



Getting Out of Harm's Way

Tsunami evacuation
research at the USGS

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U.S. Department of the Interior
U.S. Geological Survey

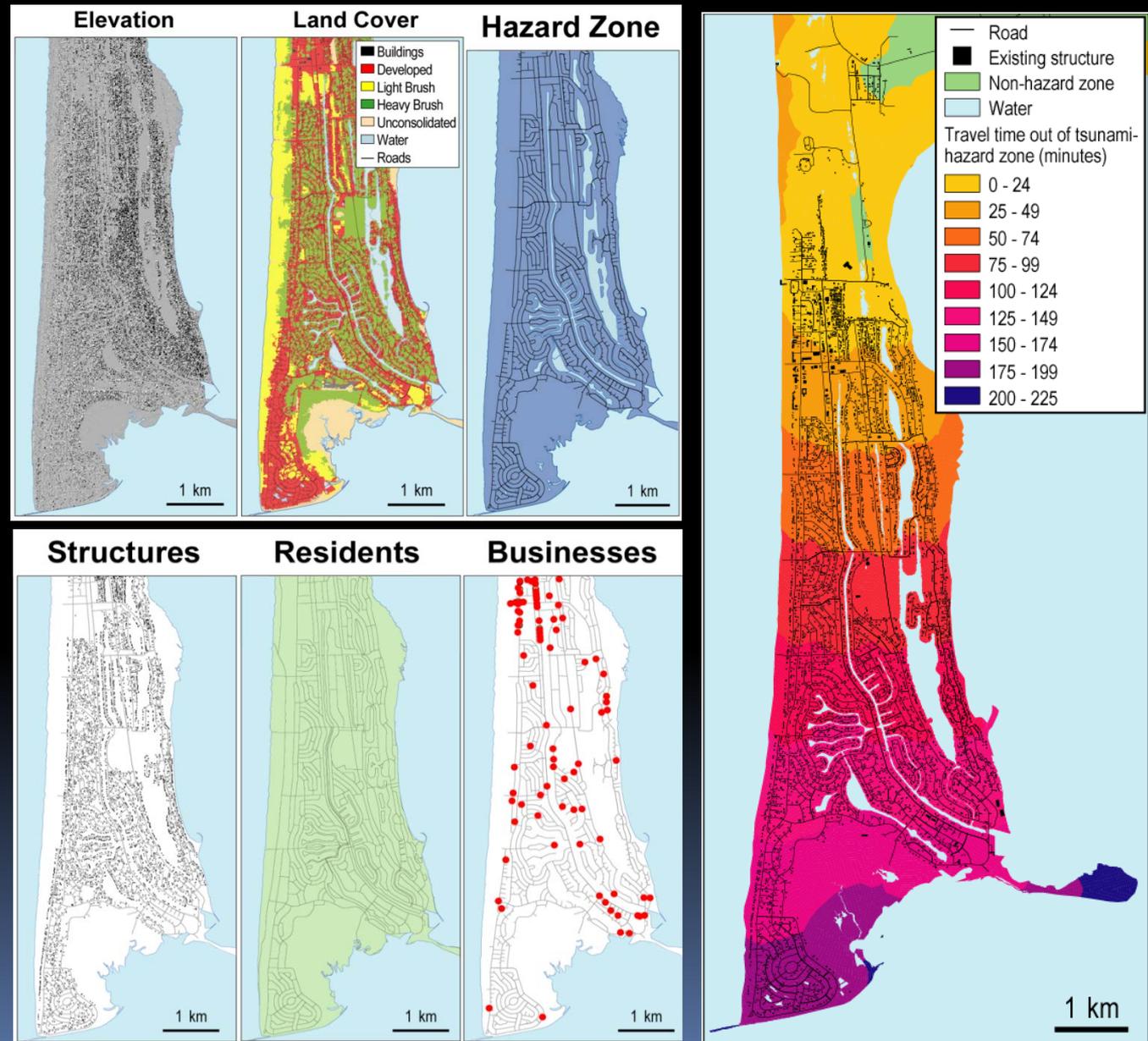
Overview of Efforts



- **Evacuation modeling**
 - Methodology
 - Free GIS tool
 - Recently published work
 - Current efforts
- **Evacuation implications for scenario-based vs. maximum hazard zones**
 - Evacuee magnitudes
 - Private and public sheltering costs
 - Business costs
 - Facilities with significant evacuation challenges

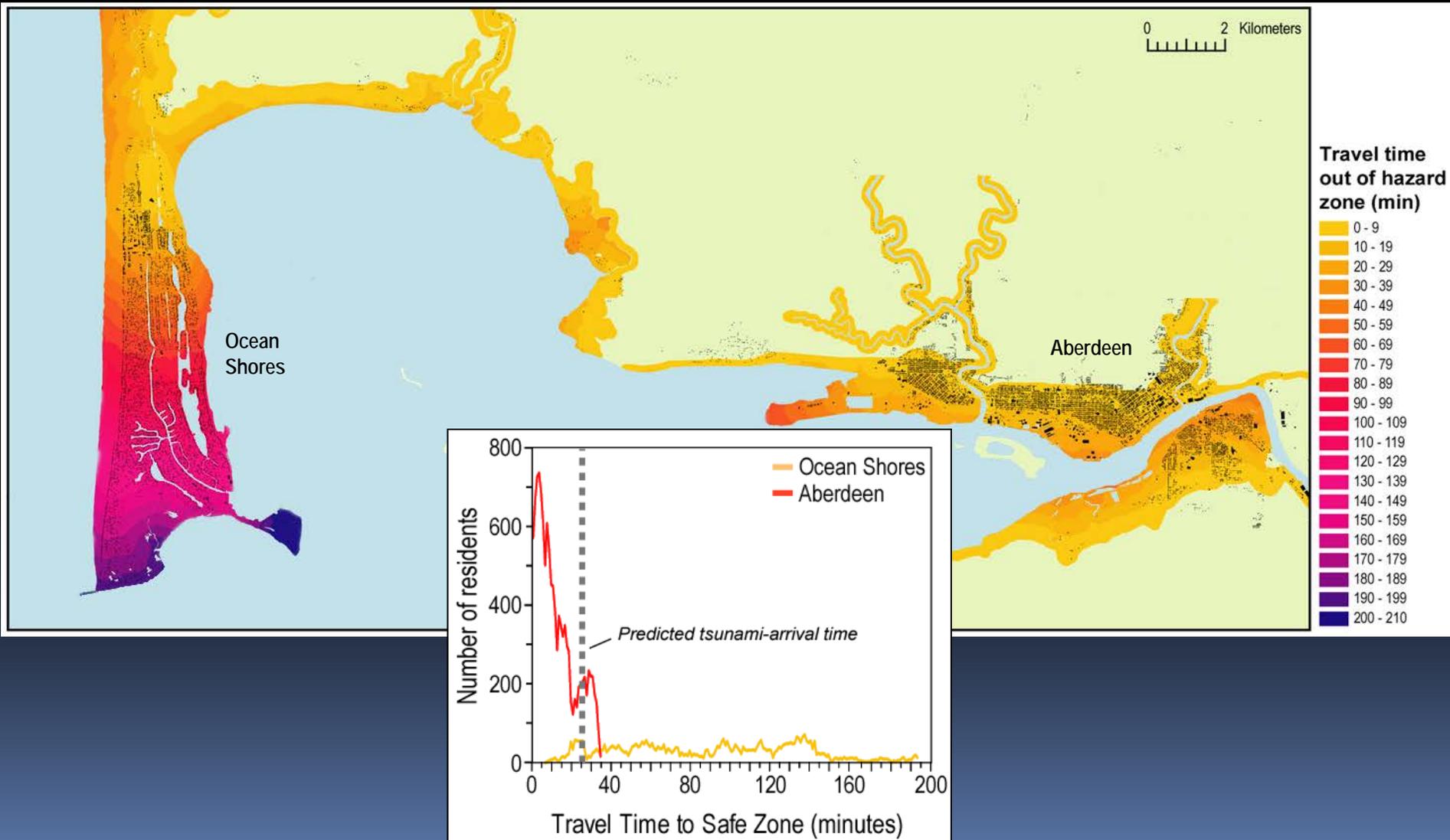
Evacuation Modeling - anisotropic path distance

- Models the paths with “least cost” due to land cover and elevation differences
- Can use various travel speeds
- Assumptions
 - Optimal path
 - Evacuees know what they are doing and where to go

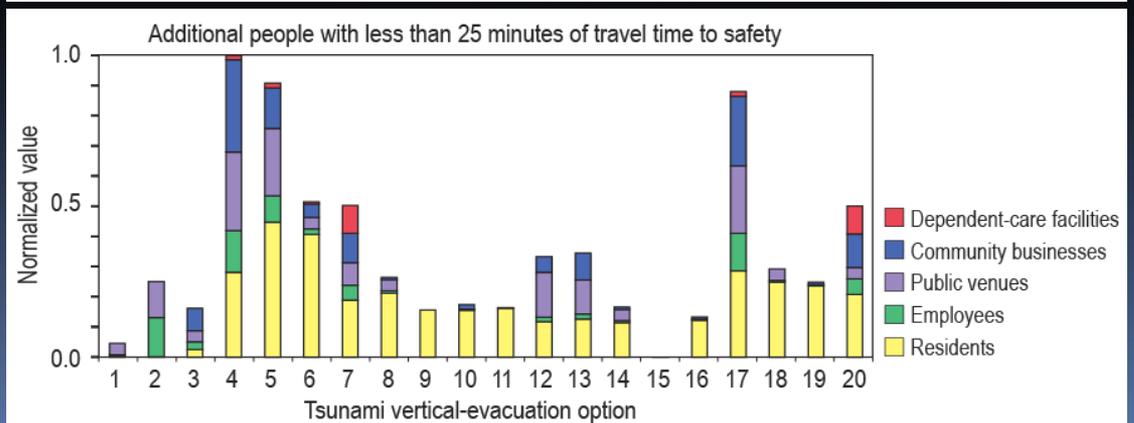
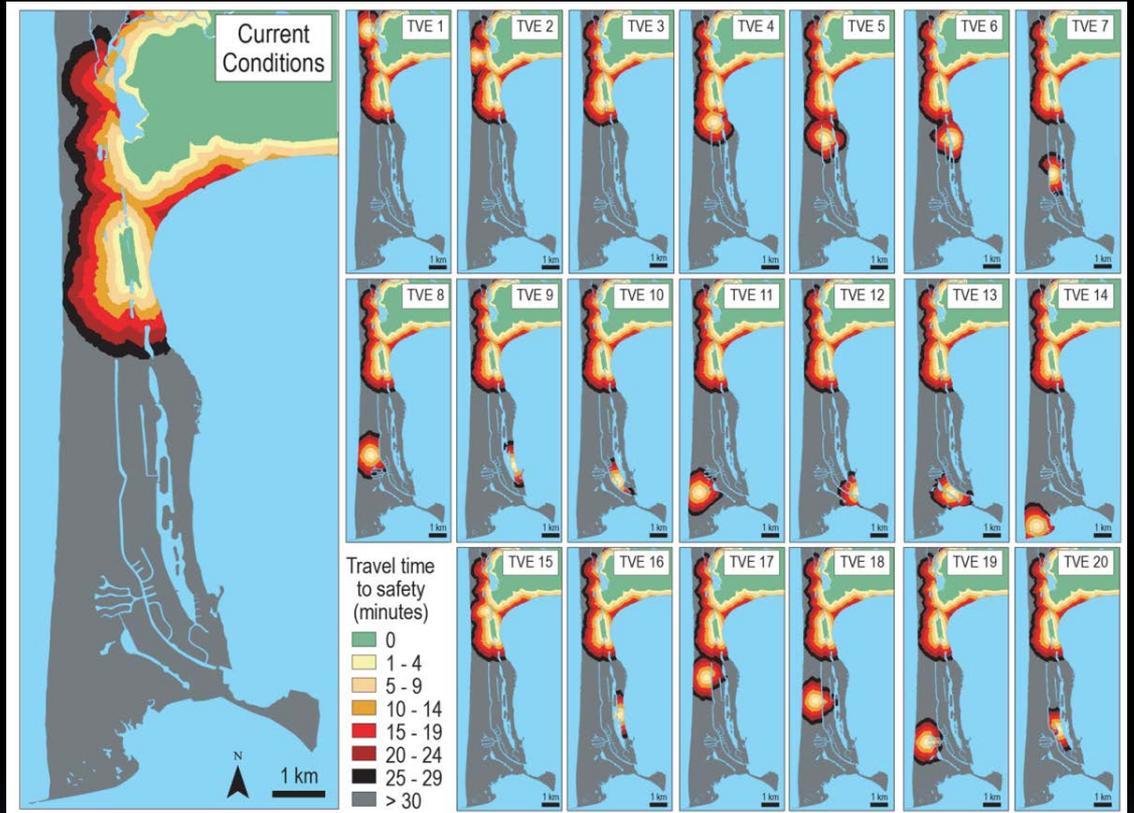
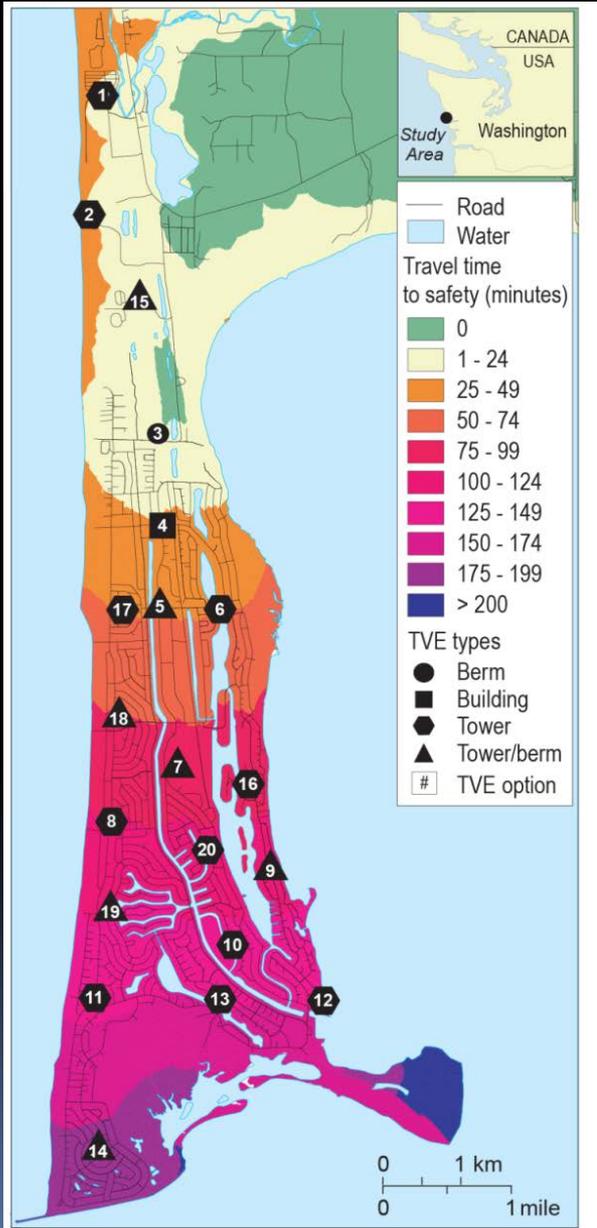


Evacuation Modeling Methods

Integrating population data and evacuation models



Methods – Modeling vertical-evacuation siting





Overview

In the News

Hazards

GIS Tools

Publications

Research Team

Pedestrian Evacuation Analyst

The Pedestrian Evacuation Analyst—Geographic Information Systems Software for Modeling Hazard Evacuation Potential

Chapter 9 of Section C, Geographic Information Systems Tools and Applications
Book 11, Collection and Delineation of Spatial Data

DOWNLOAD
TOOL

DOWNLOAD
USER'S GUIDE

Pedestrian Evacuation Analyst Workflow

1 Create a portfolio for the study area

2 Preprocess input data

Digital elevation model
Land use/land cover
Hazard zone
Safe zone

3 Create evacuation surfaces and maps

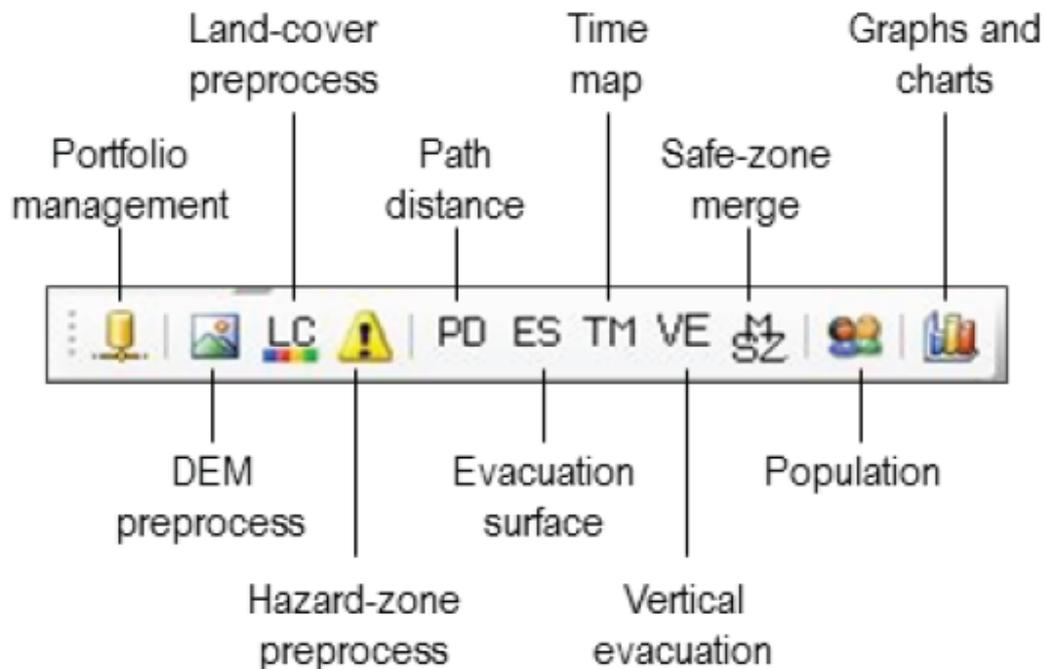
Calculate path distance
Create evacuation surface
Determine maximum time value
Create time map

4 Model potential vertical-evacuation sites

Process vertical evacuation sites
Merge safe zones

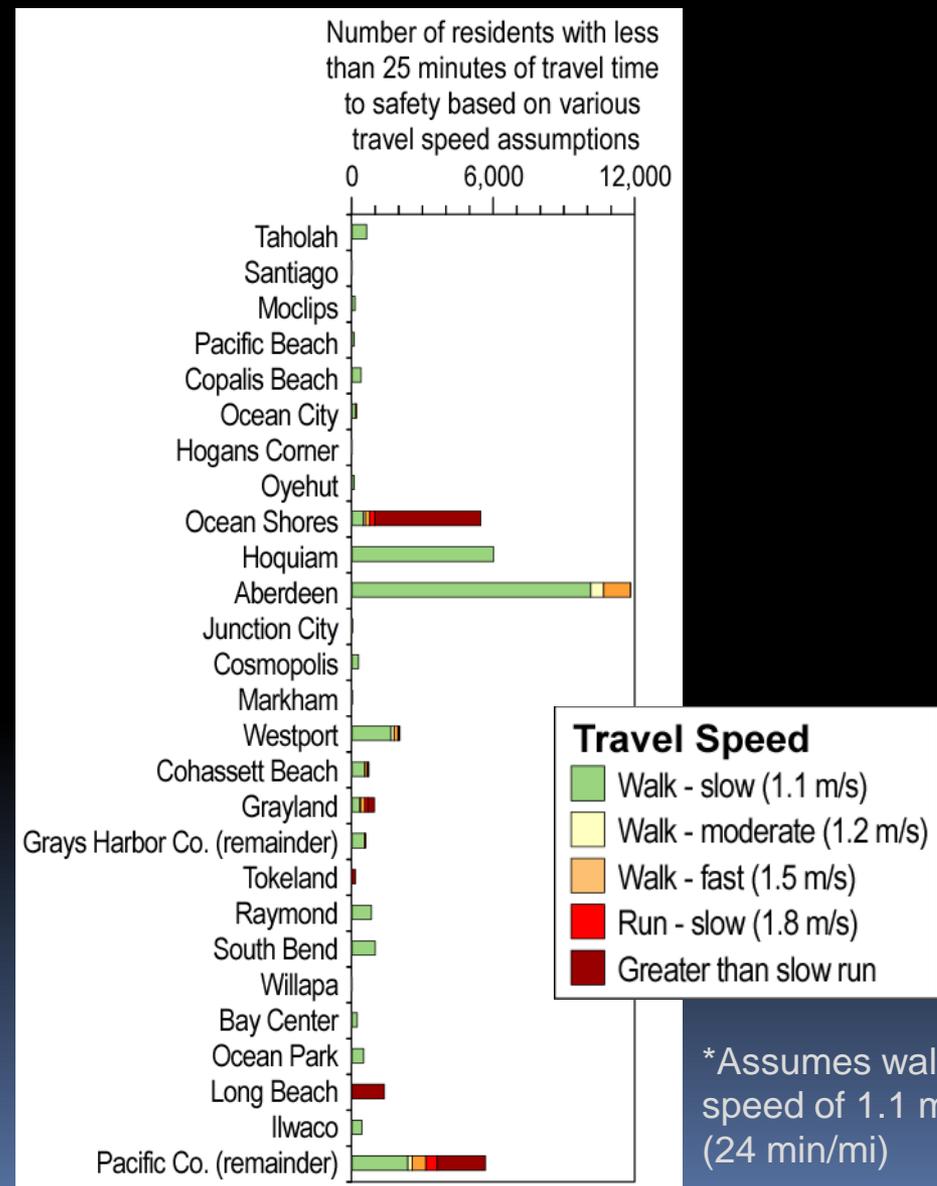
5 Incorporate population data

6 Develop charts and graphs



Recently published work

Guiding risk reduction -- education, training, and vertical evacuation



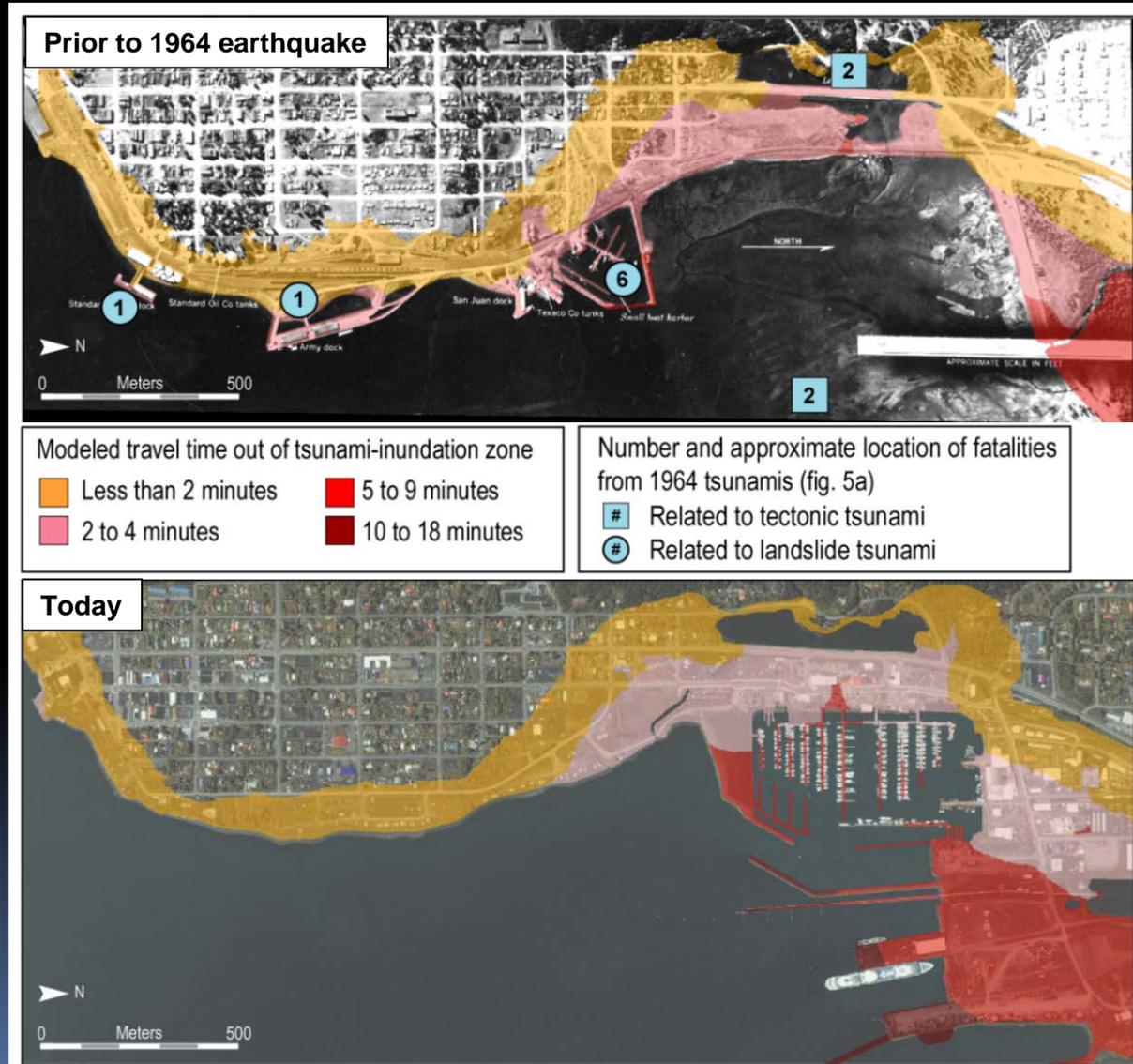
*Assumes walking speed of 1.1 m/s (24 min/mi)

Recently published work

Post-disaster analysis of evacuation landscapes

Seward, Alaska

Comparison of reported deaths with evacuation hotspots



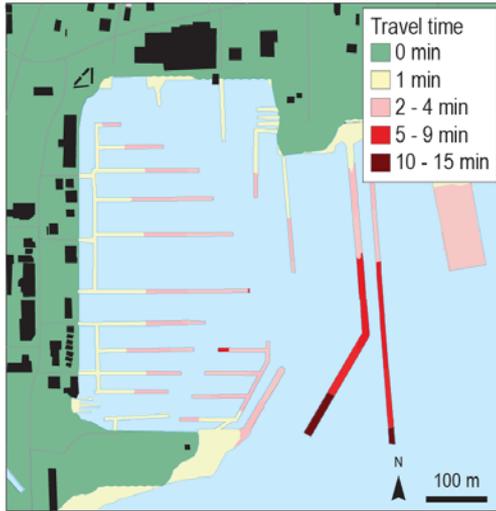
Changes in population vulnerability due to post-disaster recovery decisions

Recently published work

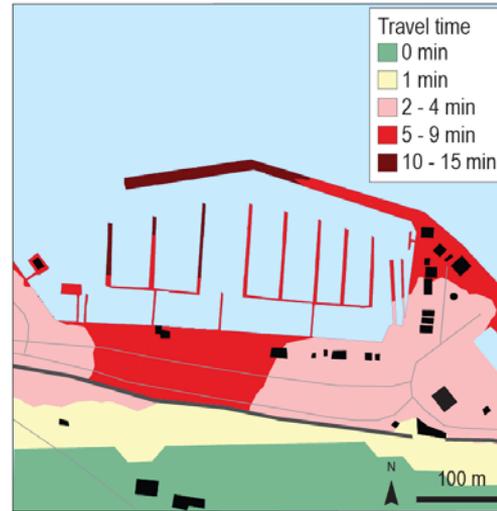
Comparing tectonic vs. landslide-related tsunamis

Landslide tsunami sources

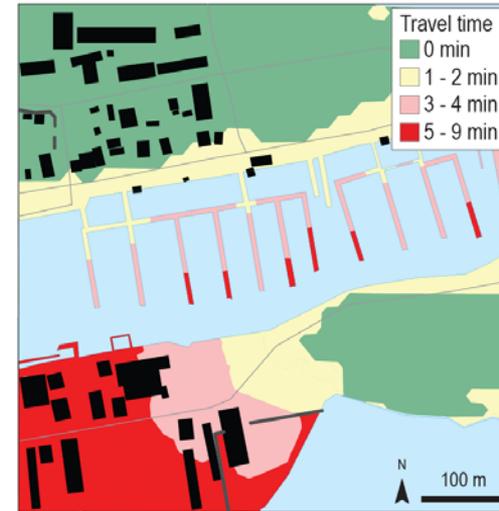
a) Seward (wave arrival = 1 min)



b) Whittier (wave arrival = 1 min)

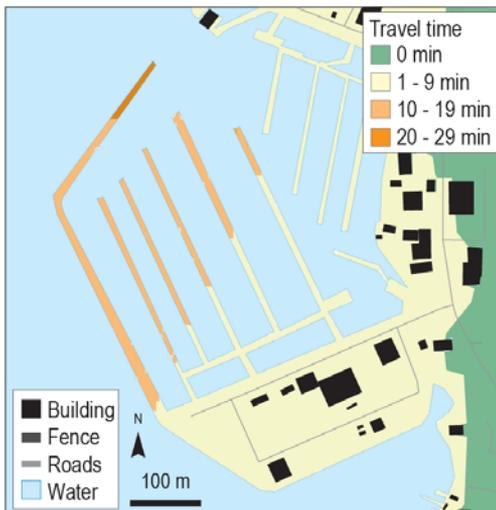


c) Valdez (wave arrival = 2 min)

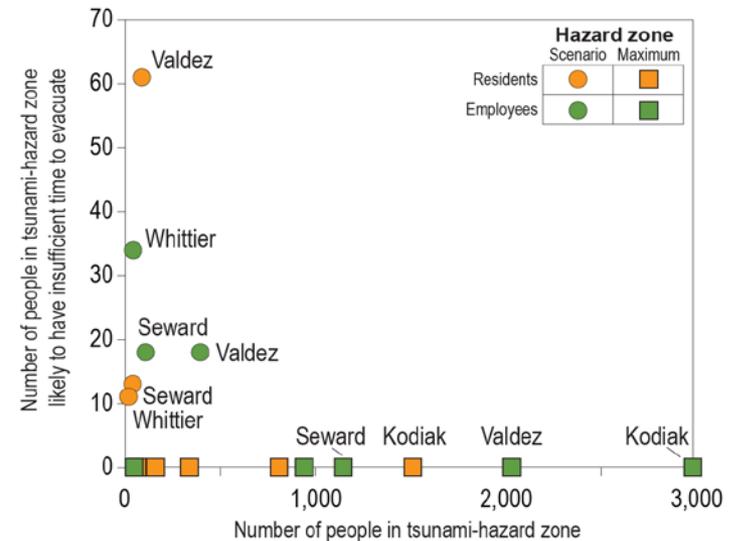
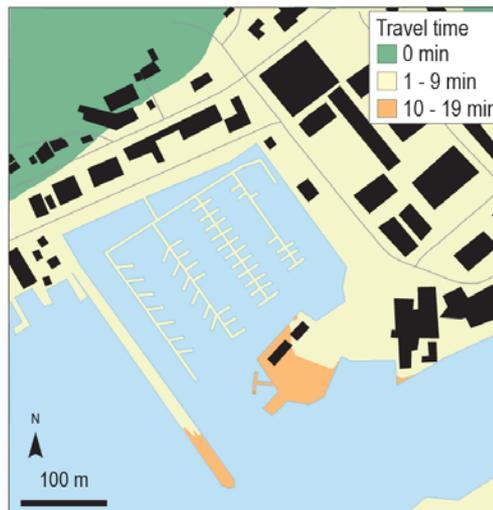


Tectonic tsunami sources

d) Cordova (wave arrival = 60 min)



e) Kodiak (wave arrival = 60 min)

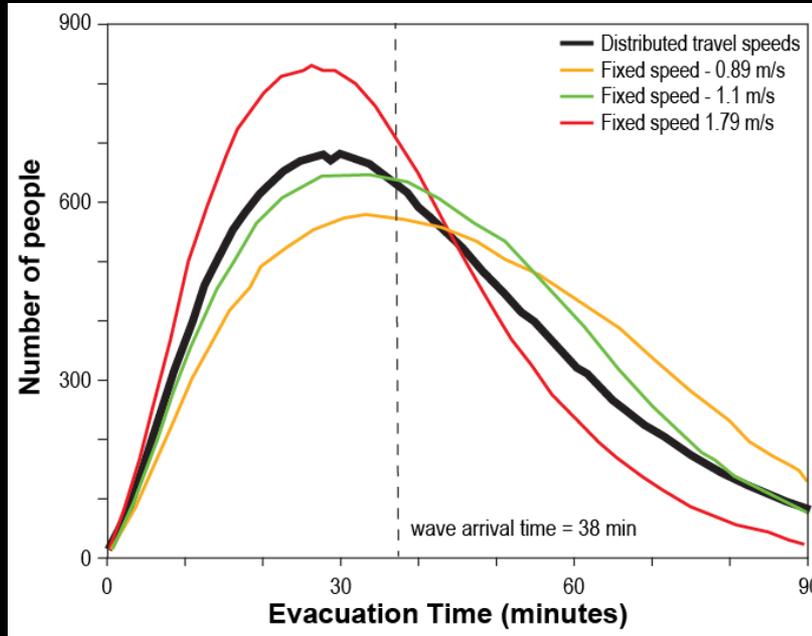


Recently published work

Testing sensitivity of modeling

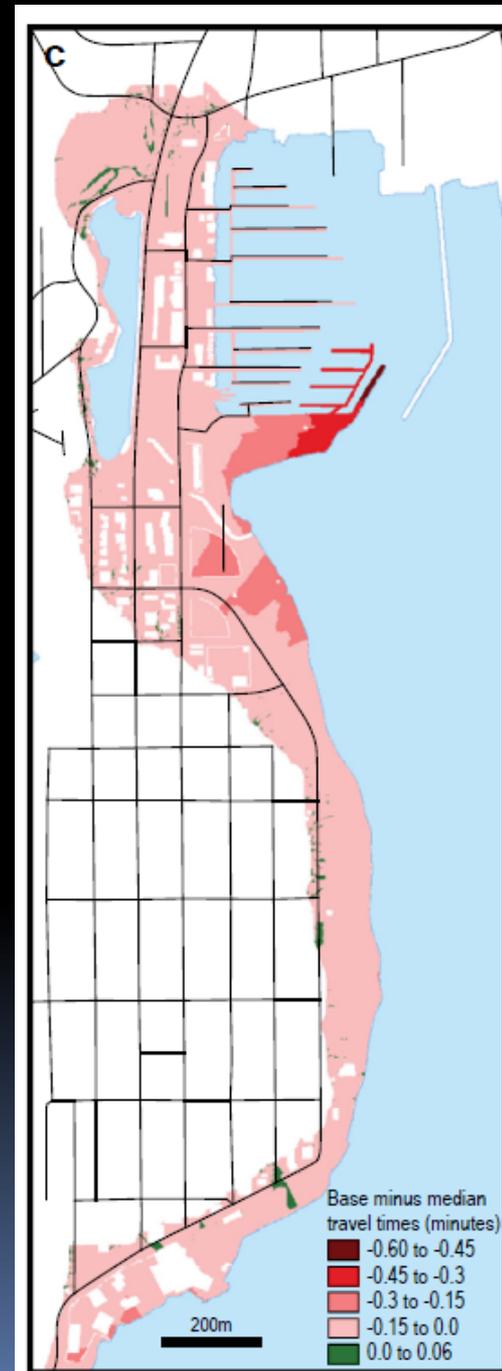
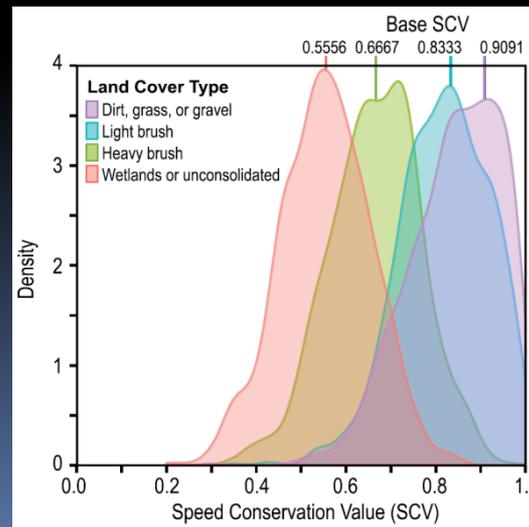
NZ Paper

Fixed
1.1 m/s best
approximation
of distributed
speeds



Alaska paper

Model not that sensitive to
varying SCV except for
wetlands and beaches



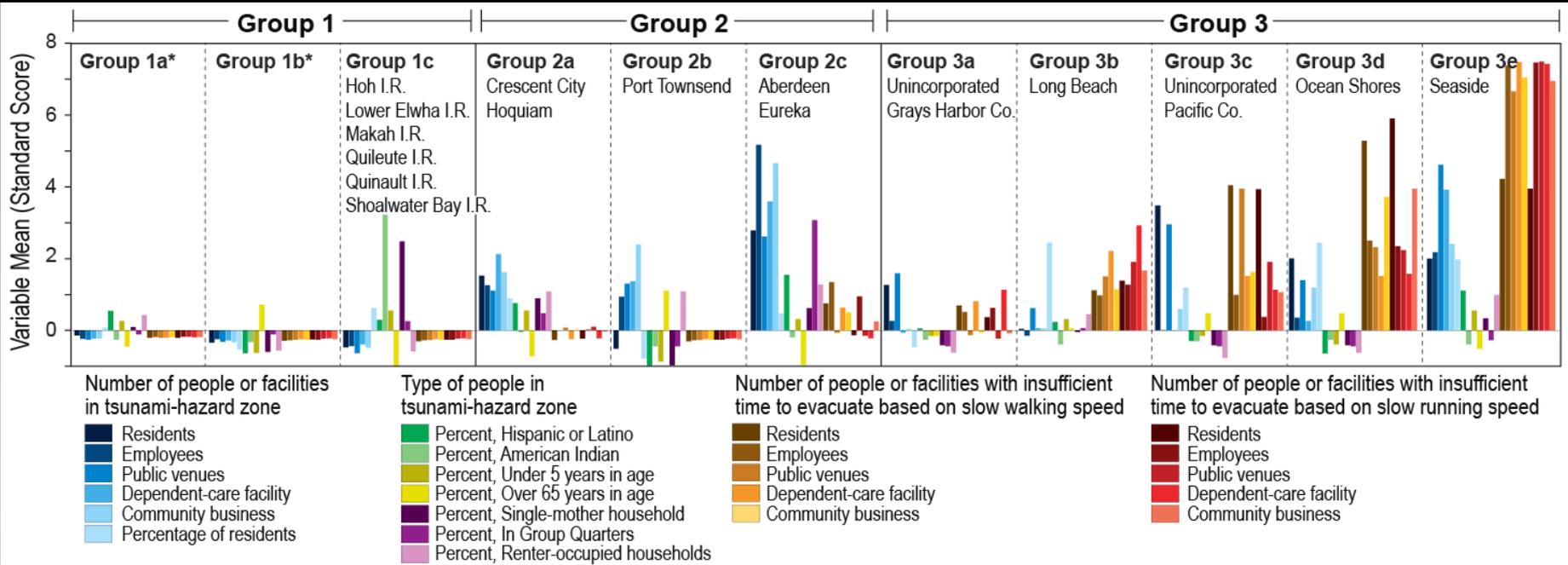
Current work

DRAFT

“Sister cities” of tsunami risk (in review)



- Evacuation modeling for entire Cascadia region
- Cluster analysis to identify similar communities
- Results identify various risk-reduction options

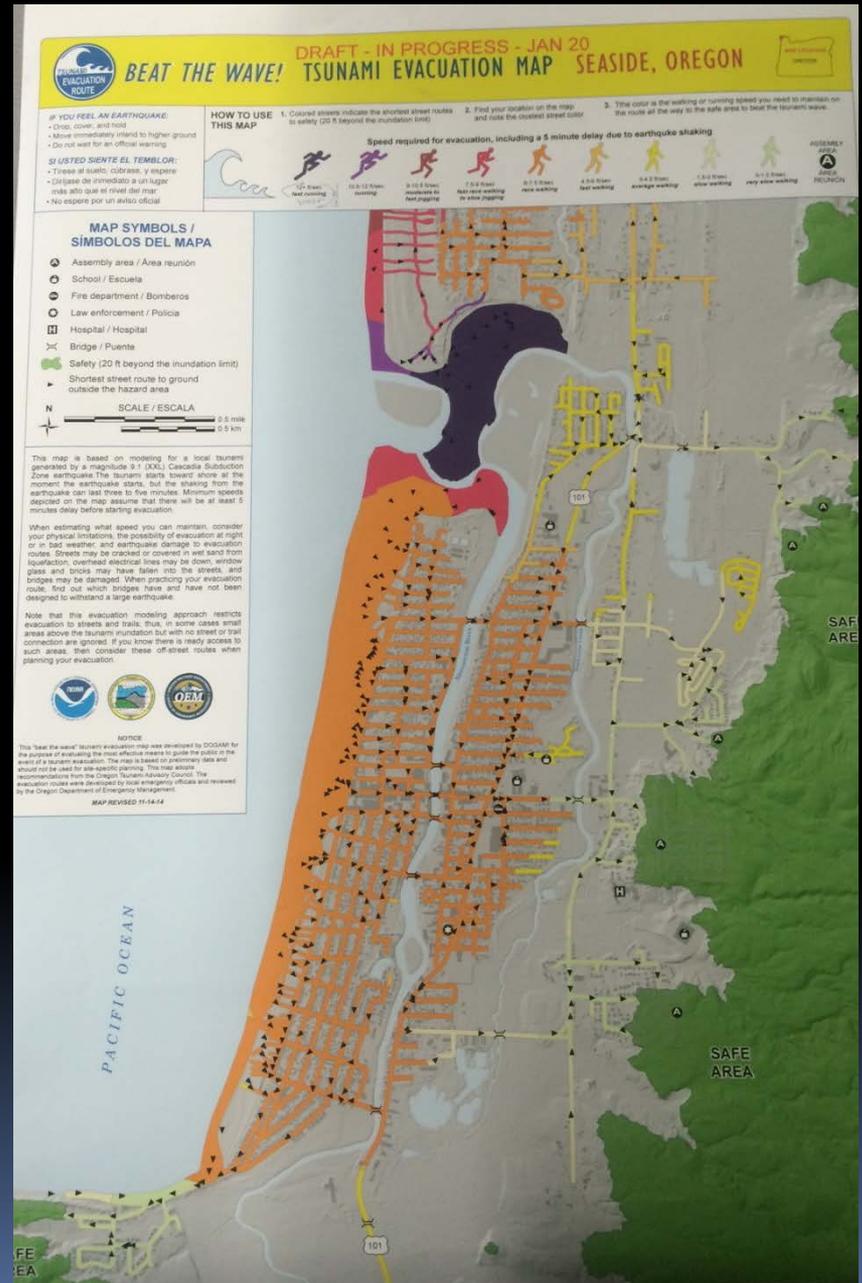


Current work

“Beat The Wave”

DRAFT

- Collaboration with DOGAMI
- Attempts to produce one map that shows speed needed to evacuate

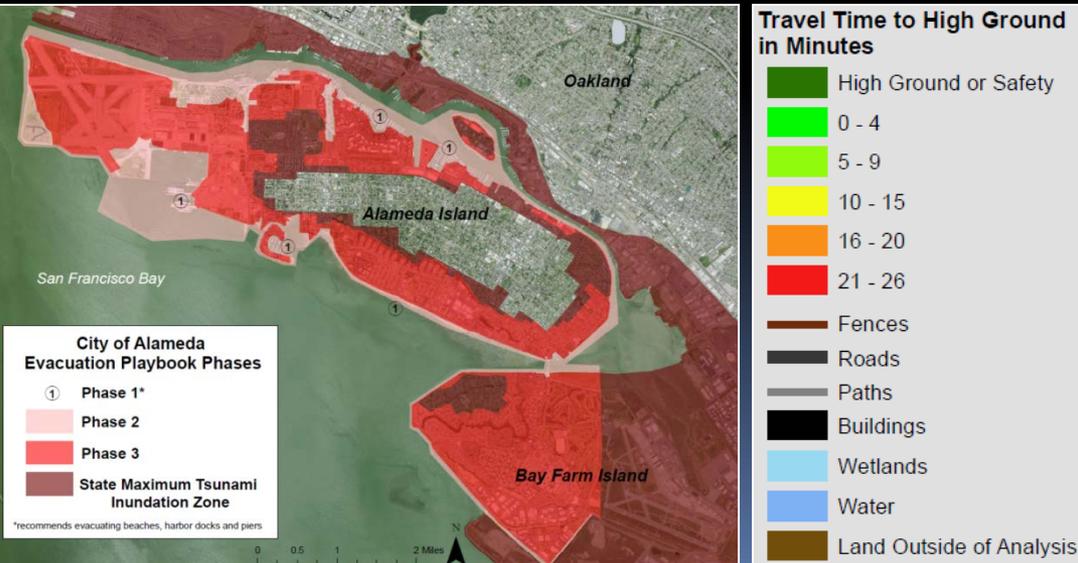
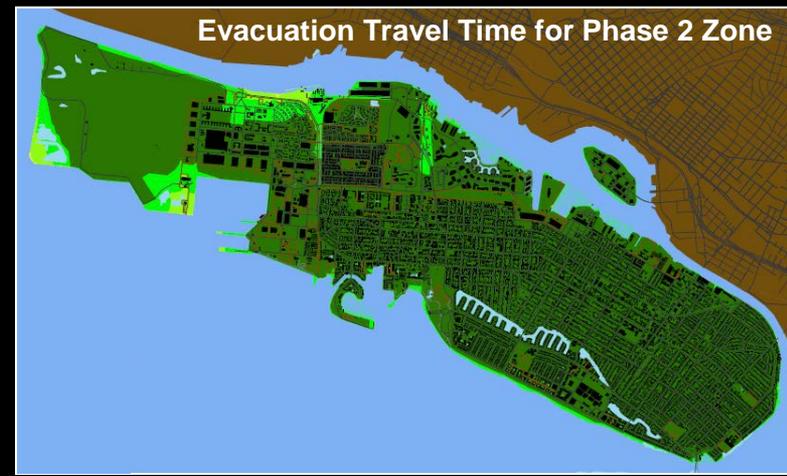


Current work

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Evacuation modeling for CA Tsunami Playbooks

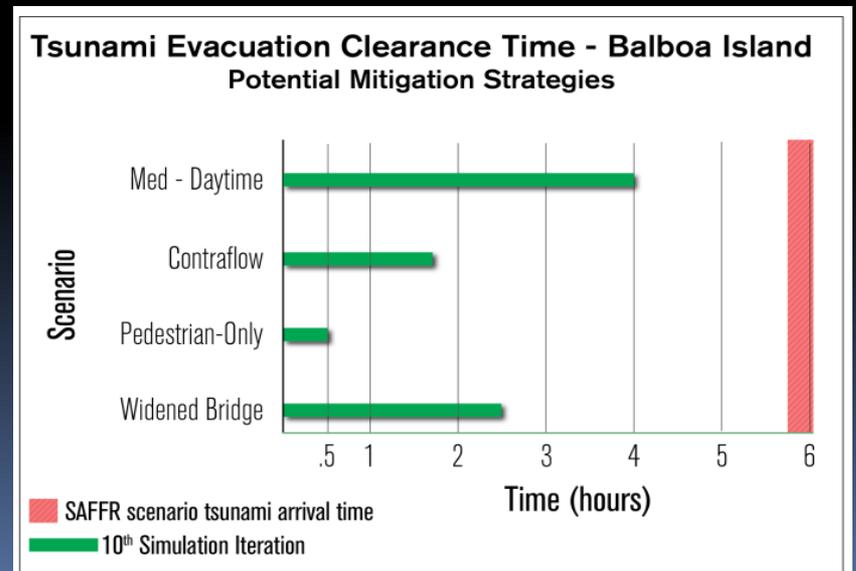
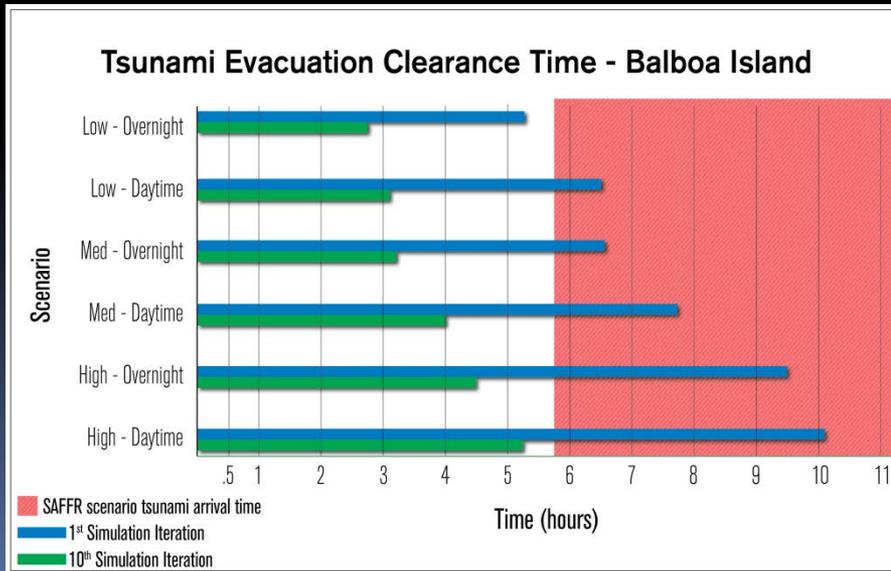
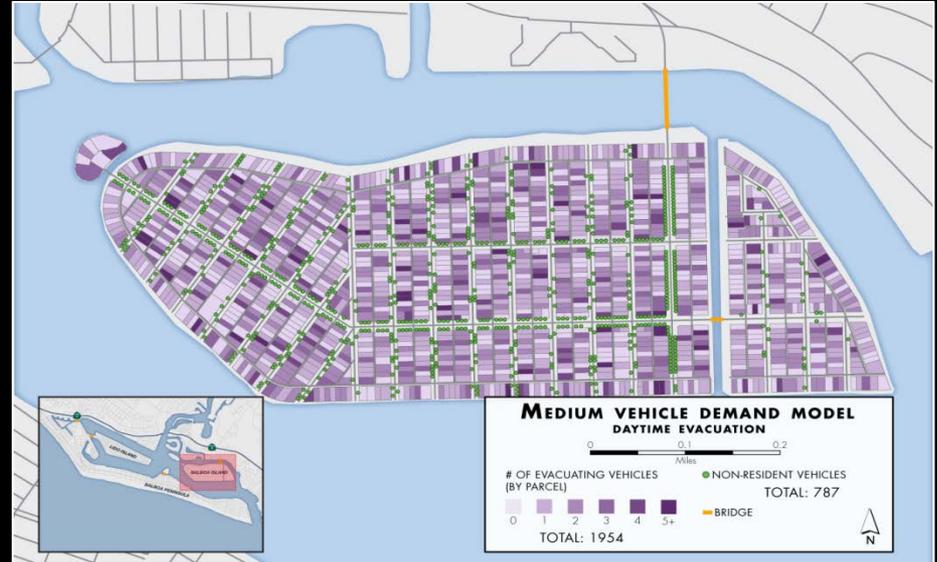
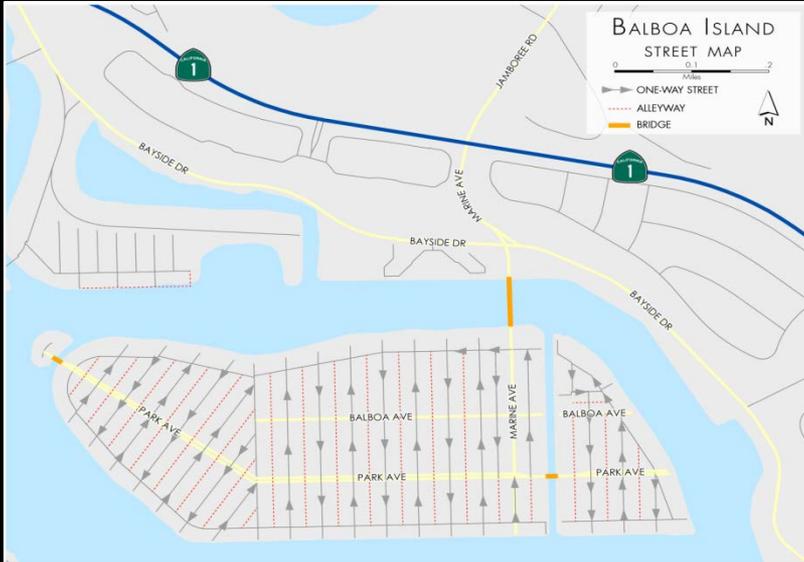
- Vehicular and car evacuation modeling
- Modeling for various evac. phases (2,3, max)
- Expected completion this summer



Current work

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Multi-modal evacuation modeling on Balboa Island



Differences in societal exposure to maximum and scenario hazard zones

USGS
science for a changing world

Prepared in cooperation with the California Emergency Management Agency and the California Geological Survey

Community Exposure to Tsunami Hazards in California



Scientific Investigations Report 2012-5222

U.S. Department of the Interior
U.S. Geological Survey

Maximum estimated inundation based on a composite of tsunami sources in Pacific Basin

USGS
science for a changing world

CGS CALIFORNIA GEOLOGICAL SURVEY

Population Vulnerability and Evacuation Challenges in California for the SAFRR Tsunami Scenario

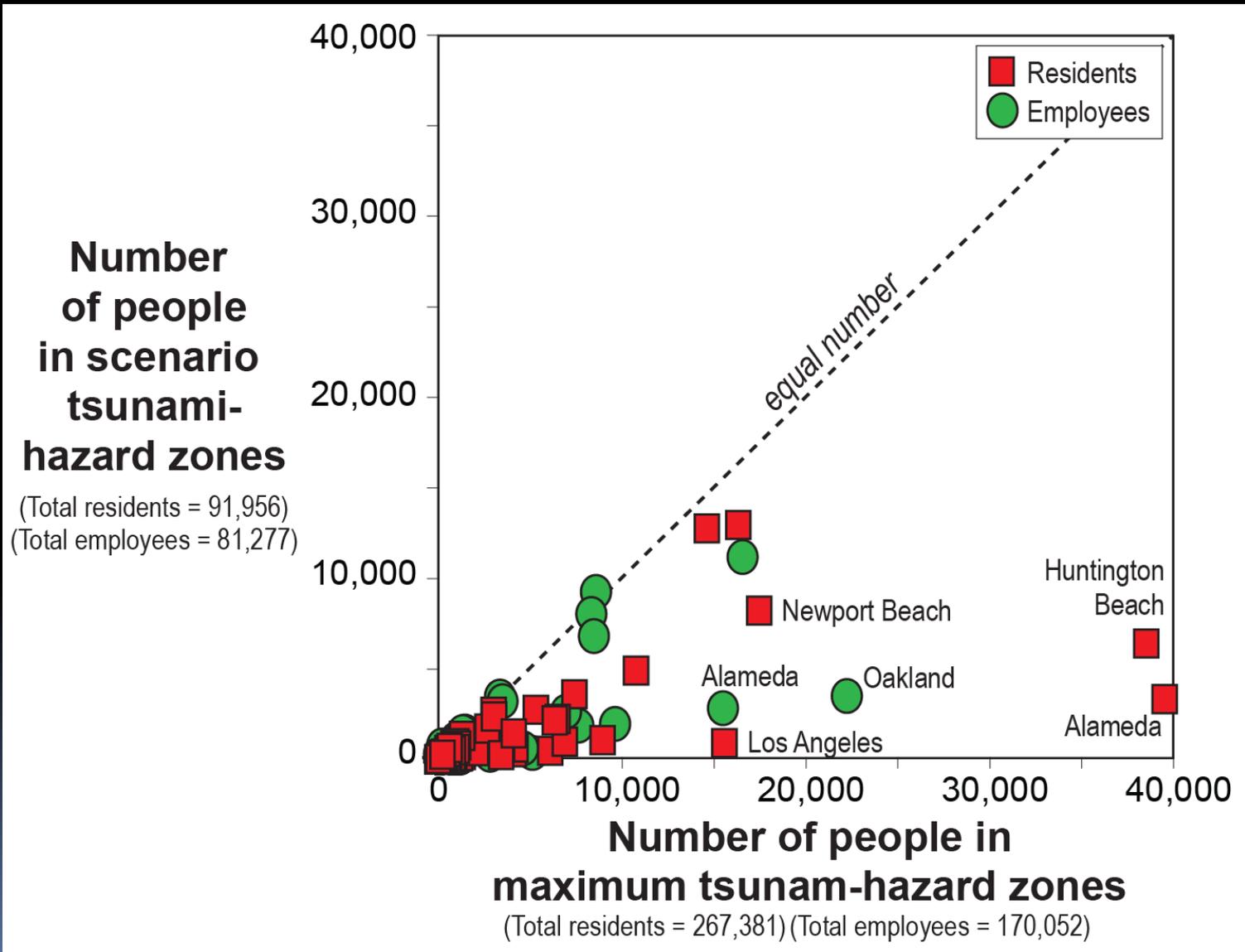


Open-File Report 2013-1170-1
California Geological Survey Special Report 229

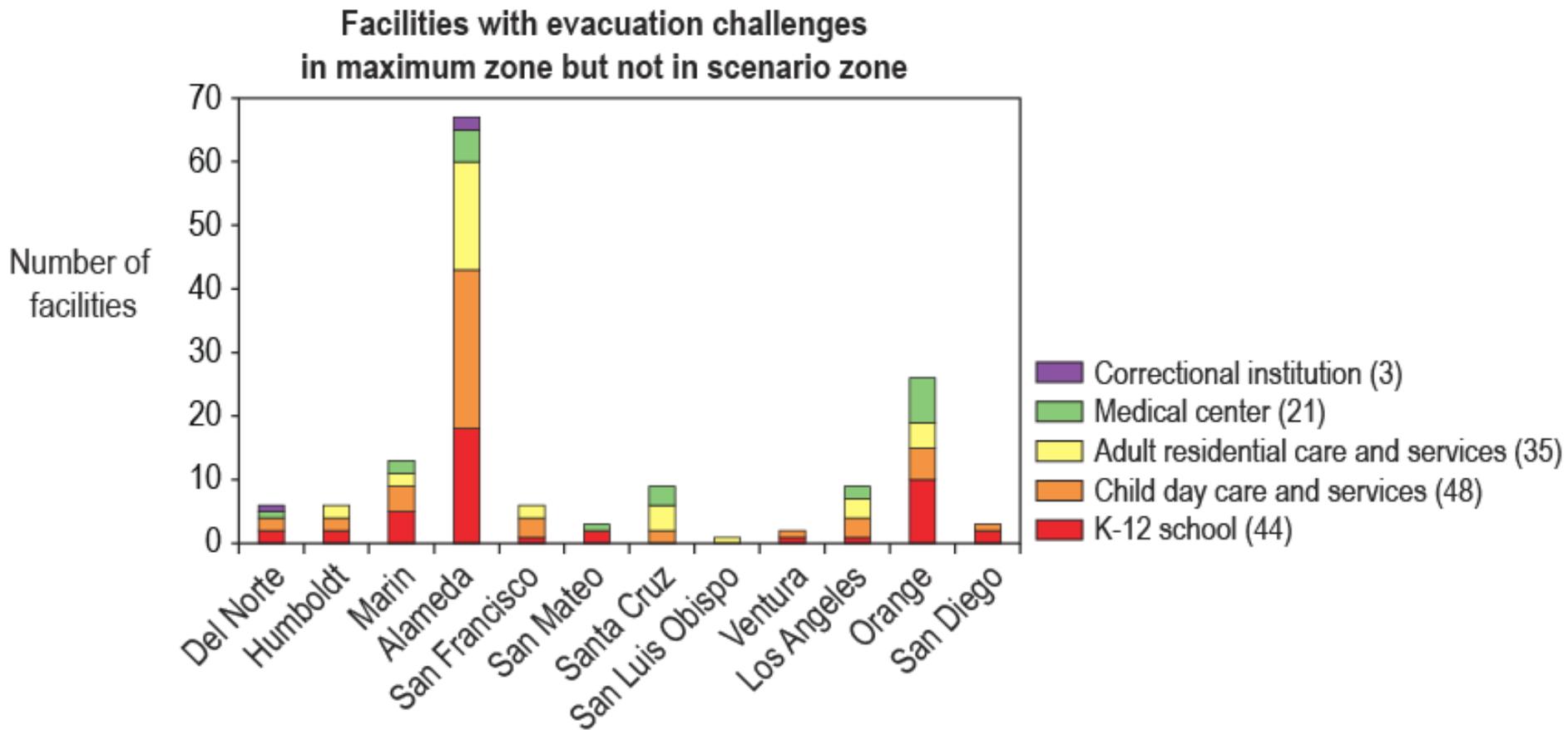
U.S. Department of the Interior
U.S. Geological Survey

Scenario Magnitude 9.1 earthquake offshore of the Alaskan peninsula

Differences in population exposure to maximum and scenario hazard zones



Facilities with evacuation challenges may be unnecessarily evacuated



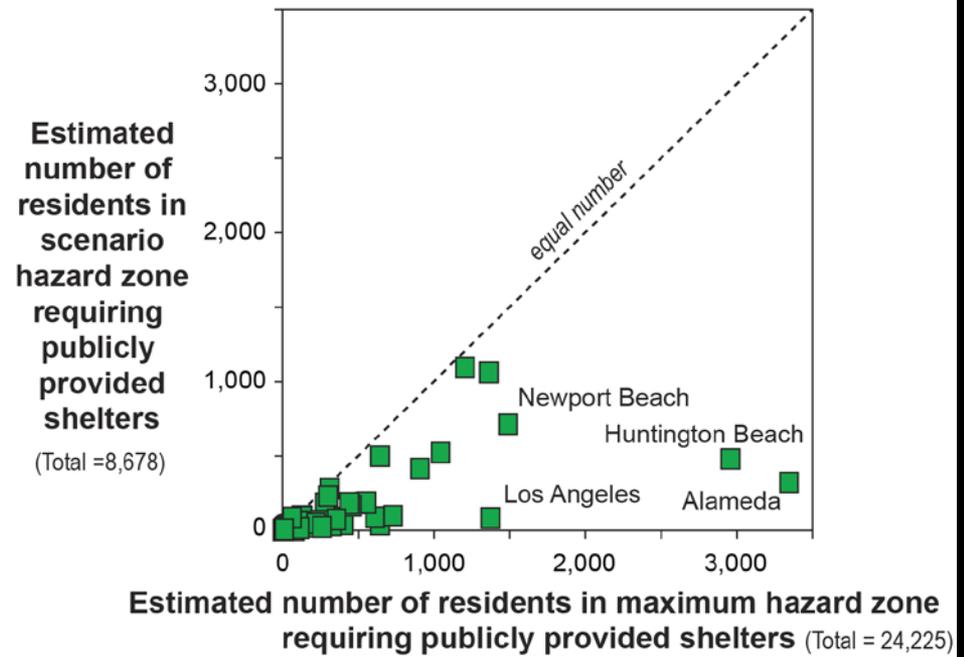
*Medical centers includes various clinics, and centers for dialysis, general surgery, eye surgery, and lung cancer

Cost implications of evacuating to maximum vs. scenario zones

- Previous cost estimates focused on “false alarms”
 - 1977 - Hawaii - \$3M (2014\$)
 - 1986 – Waikiki Beach, Hawaii - \$86M (2014\$)
 - 1996 - Hawaii - \$88M (2014\$)
- This study focuses on necessary but potentially over-evacuations
 - Differential exposure between maximum zone and scenario zone
 - Estimated costs
 - Public sheltering costs
 - Private sheltering costs
 - Business impacts – output, labor

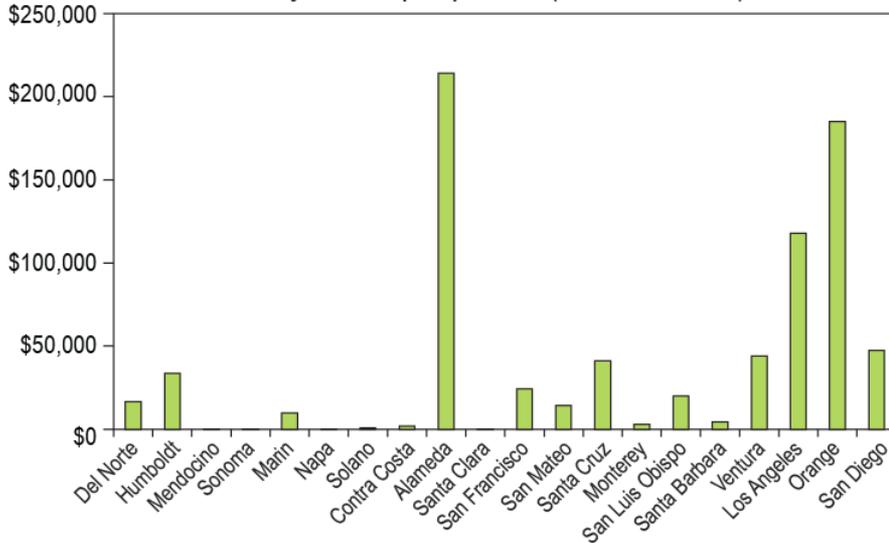
Public Shelter Costs

- Difference of 16,000 requiring public shelter
- Costs from \$50 - \$200 per person
- Potentially unnecessary expenditures of \$779k to \$1.6M
- Possible donor fatigue

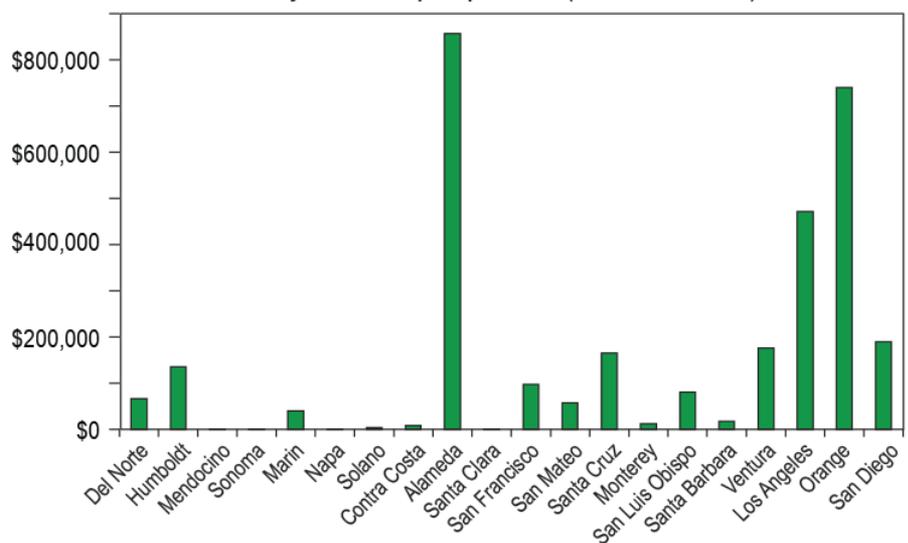


Public sheltering costs

1 day at \$50 per person (total of \$779K)



1 day at \$200 per person (total of \$1.6M)

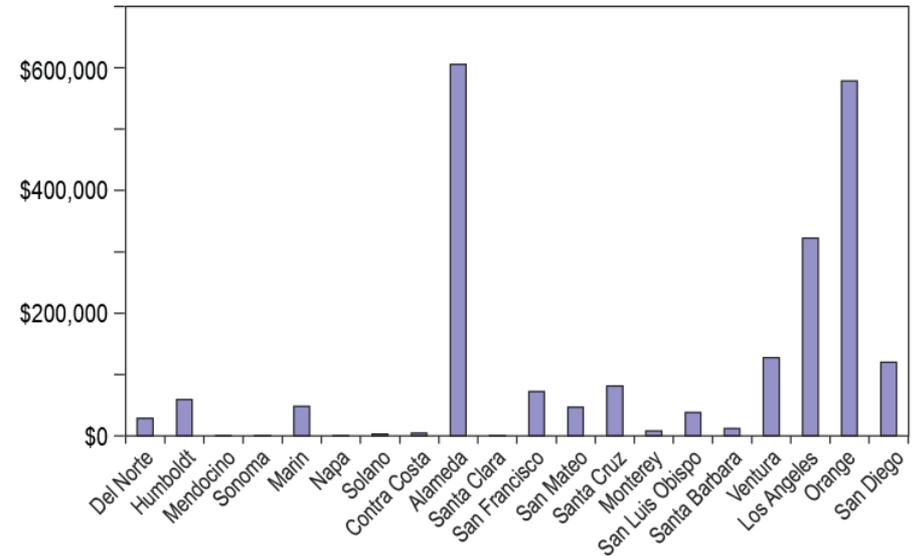


Private Shelter Costs

- 91% of evacuees (~160K) would likely find own shelter
- Based on spending during hurricane evacuations
- Costs include food, incidentals, and lodging (only for overnight evacuations)
- Doesn't include travel costs
- Costs incurred by individuals
- Possible benefits to community and regional transfer of spending

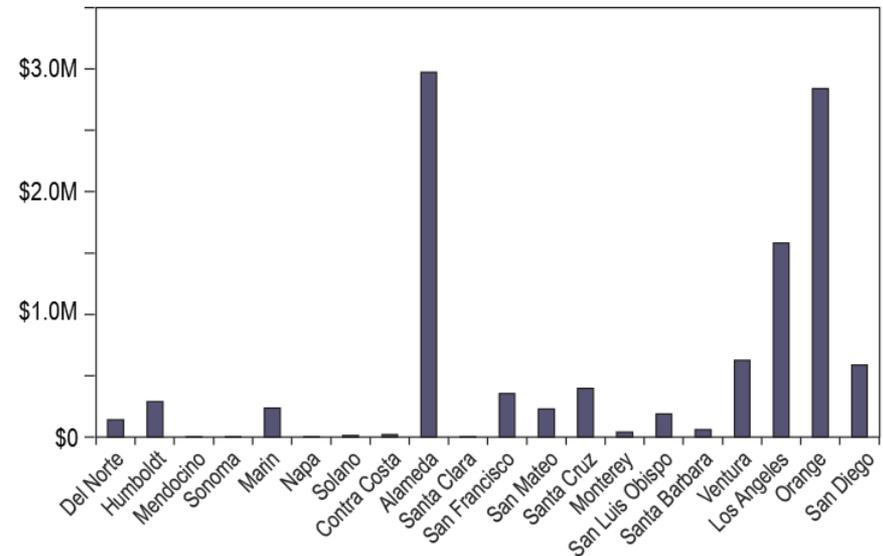
Private sheltering costs

1/2 day (total of \$2.2M)



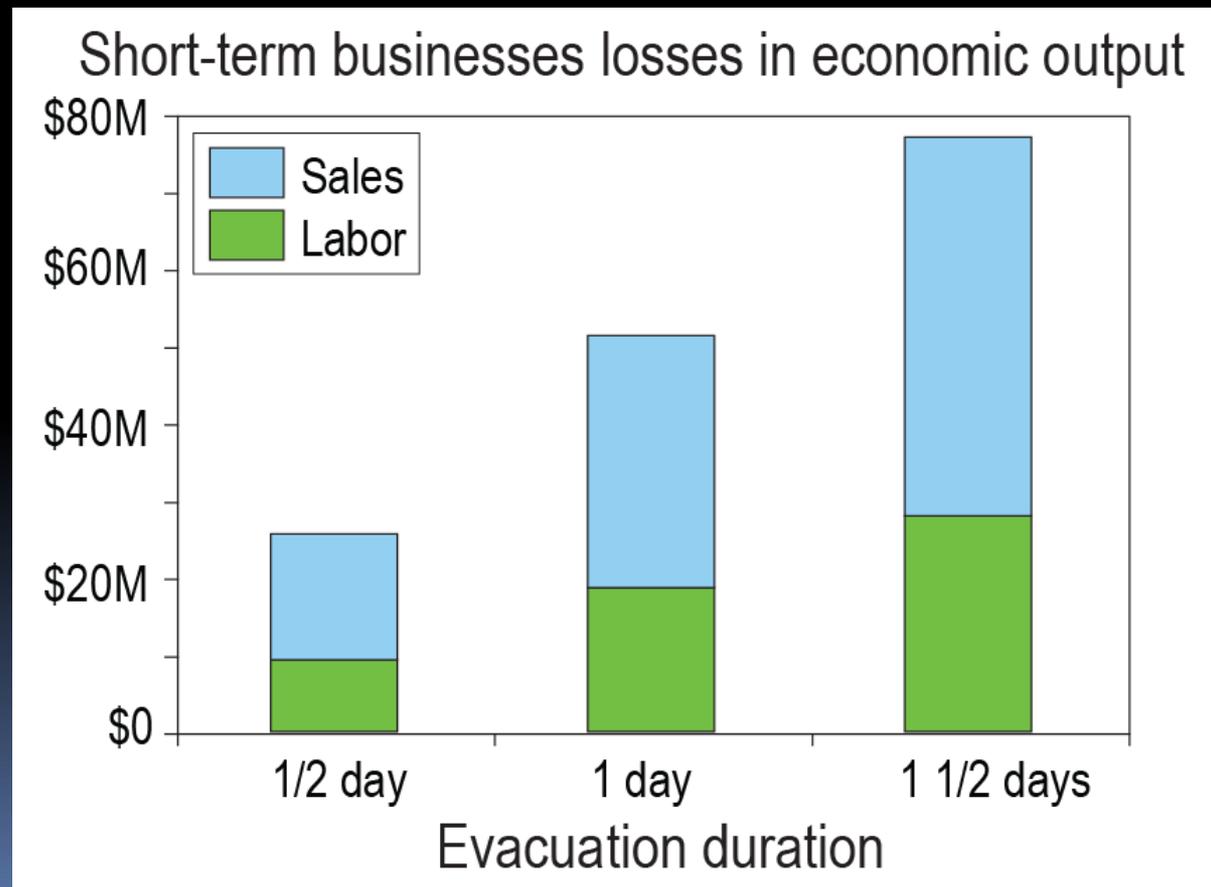
Private sheltering costs

1 day (total of \$10.6M)



Short-term business impacts

- Focus on economic output of businesses (w/ labor cost)
- Underestimates because “multipliers” excluded (e.g., delayed sales)
- Based on # of employees in max vs. scenario
- Use of “disruption coefficients” for business type



Short-term business impacts by sector

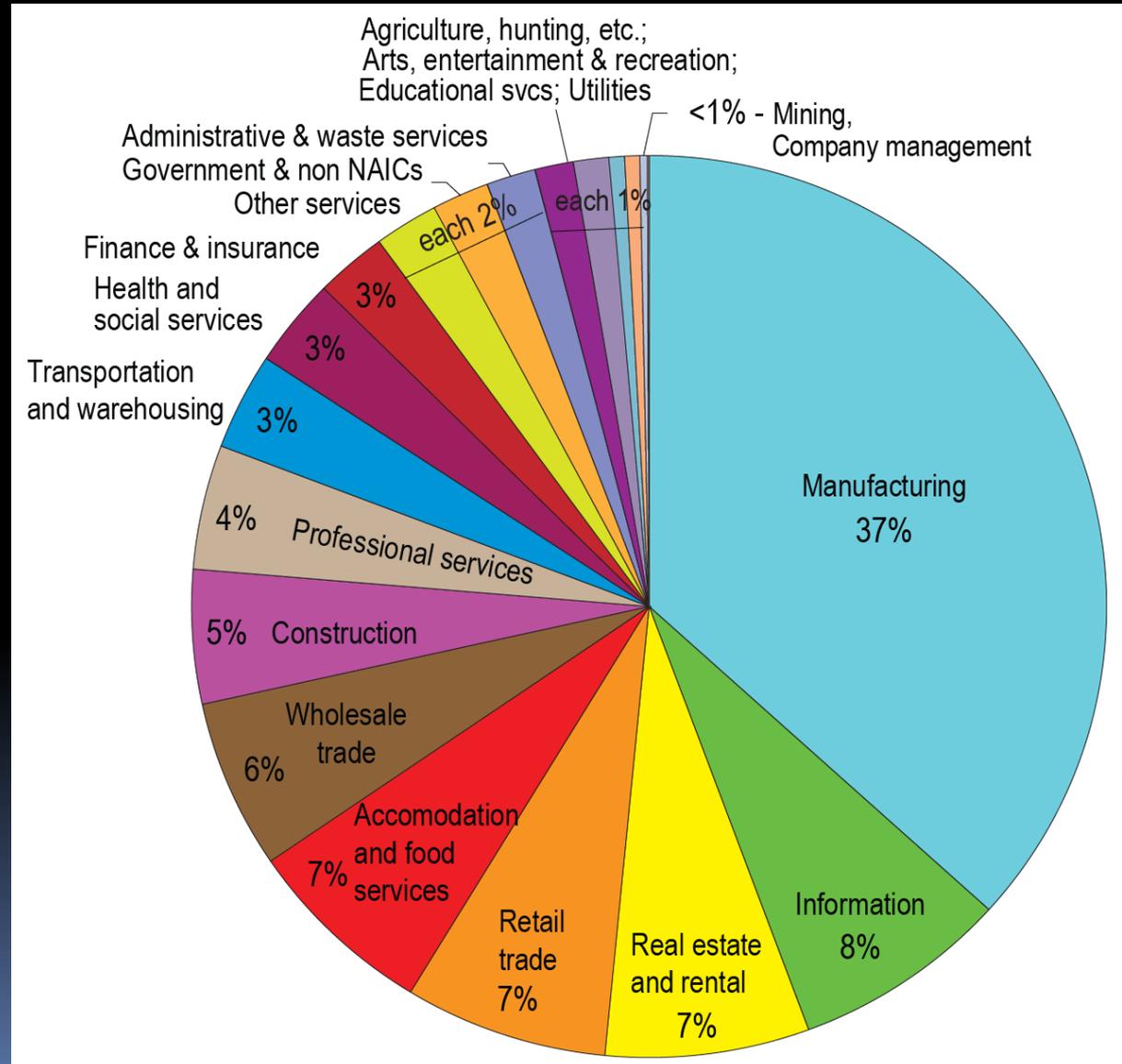
Lost Output for Businesses in Max Zone but not in SAFRR Zone (% of total)

- **Certain sectors may be able to recoup losses**

- Manufacturing
- Construction
- Real estate
- Entertainment

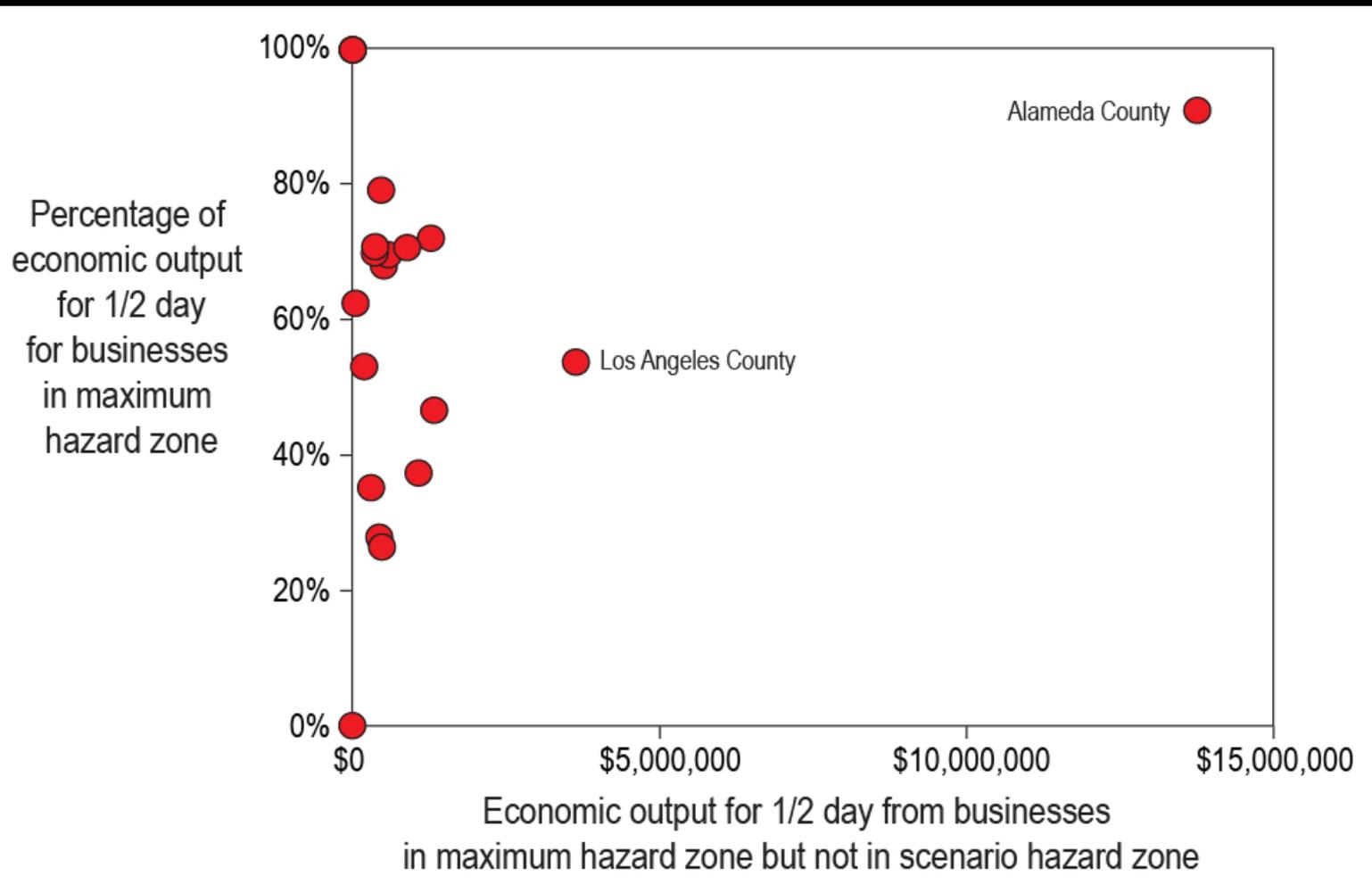
- **Others may not be able to recoup losses**

- Retail
- Accommodations
- Food services



Short-term business impacts by county

- Significant impacts and percentage of maximum evacuations in certain counties
- Lower amounts and percentages in many other counties



Summary

- Available pedestrian evacuation tool
- Published examples of use of evacuation modeling
- Current – “Sister cities”, playbook differences, evacuation costs



<http://geography.wr.usgs.gov/science/vulnerability/tools.html>

A screenshot of a web browser displaying the USGS website. The browser's address bar shows the URL 'geography.wr.usgs.gov/science/vulnerability/tools.html'. The USGS logo is visible in the top left corner, and navigation links for 'USGS Home', 'Contact USGS', and 'Search USGS' are in the top right. A blue navigation bar contains the text 'Risk and Vulnerability to Natural Hazards' and a search box. Below this is a menu with tabs for 'Overview', 'In the News', 'Hazards', 'GIS Tools', 'Publications', and 'Research Team'. The 'GIS Tools' tab is selected. The main content area features a blue header for 'Pedestrian Evacuation Analyst'. Below this, the text reads: 'The Pedestrian Evacuation Analyst—Geographic Information Systems Software for Modeling Hazard Evacuation Potential'. Underneath, it specifies 'Chapter 9 of Section C, Geographic Information Systems Tools and Applications' and 'Book 11, Collection and Delineation of Spatial Data'. Two blue buttons are positioned on the right: 'DOWNLOAD TOOL' and 'DOWNLOAD USER'S GUIDE'.