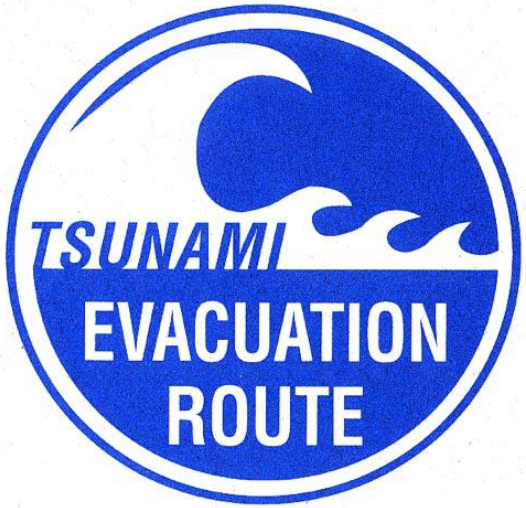
SEASIDE, OREGON TSUNAMI EVACUATION ANALYSIS



JOSEPH BARD, CHRISTINE RUTAN, AND HANNAH WELLS

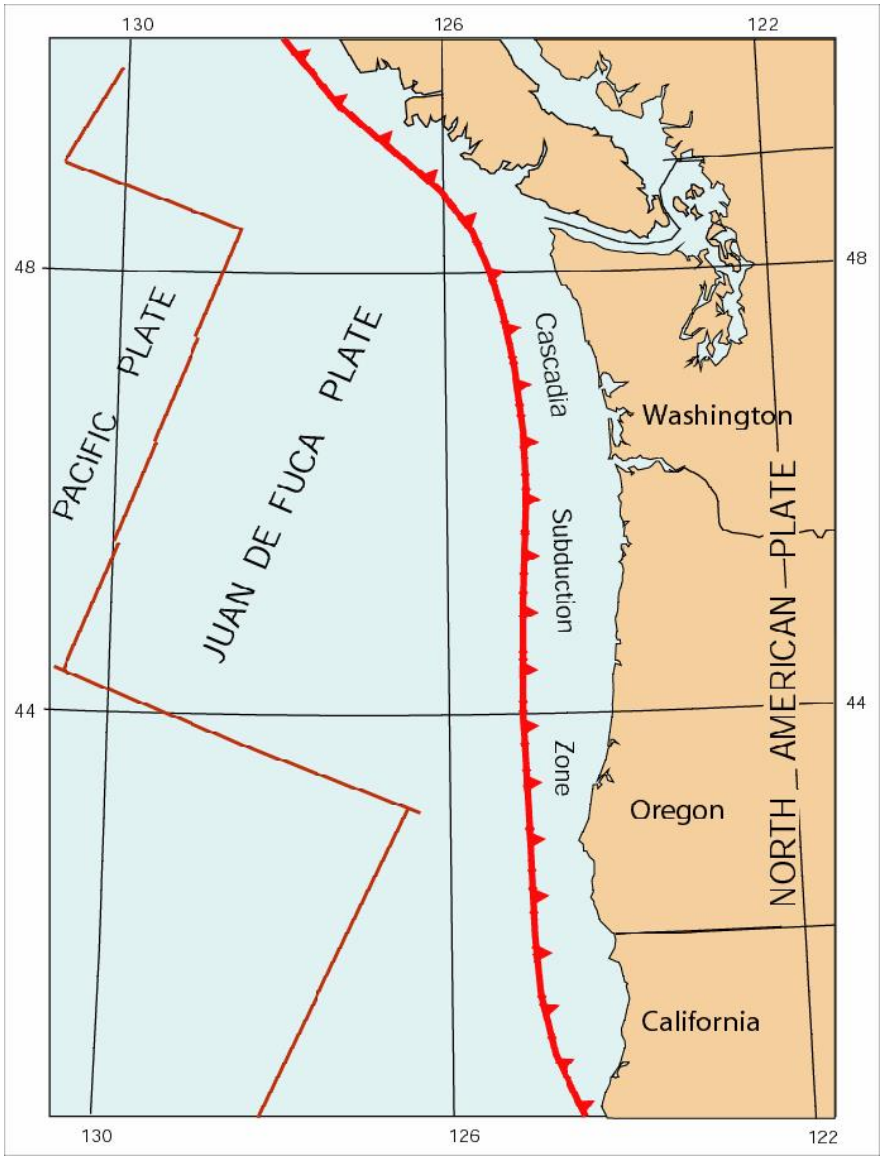
GEOGRAPHY 493/593: DIGITAL TERRAIN ANALYSIS

BACKGROUND:

CASCADIA SUBDUCTION ZONE

- 13 CSZ-related tsunamis in the last 7,600 years
  - 140 to 1,000 years apart. (1)
- Last CSZ earthquake: 1700
  - Average span between quakes: 500 years.
- 10 - 14% chance of a tsunami in the next 50 years. (2)
- Magnitude 9.0 will render many roads and bridges unusable by cars.

→ Many people will have evacuate to the safety of high ground by foot.



(1) Wood N, Soulard C (2008) Variations in community exposure to tsunami hazards on the open-ocean and Strait of Juan de Fuca coasts of Washington. USGS Scientific Investigations Report 2008-5004, 34

(2) Cascadia Region Workgroup (2005) Cascadia subduction zone earthquakes—a magnitude 9.0 earthquake scenario. Oregon Department of Geology and Mineral Industries, Portland

RESEARCH QUESTION:

Assuming:

- **Evacuees are on foot**
- **25 minute evacuation window**
- **An average walking speed of 1.1 m/s**

1. **What areas within the tsunami inundation zone are within range of safe ground?**

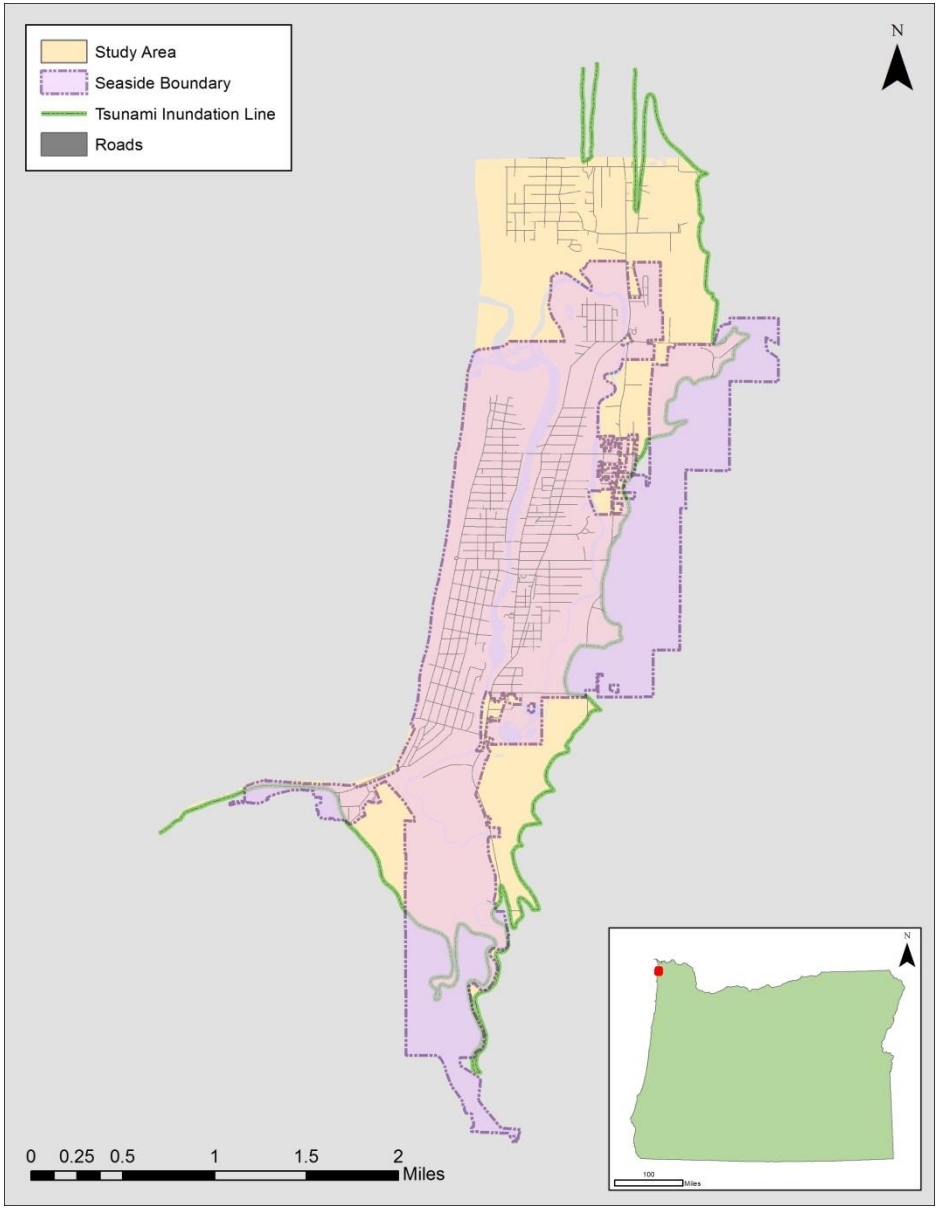
2. **What sensitive sites, such as schools, hospitals, and elderly care facilities, are in dangerous locations?**

3. **How much of the population is in danger?**

4. **How will evacuation potential be affected by route restrictions?**

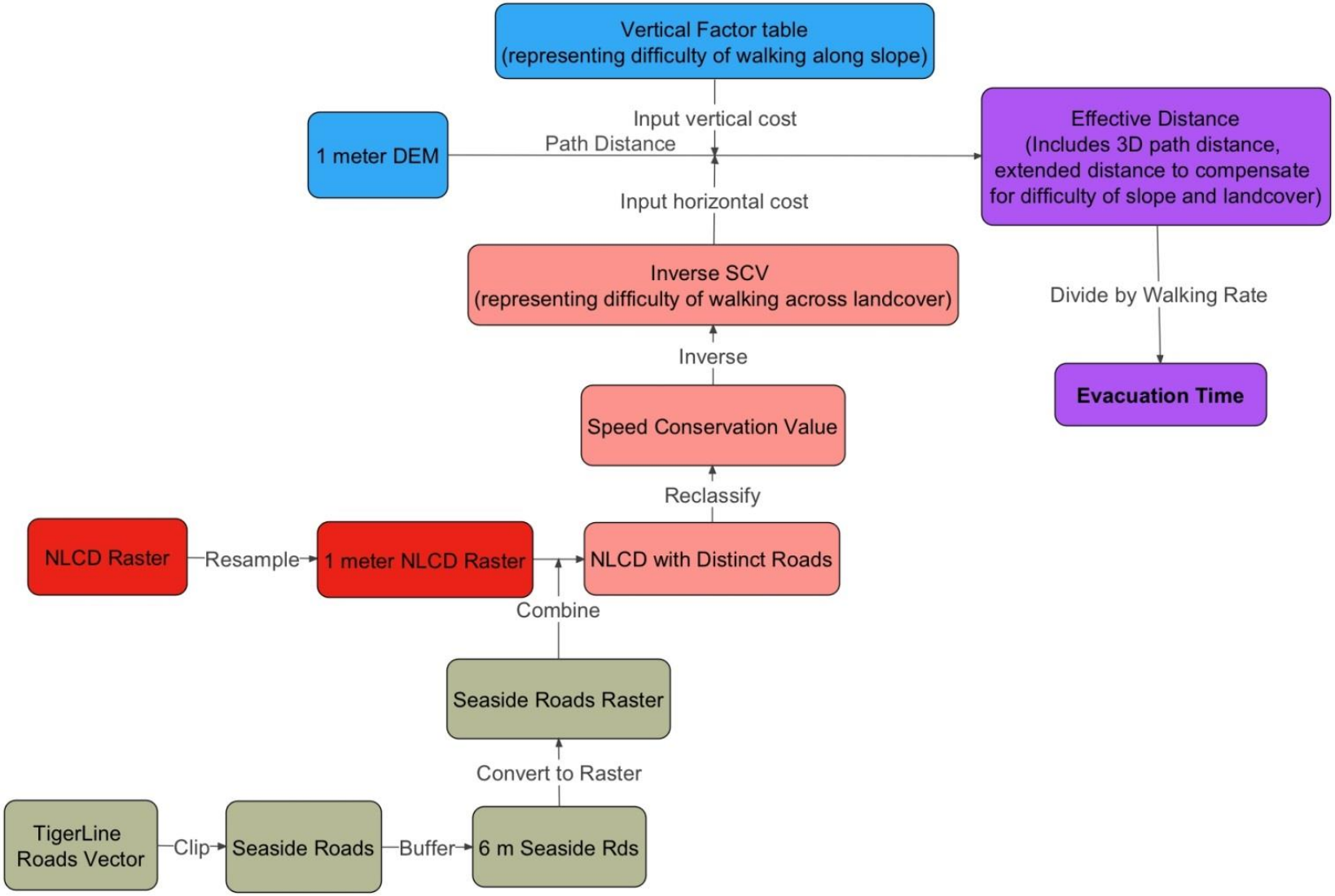
STUDY AREA

- **Census Population (2010): 6,457[(1)]**
- **Total Area within in City Limits: 3.84 Square Miles**
- **Total Area within Study Area: 4.09 Square Miles**
- **Tourism is a major portion of the city's economy – seasonal variations in population need to be taken into account for disaster planning.**
  - 27.3 % of all housing units were "for seasonal, recreational, or occasional use."[(1)]
- **Daily changes in population between home and work/school also need to be considered.**



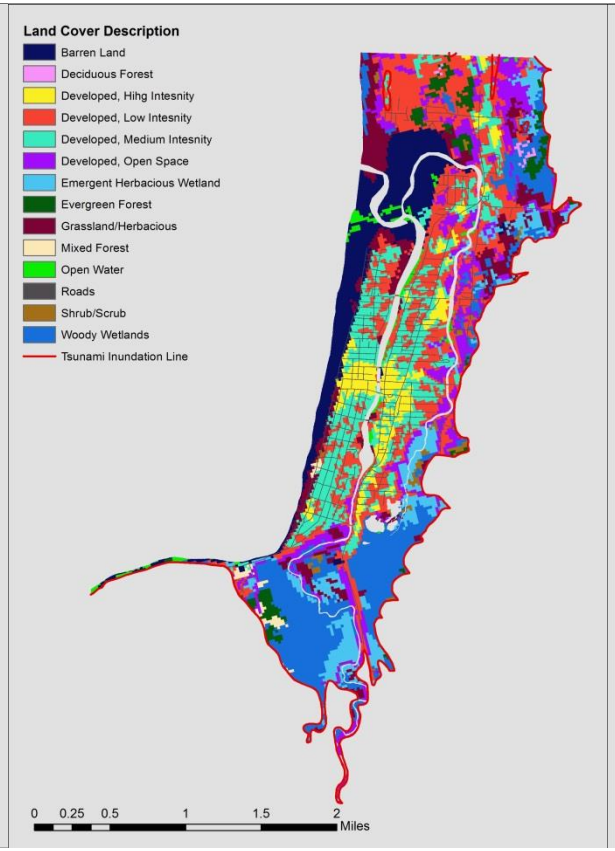
(1) U.S. Census Bureau. American Fact Finder. Accessed December 3 2013. <http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk>.

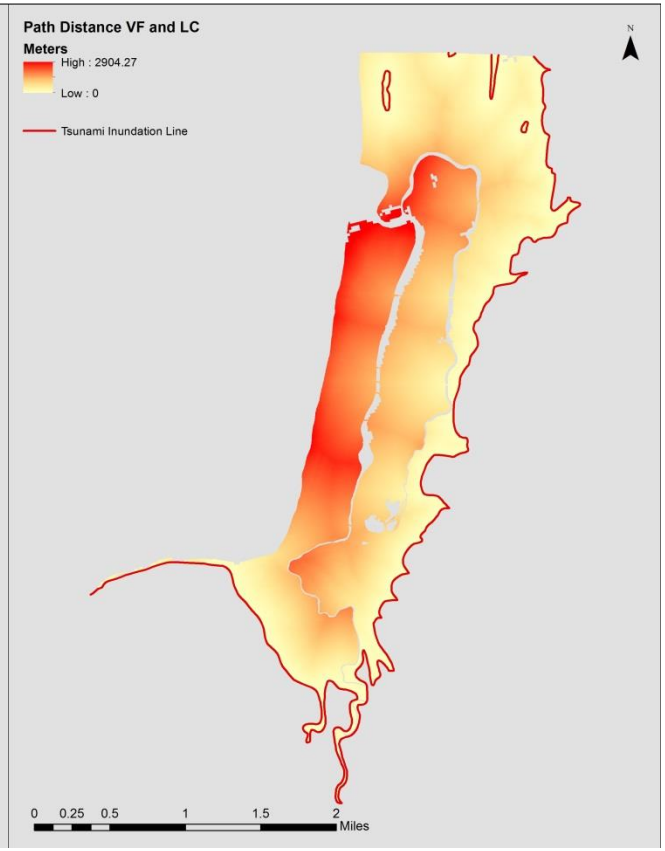
METHODS OVERVIEW:



PATH DISTANCE TOOL:

Speed Conservation Value: The factor by which walking speed is reduced when crossing a surface that impedes optimal travel speed. Expressed as a number between 1.0 - 0.





Input 1: DEM
- Slope VF SCV
- Distance

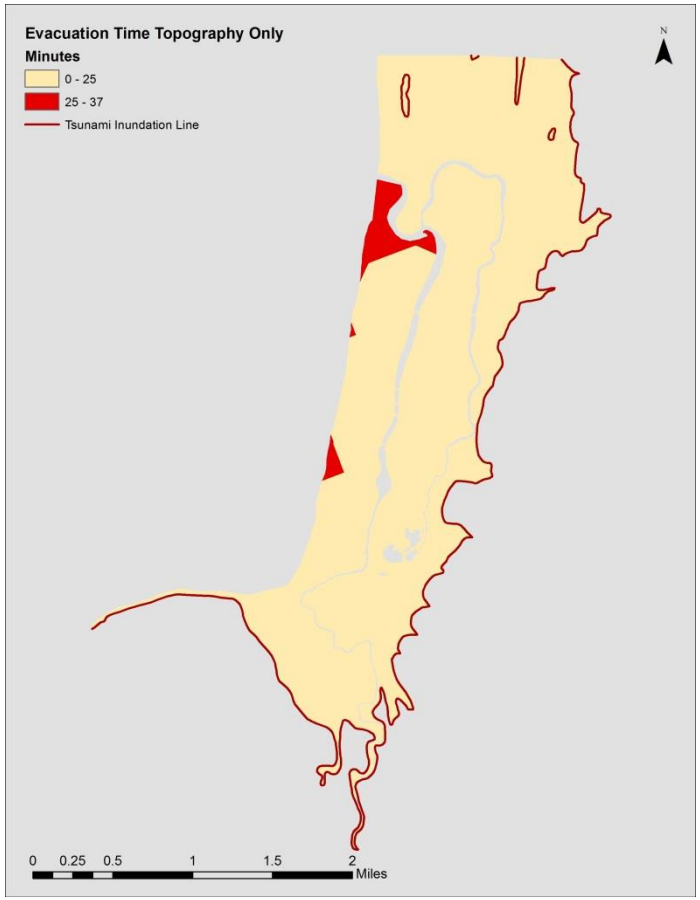
Input 2: Land Cover
- Cost Surface LC SCV

Output: Distance Raster
- Meters to Safe Zone

WALKING TIME:

$$Time = \frac{Distance}{Rate}$$

$$25\ Minutes = \frac{(1650m)}{66\ m/minute}$$



Comparing the findings from the TCRP/ NCHRP study with previous work resulted in the following recommendations:

- 3.5 ft./sec. (1.1 m/sec.) walking speed for general population

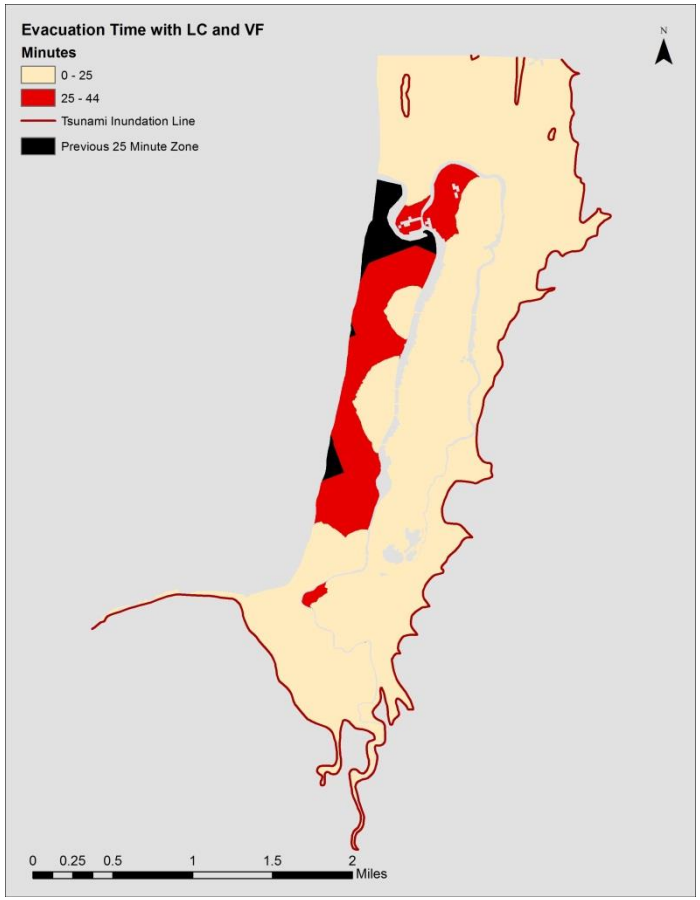
For our study:

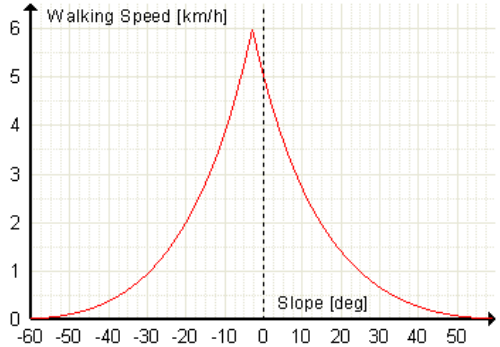
$$66\,m/minute = 1.1m * 60\ seconds$$

WALKING TIME:

$$Time = \frac{Distance}{Rate}$$

$$37.5\ Minutes = \frac{(1650m * SCVvf_{*\ lc})}{66\ m/minute}$$





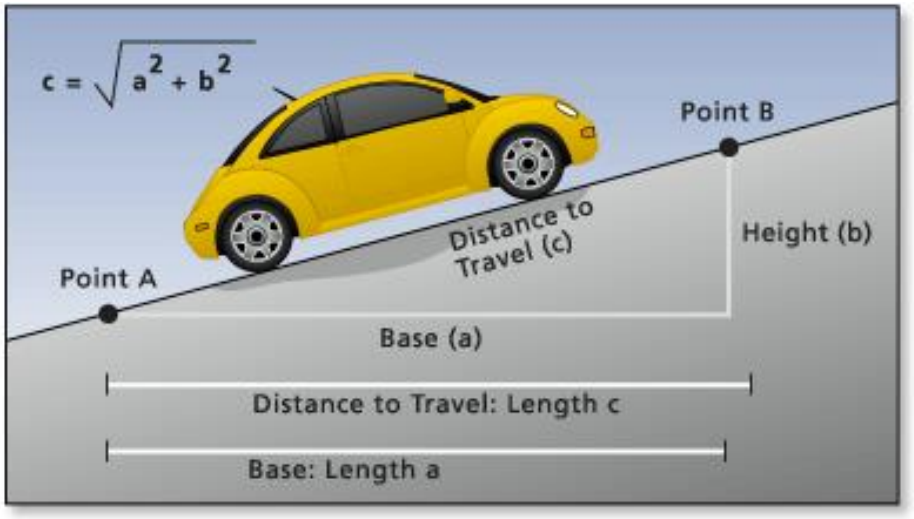
$$Walking\ Speed = 6e^{-3.5|\mathrm{TAN}\ \theta + .05|}$$

Tobler (1993)

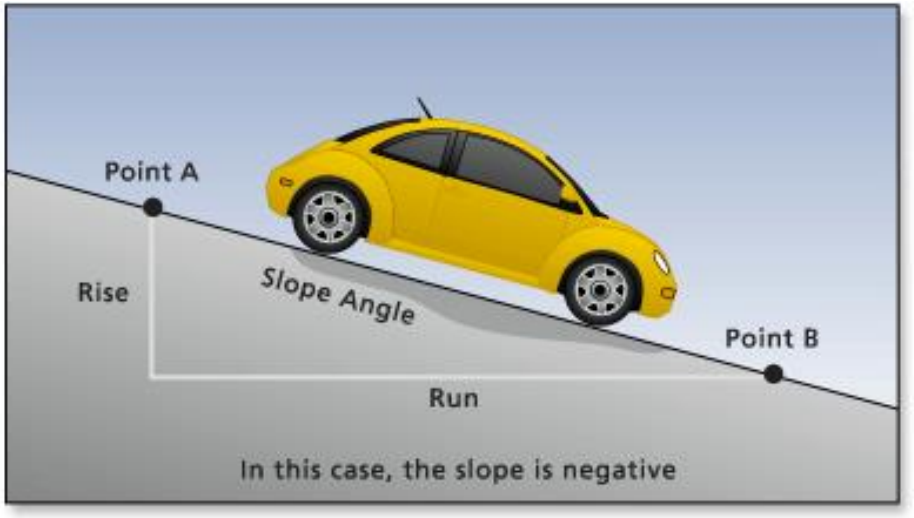
	VALUE	DESCRIPTION	SCV	INVERSE_SCV
▸	0	Roads	1	1
	11	Open Water	0	0
	21	Developed, Open Space	0.9091	1.1
	22	Developed, Low Intesnity	0.9091	1.1
	23	Developed, Medium Intesnity	0.9091	1.1
	24	Developed, Hihg Intesnity	0.9091	1.1
	31	Barren Land	0.5556	1.7999
	41	Deciduous Forest	0.8883	1.1257
	42	Evergreen Forest	0.8883	1.1257
	43	Mixed Forest	0.8883	1.1257
	52	Shrub/Scrub	0.6667	1.4999
	71	Grassland/Herbacious	0.8333	1.2
	90	Woody Wetlands	0.5556	1.7999
	95	Emergent Herbacious Wetland	0.5556	1.7999

Soule and Goodman(1972) in Wood (2011)

PATH DISTANCE EXPLANATIONS:



Trigonometric distance

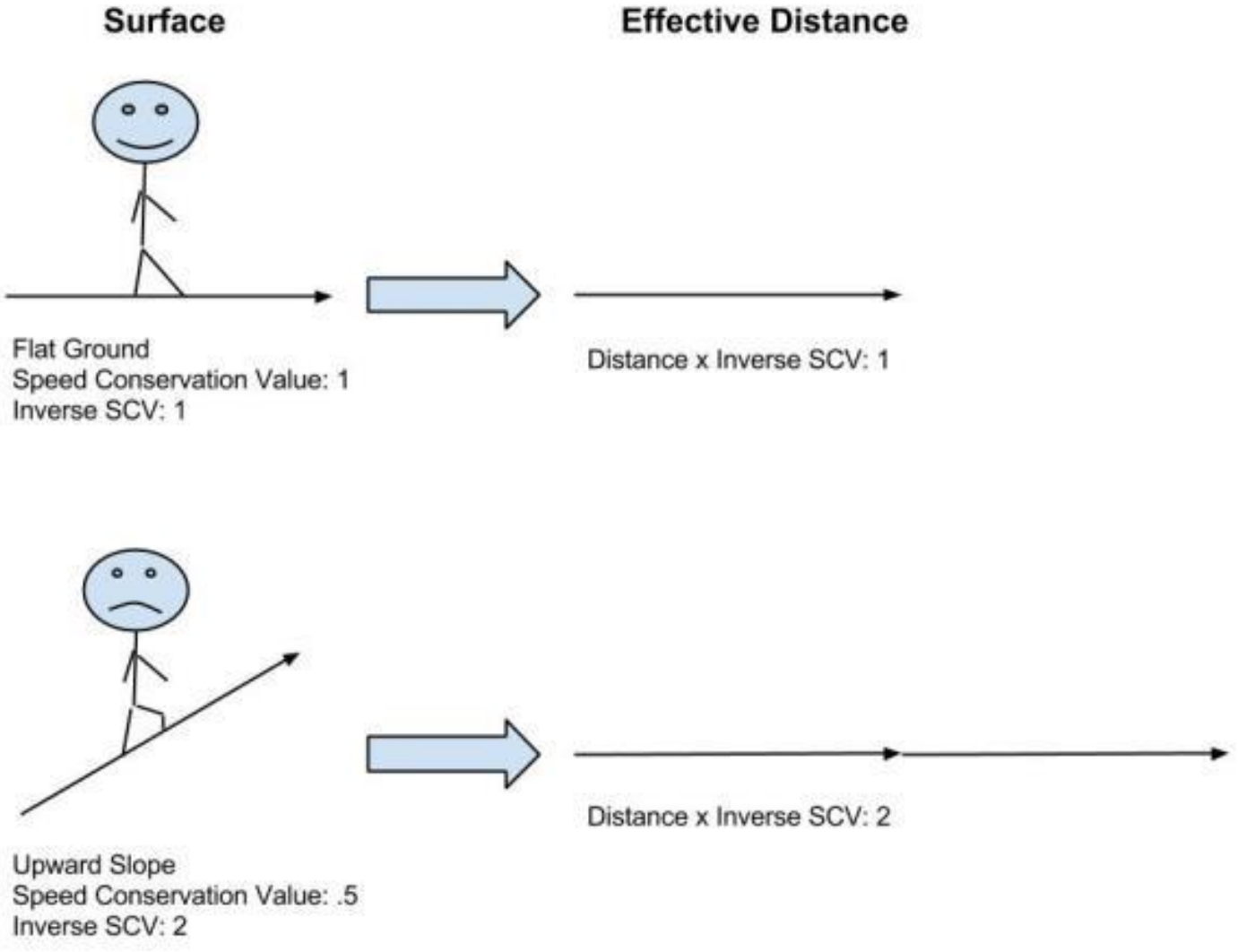


Reduced Travel Impedance: SCV ~ 1.0

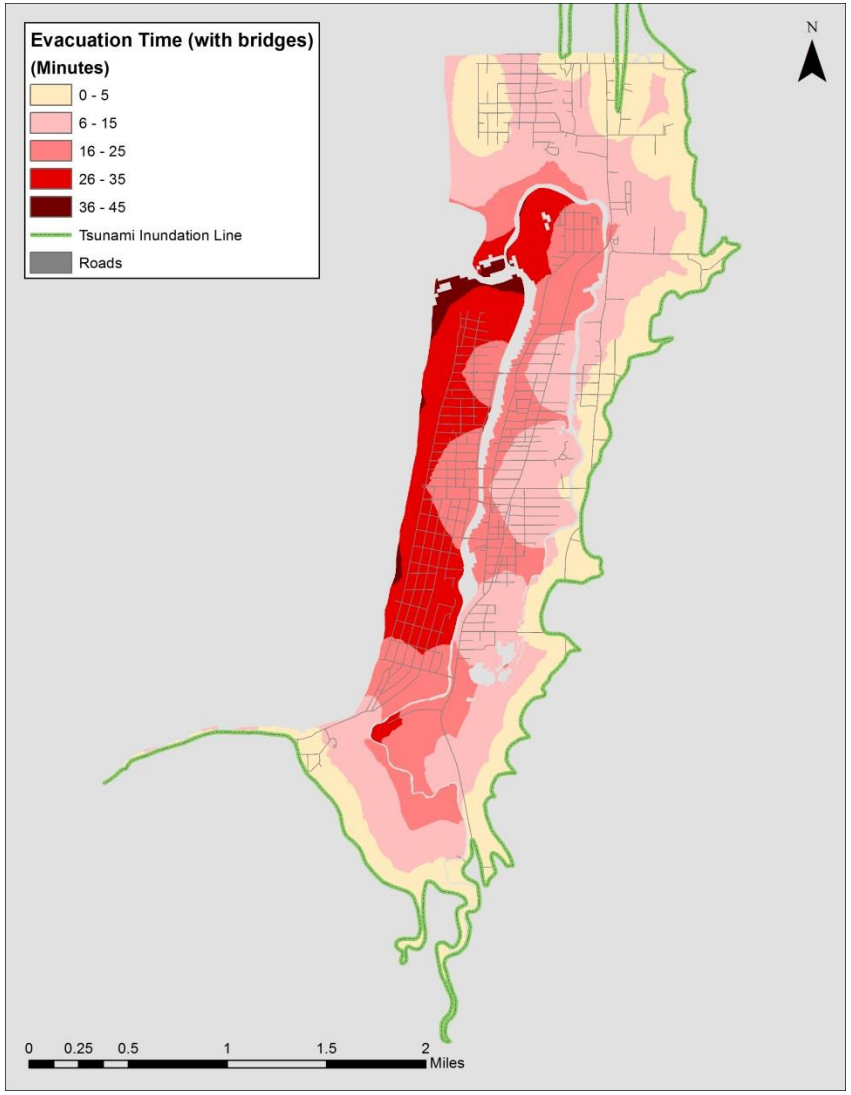
ESRI Path Distance Tool Help

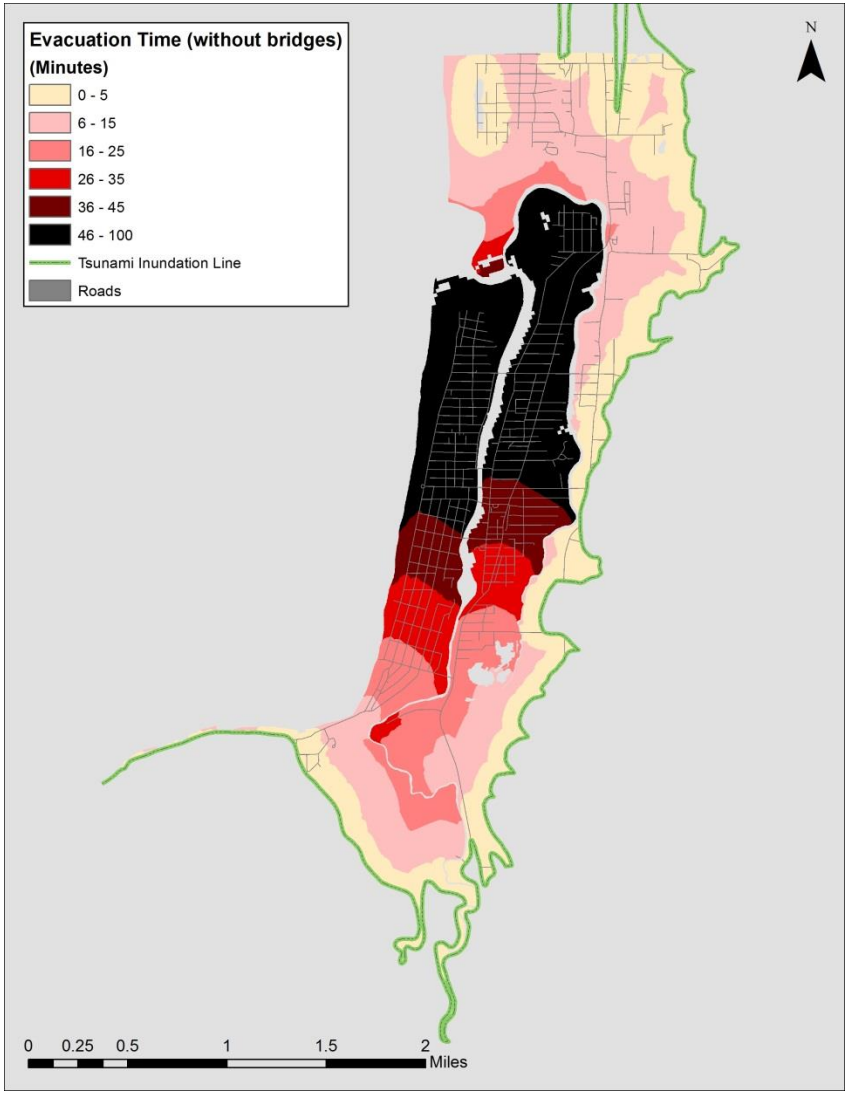
SPEED CONSERVATION VALUE

EFFECTIVE WALKING DISTANCE



EVACUATION TIME





With Bridges

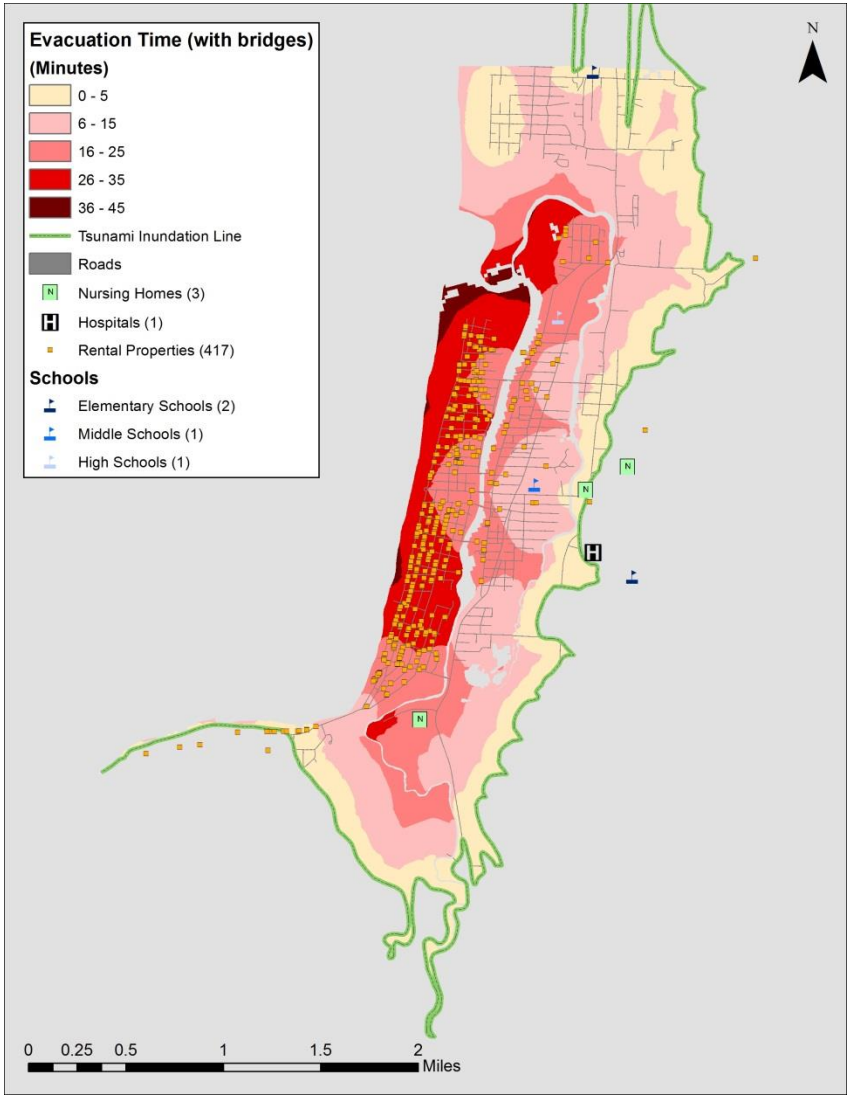
- Longest evacuation time: 44 minutes

Without Bridges

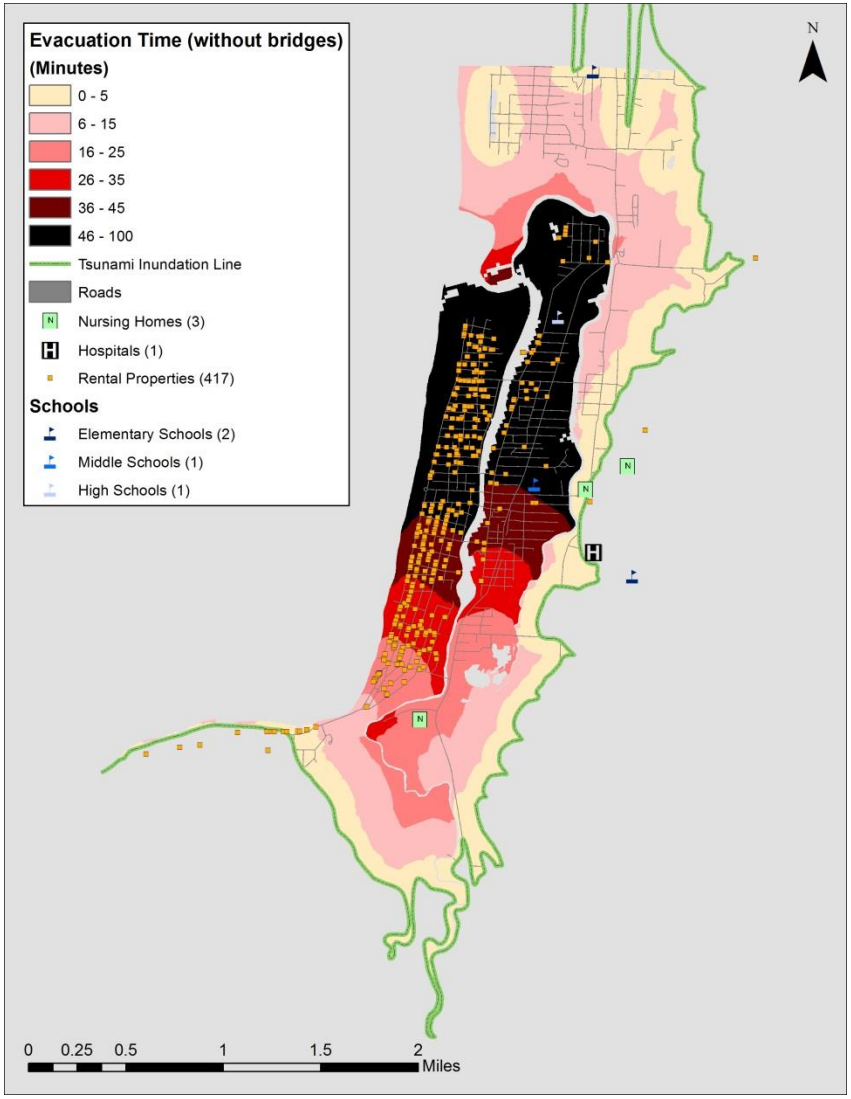
- Longest evacuation time: 97 minutes

INFRASTRUCTURE

HIGH RISK POPULATIONS



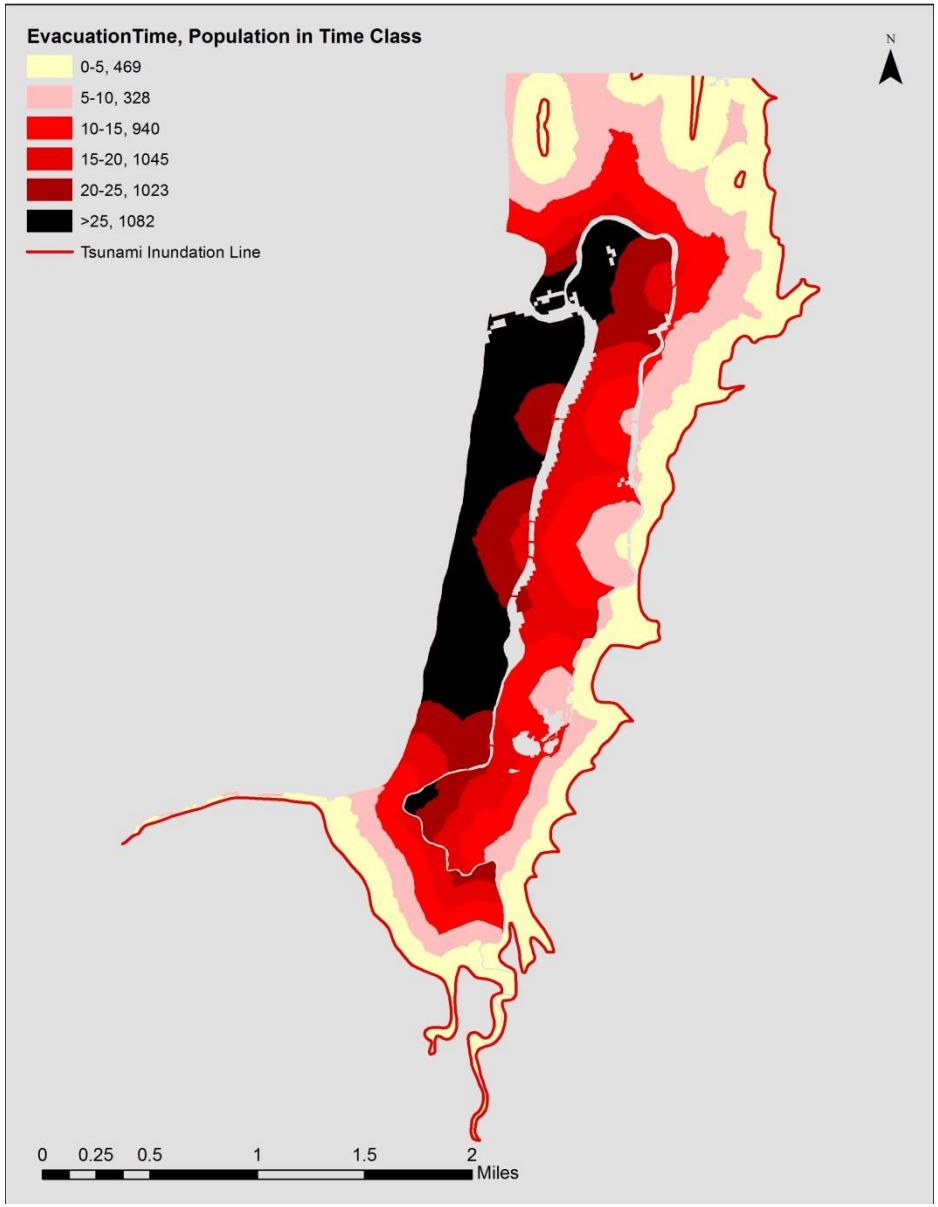
With Bridges



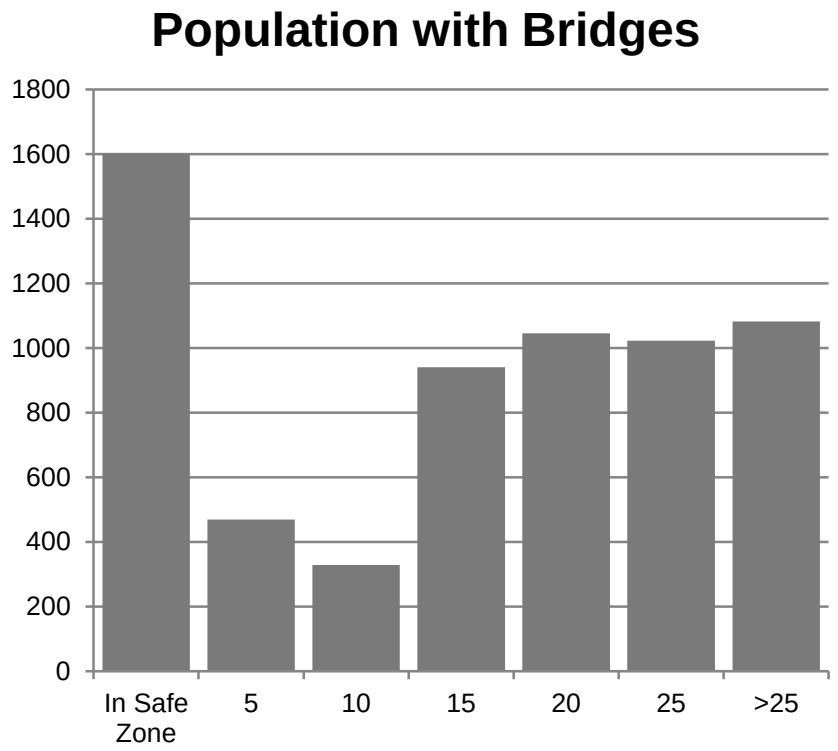
Without Bridges

POPULATION IN PERIL:

EVACUATION WITH BRIDGES INTACT

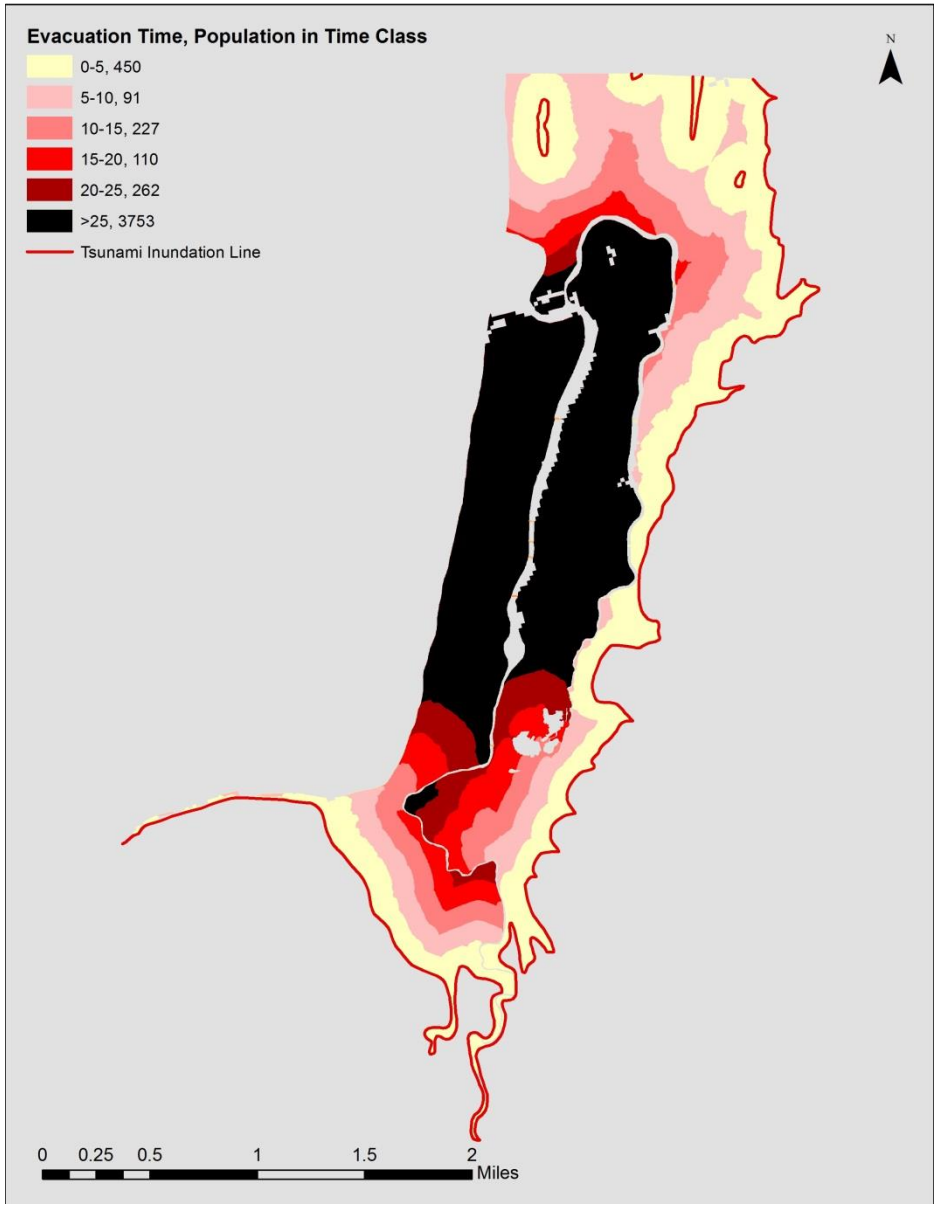


Evacuation Time	Population with Bridges	Percent	
In Safe Zone	1601	24.68	
5	469	7.23	
10	328	5.06	
15	940	14.49	
20	1045	16.11	
25	1023	15.77	
>25	1082	16.68	
	6488	100.00	Total

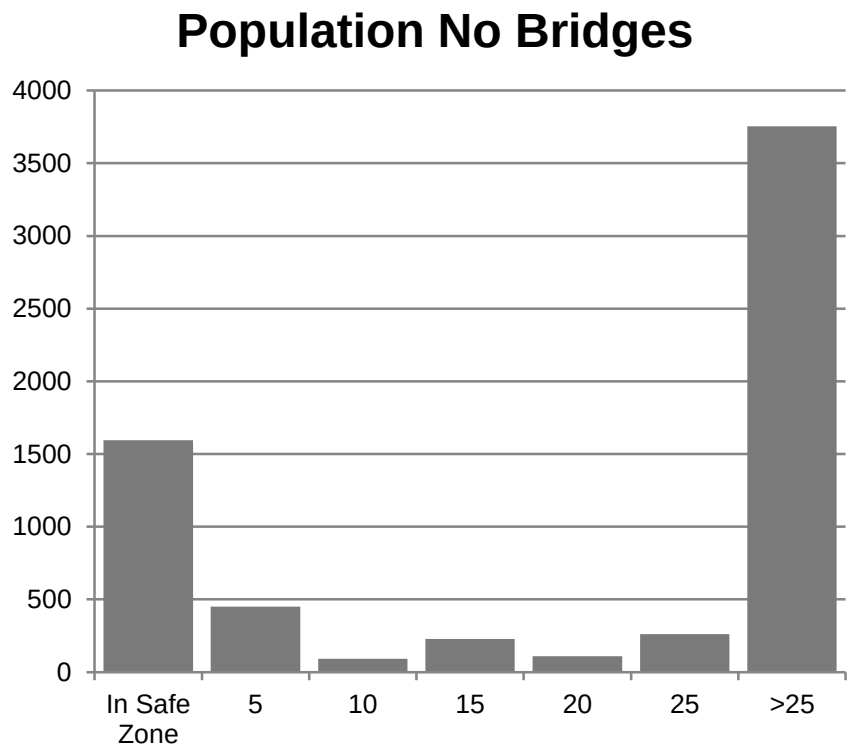


POPULATION IN PERIL:

EVACUATION WITHOUT BRIDGES INTACT



Evacuation Time	Population No Bridges	Percent	
In Safe Zone	1595	24.58	
5	450	6.94	
10	91	1.40	
15	227	3.50	
20	110	1.70	
25	262	4.04	
>25	3753	57.85	
	6488	100.00	Total



CONCLUSIONS & LOOKING TO THE FUTURE

- **Expand analysis to other coastal communities along the Pacific Ocean, especially those with extensive low lying areas.**

- **Consider alternative evacuation means for people living and working in the northern park of the City where evacuation times exceed 25 minutes, especially for venerable populations (young, elderly, and ill).**
  - Consider vertical evacuation structures.

- **Evaluate structural integrity of bridges and other navigational routes, *as well as* buildings and objects that may impede traffic if they were to collapse following an earthquake.**

- **Begin developing City specific resiliency plans (see the *Oregon Resilience Plan*, 2013) for disaster planning, preparedness, and post disaster operations.**