



The Oregon Department of Geology and Mineral Industries (DOGAMI) has been identifying and mapping the tsunami inundation hazard along the Oregon coast since 1994. In Oregon, DOGAMI manages the National Tsunami Hazard Mitigation Program, which has been administered by the National Oceanic and Atmospheric Administration (NOAA) since 1995. DOGAMI's work is designed to help cities, counties, and other sites in coastal areas reduce the potential for disastrous tsunami-related consequences by understanding and mitigating this geologic hazard. Using federal funding awarded by NOAA, DOGAMI has developed a new generation of tsunami inundation maps to help residents and visitors along the entire Oregon coast prepare for the next Cascadia Subduction Zone (CSZ) earthquake and tsunami.

CSZ Frequency: Comprehensive research of the offshore geologic record indicates that at least 19 major ruptures of the full length of the CSZ have occurred off the Oregon coast over the past 10,000 years (Figure 3). All 19 of these large rupture CSZ events were likely magnitude 8.9 to 9.2 earthquakes (Witter and others, 2011). The most recent CSZ event happened approximately 300 years ago on January 26, 1700. Sand deposits carried offshore and left by the 1700 event have been found 12 miles inland; other tsunami sand deposits have also been discovered in estuaries 6 miles inland. As shown in Figure 3, the range in time between these 19 events varies from 110 to 1,150 years, with a median time interval of 490 years. In 2008 the United States Geological Survey (USGS) released the results of a study announcing that the probability of a magnitude 8-9 CSZ earthquake occurring over the next 30 years is 10% and that such earthquakes occur about every 500 years (WGCEP, 2008).

Cascadia Subduction Zone Setting

The diagram illustrates the tectonic setting of the Cascadia Subduction Zone. The Pacific Plate is shown subducting beneath the North American Plate. The Juan de Fuca Plate is also shown subducting beneath the Pacific Plate. The Cascadia Subduction Zone is marked by a dashed line. The Juan de Fuca Ridge is marked by a solid line. The diagram also shows the location of the subduction zone relative to the Pacific Northwest, including the cities of Seattle and Vancouver, and the state of Washington. The diagram is labeled with 'Magma' at the subduction zone and 'Lithostatic Zone' at the ridge.

A

B

C

D

E

Figure 2: The North American Plate rides over the descending Juan de Fuca Plate at a rate of approximately 1.5 inches per year.

Because the two plates are stuck in place at the "locked zone," strain builds up over time and the North American Plate bulges up.

Eventually the locked zone ruptures and causes a great earthquake. The sudden slip of the two plates displaces Pacific Ocean water upwards and creates a tsunami.

Displaced and uplifted Pacific Ocean water rushes in all directions.

Along the Oregon coast, tsunami waves run up onto the land for several hours.

Figure 3: This chart depicts the timing, frequency, and magnitude of the last 19 large Cascadia Subduction Zone events over the past 1,000 years. The most recent event occurred on January 26, 1700. The 1700 event is considered to be a "megatrust" sized event. The data used to create this chart came from research that examined the many submarine landslides, known as "turbidites," that are triggered only by these great earthquakes (Witter and others, 2011). The color correction is the bigger the turbidite, the bigger the earthquake.

Total Buildings	Entire Map		Unincorporated
	Area	Newport	Areas
Buildings within Tsunami Zones*	5,098	4,801	197
Small	173	162	11
Medium	200	278	12
Large	376	361	15
Extra Large	698	672	26
Extra Extra Large	786	760	26
Percent of Buildings within Tsunami Zones			
Small	3.4%	3.3%	5.6%
Medium	5.7%	5.7%	6.1%
Large	7.4%	7.4%	7.6%
Extra Large	13.7%	13.7%	13.2%
Extra Extra Large	15.4%	15.5%	13.2%

*Building counts shown are based on polygon centroids and are cumulative within the map area.

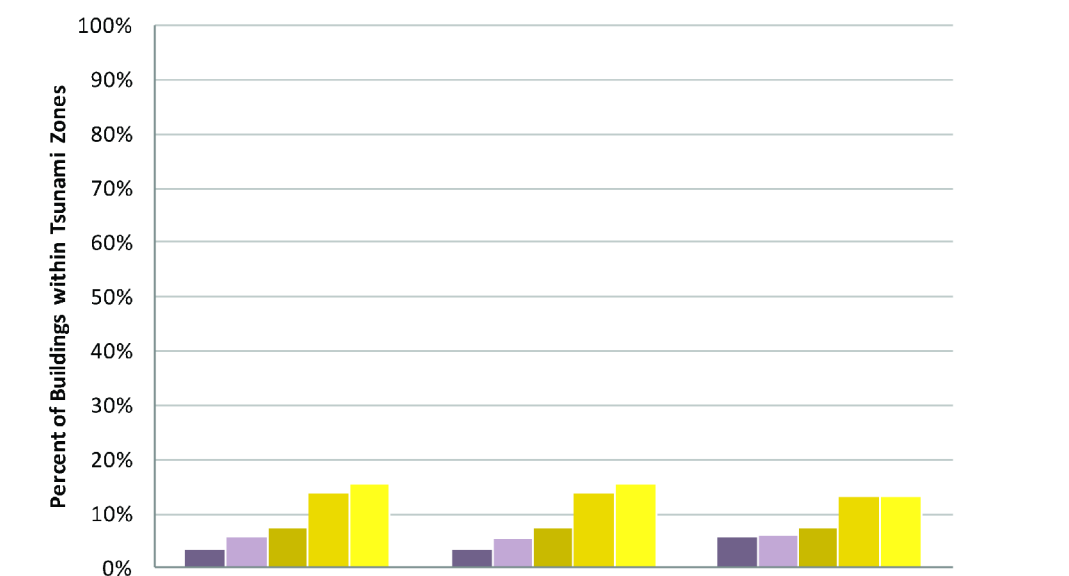


Figure 4: The table and chart show the number of buildings inundated for each "tsunami T-shirt scenario" for cities and unincorporated portions of the map.

Change in water level for five tsunami scenarios at the simulated gauge station shown on the map

Legend: JOL (Yellow), AL (Orange), I (Green), M (Purple), S (Dark Purple)

Station B127 Nye Beach (Station B127)

Y-axis: Elevation, feet (NAD83)

X-axis: Time since Earthquake (hours)

Figure 5. This chart depicts the tsunami waves as they arrive at the selected reference point (simulated gauge station). It shows the change in wave height as the tsunami somas rolls over an 8-hour period. The starting water elevation (0.00 hour) takes into account the local land subsidence or uplift caused by the earthquake. Wave heights vary through time, and the first wave will not necessarily be the largest as waves interfere and reflect off local topography. Symmetry. Any absence of data indicates periods for which tsunami inundation has not yet reached or has receded from the station location and dry land is exposed.

[illegible]

Figure 6: These profiles depict the expected maximum tsunami wave elevation for the five "tsunami T-shirt scenarios" along lines A-A' and B-B'. The tsunami scenarios are modeled to occur at high tide and to account for local subsidence or uplift of the ground surface.

Map Explanation

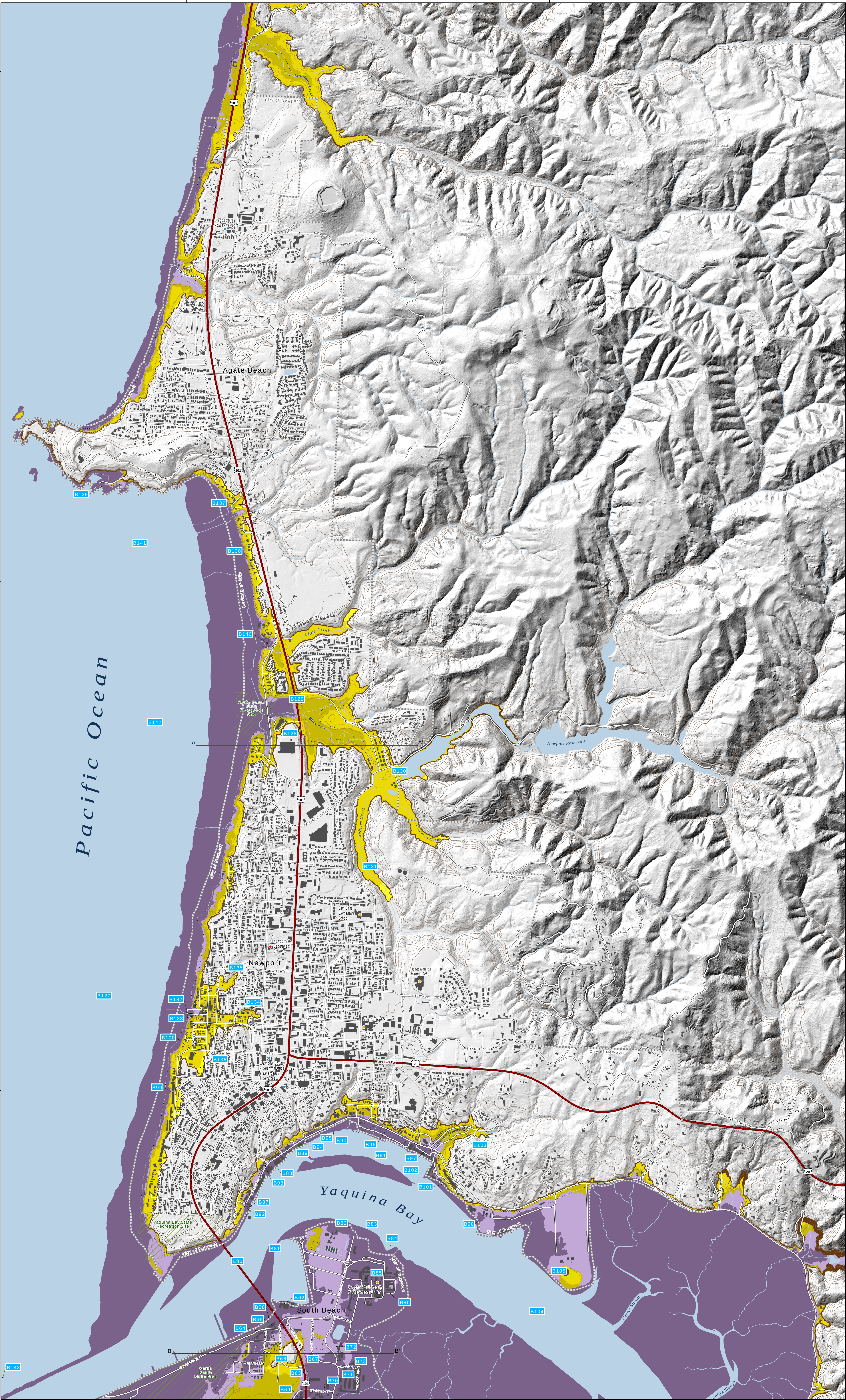
This tsunami inundation map displays the output of computer models representing five selected tsunami scenarios, all of which include the earthquake-produced subsidence and the tsunami-amplifying effects of the splay fault. Each scenario assumes that a tsunami occurred at Maunaloa. Higher High Water (MHHW) tide; MHHW is defined as the average height of the highest high tides observed over an 18-year period at the Yaquina Bay (Central Coast Model) tide gauge. To make it easier to understand this scientific material and to enhance the educational aspects of hazard mitigation and response, the five scenarios are labeled as T-shirt sizes¹ ranging from Small, Medium, Large, Extra Large to Extra Extra Large (S, M, L, XL, XXL). The map legend depicts the respective amounts of slip, the frequency of occurrence, and the earthquake magnitude for these five scenarios. Figure 4 shows the cumulative number of buildings inundated within the map area.

The computer simulation model output is provided to DOGAMI as millions of points with values that indicate whether the location of each point is wet or dry. These points are converted to wet and dry contour lines that form the extent of inundation. The transition area between the wet and dry contour lines is termed the Wet/Dry Zone, which equates to the amount of error in the model when determining the maximum inundation for each scenario. Only the XXL Wet/Dry Zone is shown on this map.

This map also shows the regulatory tsunami inundation line (Oregon Revised Statutes 455.446 and 455.447), commonly known as the Senate Bill 379 line. Senate Bill 379 (1995) instructed DOGAMI to establish the area of expected tsunami inundation based on scientific evidence and tsunami modeling in order to prohibit the construction of new essential and special occupancy structures in this tsunami inundation zone (Priest, 1995).

Time Series Graphs and Wave Elevation Profiles: In addition to the tsunami scenarios, the computer model produces time series data for "gauge" locations in the area. These points are simulated gauge stations that record the time, in seconds, of the tsunami wave arrival and the wave height observed. It is especially noteworthy that the greatest wave height and velocity observed are not necessarily associated with the first tsunami wave to arrive onshore. Therefore evacuees should not assume that the tsunami event is over until the proper authorities have sounded the all-clear signal at the end of the evacuation. Figure 5 depicts the tsunami waves as they arrive at a simulated gauge station. Figure 6 depicts the overall wave height and inundation extent for all five scenarios at the profile locations shown on this map.

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Earthquake Size	Average Slip Range (ft)	Maximum Slip Range (ft)	Time to Accumulate Slip (yrs)	Earthquake Magnitude
XXL	59 to 72	118 to 144	1,200	-9.1
XL	56 to 72	115 to 144	1,050 to 1,200	-9.1
L	36 to 49	72 to 98	650 to 800	-9.0
M	23 to 30	46 to 62	425 to 525	-8.9
S	13 to 16	30 to 36	300	-8.7
XXL Wet/Dry Zone				

	Urban Growth Boundary		Fire Station
	Building Footprint		Police Station
	Simulated Gauge Station		School
	Profile Location		Hospital/Urgent Care Clinic
	Senate Bill 379 Line		U.S. Highway
	State Park		State Highway
	Elevation Contour (25 ft intervals up to 200 ft)		Improved Road

[illegible][illegible]

References:
2007 Working Group on California Earthquake Probabilities (WGCEP): The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2). U.S. Geological Survey Open-File Report 2007-1437 and California Geological Survey Special Report 203 [<http://pubs.usgs.gov/of/2007/1437/>].

Priest, G. R., 1995. Exploration of mapping methods and use of the tsunami hazard maps of the Oregon coast. Oregon Department of Geology and Mineral Industries Open-File Report G-95-67, 95 p.

Witter, R.C., Zhang, Y., Wang, K., Priest, G.R., Goldfinger, C., Stirmey, L., Forde, J.T. and Ferro, P.A. 2011. Simulating tsunami inundation at Cannon Beach, Oregon. Oregon Department of Geology and Mineral Industries Special Paper 41, 87 p.

earthquake scenarios: Oregon Department of Geology and Mineral Industries Special Paper 43, 57 p.

Software: Esri ArcGIS® 10.1, Microsoft® Excel®, and Adobe® Illustrator®

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