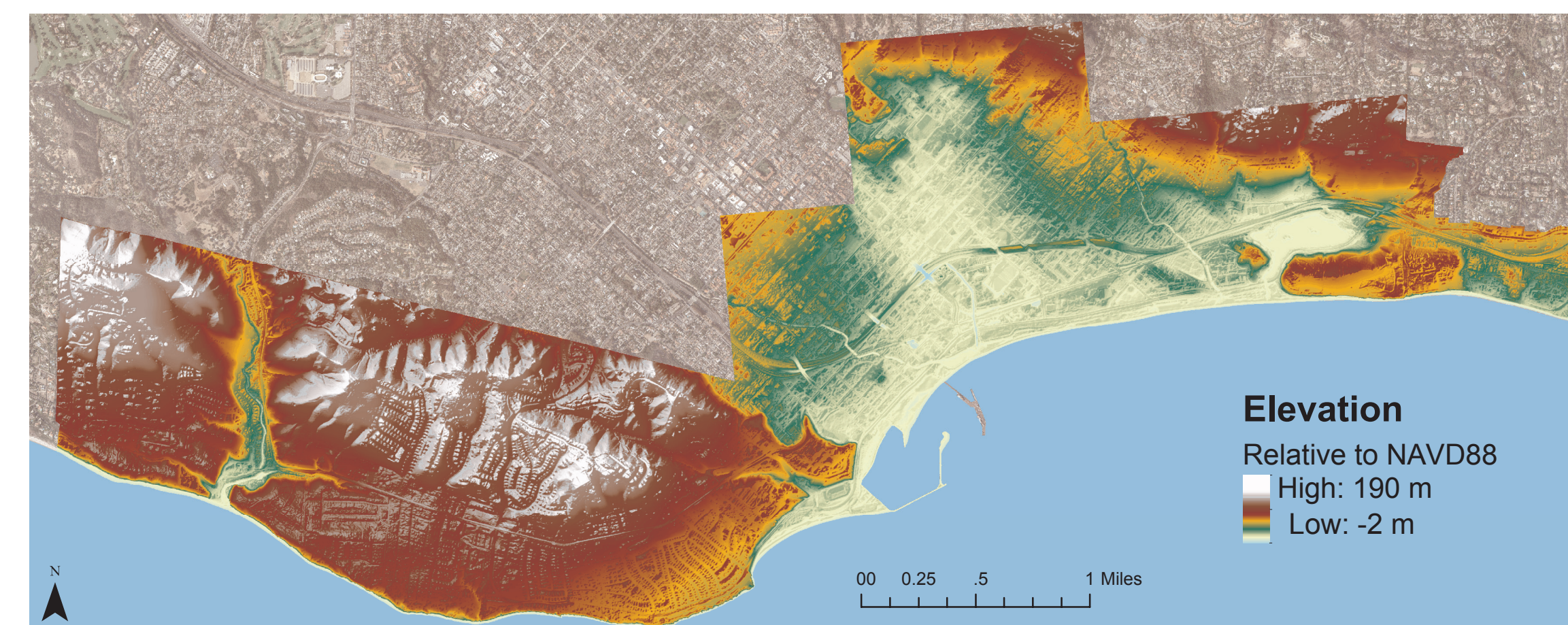
Year	Sea Level Rise (relative to 2000)	
2030	1.8 – 11.8 inches	0.05 – 0.30 meters
2050	5.0 – 23.9 inches	0.13 – 0.61 meters
2100	17.4 – 64.6 inches	0.44 – 1.67 meters

Sea level rise projections for southern California from the Nation Research Council 2012 report.



We modeled the city's exposure to three hazards: permanent inundation, storm surge, and bluff erosion.

All models used elevation data from LIDAR (Light Detection and Ranging), giving us some of the most precise elevation without measuring it on the ground.



Elevation map of the city of Santa Barbara from a LiDAR digital elevation model.

Erosion

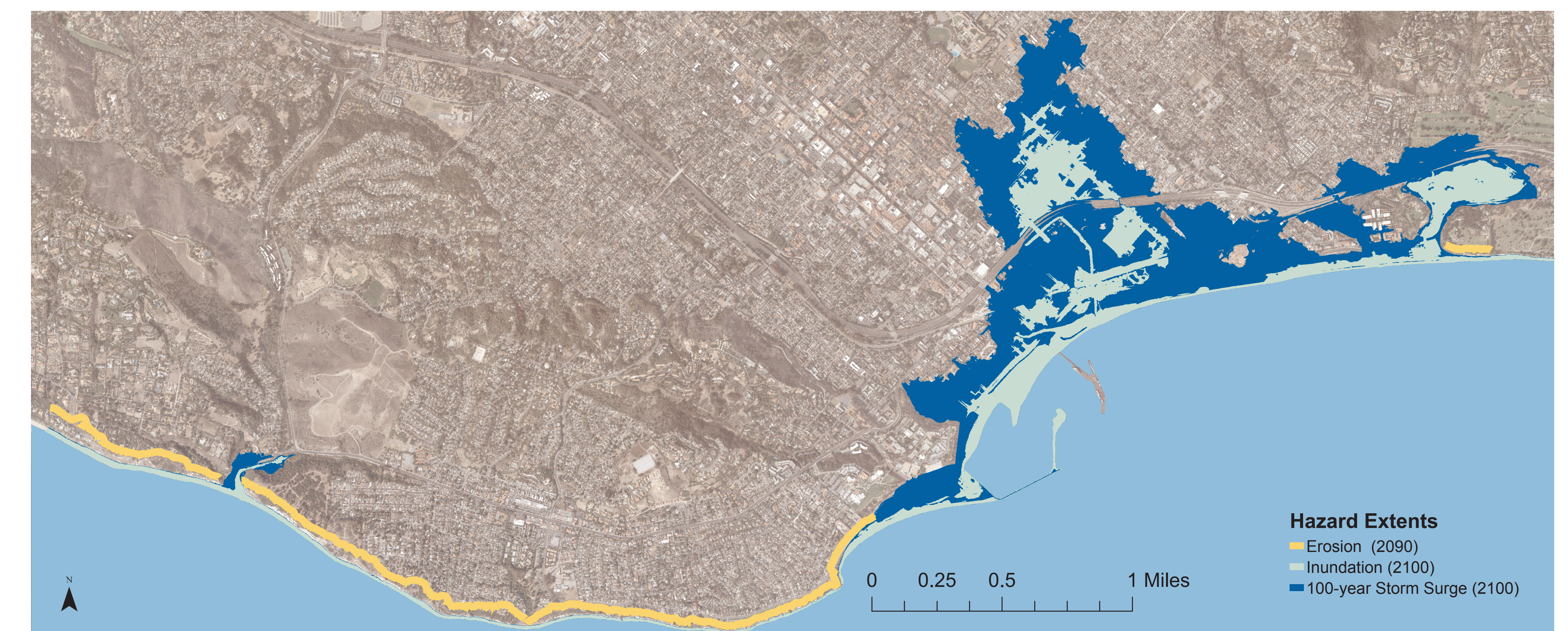
The current bluff edge was set back with historical erosion rates plus a "factor of safety" to account for sea level rise.

Permanent Inundation

Sea level rise values were added to current conditions to assess land area projected to be under water.

Storm Surge

Flood level values were added to sea level rise to assess overall exposure from a 100-year storm.

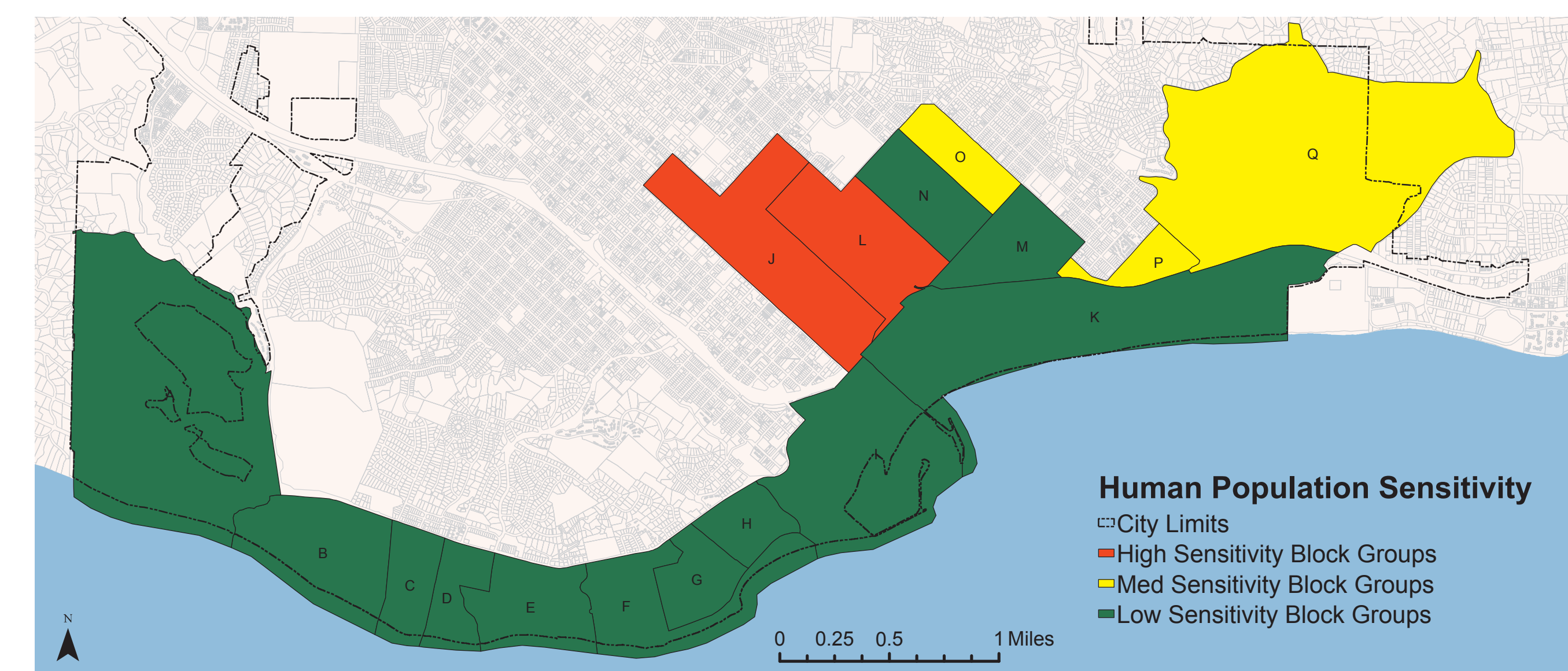


Map of the extent of hazard zones for the 2100 high sea level rise projection (1.67 m) for permanent inundation and storm surge, and an erosion rate of 24 inches per year for 75 years.

Key Findings

Human Populations

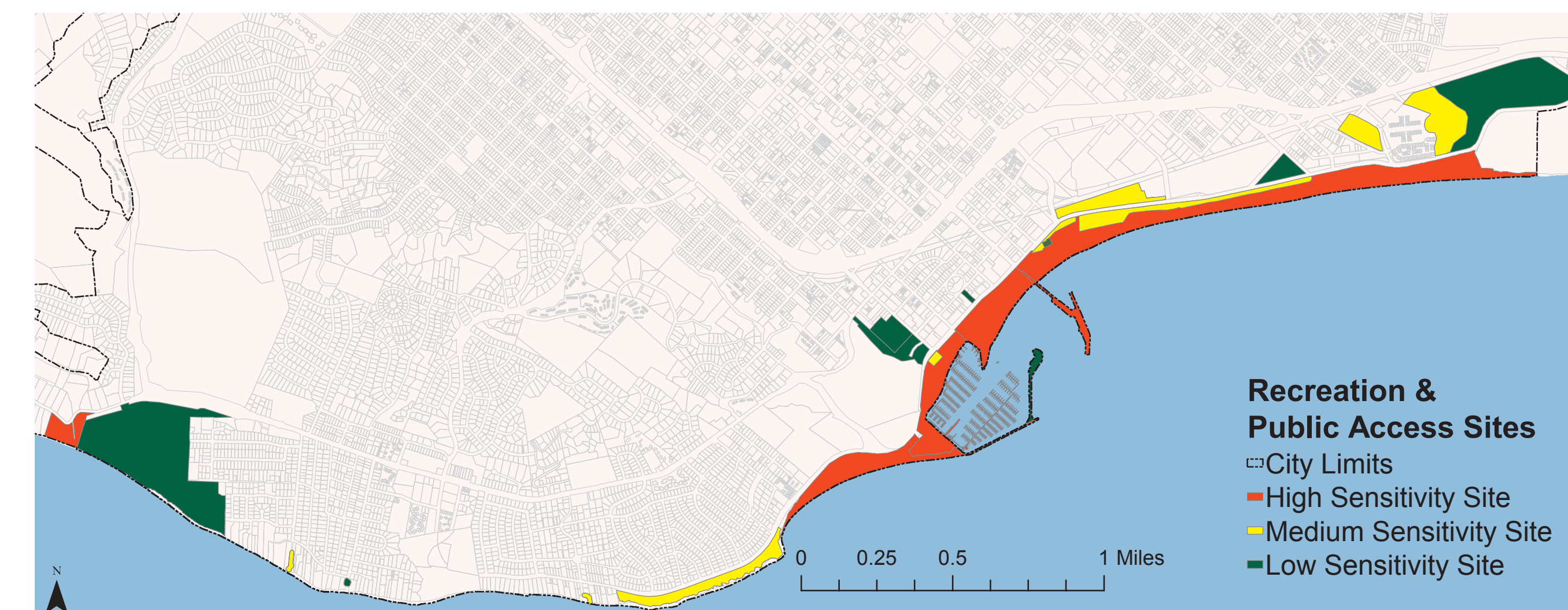
Our analysis shows that the human populations most exposed to sea level rise hazards have a low sensitivity (at the block group level) based on demographic information. Furthermore, the most sensitive populations of Santa Barbara may not be impacted by permanent inundation until 2100 or later. However, some medium and high sensitivity populations are currently in the 100-year storm hazard zone.



Map of the sensitivity evaluation for human populations. The city was divided into Census block groups and given a ranking of high, medium, or low based on demographic information.

Recreation & Public Access

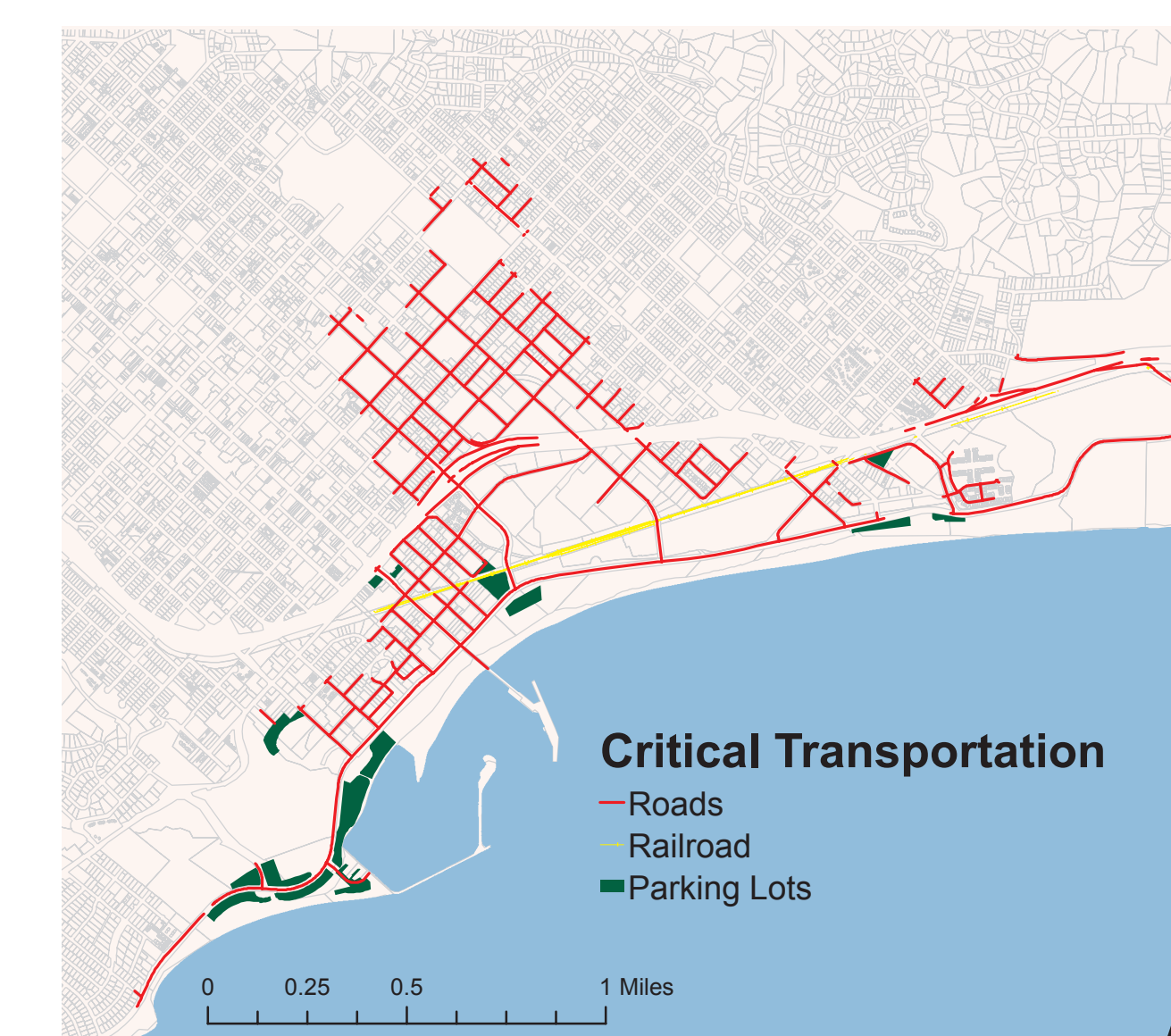
Nearly all of the recreation sites within our study area lie directly along the coastline, making them the most exposed to sea level rise hazards and the only public resources at risk from increased bluff erosion. We identified the Harbor, Stearns Wharf, and major City beaches as the most sensitive assets in this category.



Map of the sensitivity evaluation for recreation and public access sites in Santa Barbara. The sites were given a ranking of high, medium, or low based on the number of assets contained at the site.

Critical Infrastructure

Permanent inundation is a minor threat to most infrastructure, while a 100-year storm will cause increasing damages as sea levels rise. Transportation along the coastline including roads, bikepaths, and railroads are vulnerable to a 100-year storm today and may be at risk of permanent inundation by 2100. Critical buildings will not be permanently inundated, but backflow conditions for underground infrastructure (e.g. storm drains) will increase.



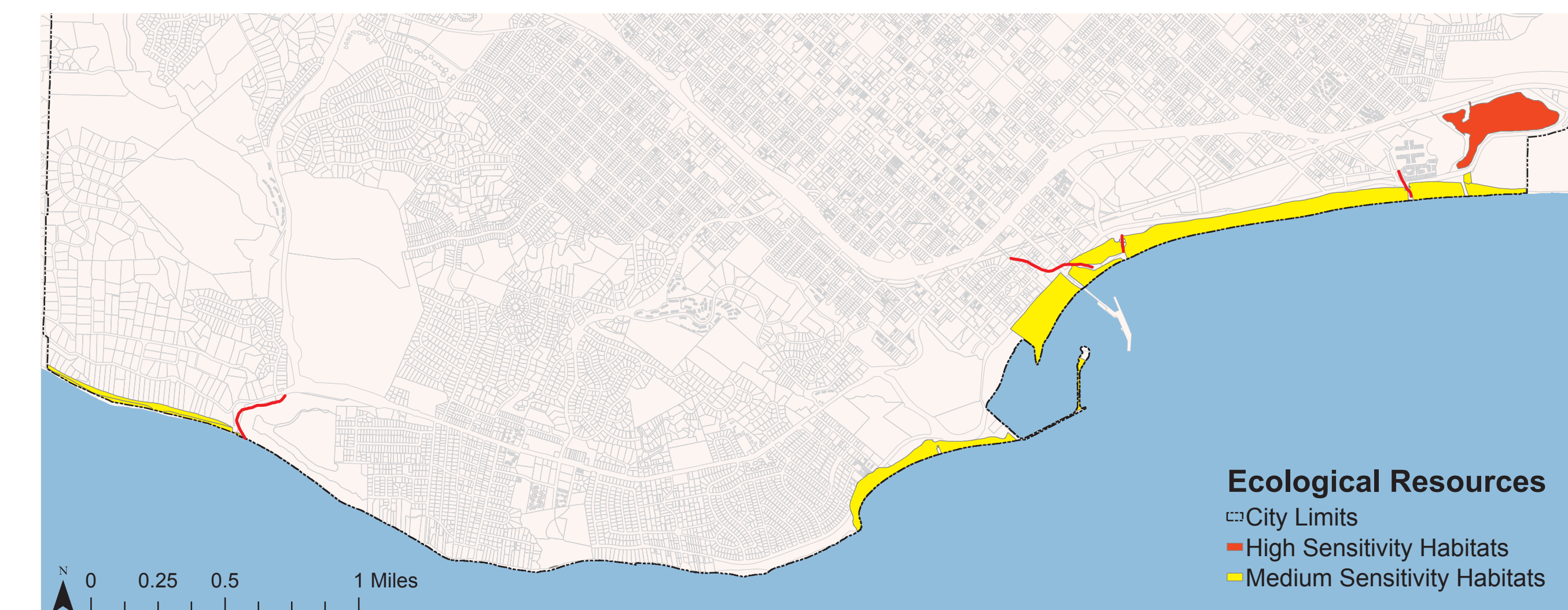
Map of the critical transportation infrastructure in the downtown area. Transportation infrastructure was given a ranking of high, medium, or low based on the relative contribution to the city's functioning.



Map of the sensitivity evaluation for buildings listed as critical infrastructure in the downtown area. Structures were given a ranking of high, medium, or low based on the relative contribution to the city's functioning.

Ecological Resources

Ecological resources within the coastal area of Santa Barbara are important habitats for federally listed species, specifically the tidewater goby and the southern California steelhead trout. Based on our analysis, Santa Barbara's coast includes high and medium sensitivity ecological resources. High sensitivity ecological resources are also the most exposed.



Map of the sensitivity evaluation for ecological resources. Resources were ranked as high, medium, or low based on the presence of critical habitat for federally listed species.

Recommended Adaptation Strategies

Three major sea level rise adaptation strategies for any resource are: retreat, accommodate, or protect.

Human Populations: Retreat

- Limit increased population vulnerability to sea level rise related hazards.
- Coordinate with stakeholders to develop a system of managed retreat that balances risks of exposure.

Critical Infrastructure: Protect and/or accommodate

- Prepare structures for flooding by increasing waterproofing or protective standards.
- Allocate funds for the rebuilding of damaged infrastructure.

Recreation & Public Access: Protect, accommodate, and/or retreat

- Short-term: continue or expand beach berms to protect beach assets from flooding.
- Mid- to long-term: land easements could help the natural inland migration of beach areas over time and allow for recreational facilities to be set back if and when it becomes necessary in the future.

Ecological Resources: Accommodate and/or retreat

- Protect the habitats of endangered or threatened species with restoration efforts and allowing for the upstream inland migration of these species.

The City, in conjunction with its stakeholders, will be ultimately responsible for determining appropriate actions, thresholds, and triggers for implementing adaptation strategies.

Acknowledgements

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