

STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES  
www.OregonGeology.org  
Larry Givens, Governing Board Chair  
Vicki S. McConnell, Director and State Geologist  
Don W.T. Lewis, Assistant Director  
Rachel R. Lyles Smith, Project Operations Manager  
Ian P. Madin, Chief Scientist

## Introduction

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, as well as for far-travelled or "distant" tsunamis.

The "Ring of Fire", also called the Circum-Pacific belt, is the zone of earthquake activity surrounding the Pacific Ocean. It is an arc stretching from New Zealand, along the eastern edge of Asia, north across the Aleutian Islands of Alaska, and south along the coast of North and South America (Figure 1). The Ring of Fire is located at the borders of the Pacific Plate and other major tectonic plates. The Pacific Plate is colliding with and sliding underneath other plates creating subduction zones that eventually release energy in the form of an earthquake rupture. This rupture causes a vertical displacement of water that creates a tsunami. When these events occur around the Ring of Fire but not directly off the Oregon coast, they take more time to travel the Pacific Ocean and arrive onshore in Oregon (Figure 2). Distant earthquake/tsunami events have affected the Oregon coast; for example, offshore Alaska in 1964 and offshore Japan in March 2011.

Historically, about 28 distant tsunamis have been documented by Oregon tide gauges since 1854. The most severe was generated by the 1964 M9.2 Prince William Sound earthquake in Alaska. Oregon was hit hard by the tsunami, which killed four people and caused an estimated \$700,000 to 1 million dollars in damage to bridges, houses, cars, boats, and sea walls. The greatest tsunami damage in Oregon did not occur along the ocean front as one might expect, but in the estuary channels located further inland. Of the communities affected, Seaside was inundated by a 10 foot tsunami wave and was the hardest hit. Tsunami wave heights reached 10 to 11.5 feet in the Nehalem River, 10 to 11.5 feet at Depoe Bay, 11.5 feet at Newport, 10 to 11 feet at Florence, 11 feet at Redwood, 11 feet at Brookings, and 14 feet at Coos Bay (Witter and others, 2013).

**Alaska-Aleutian Model Specifications:** DOGAMI modeled two distant earthquake and tsunami scenarios involving M9.2 earthquakes originating near the Gulf of Alaska. The first scenario attempts to replicate the 1964 Prince William Sound event, and the second scenario represents a hypothetical maximum event. This maximum event is the same model used by the U.S. Geological Survey (USGS) in their 2006 tsunami hazard assessment of Seaside (1994/2006). This model uses extreme fault model parameters that result in maximum seafloor uplift, nearly twice as large as in the 1964 earthquake. The selected source location on the Aleutian chain of islands also shows higher energy directed toward the Oregon coast than other Alaska source locations. For these reasons the hypothetical Alaska Maximum scenario is selected as the worst case distant tsunami scenario for Oregon. Detailed information on fault geometries, subsidence, computer models, and the methodology used to create the tsunami scenarios presented on this map can be found in DOGAMI Special Paper 43 (Witter and others, 2013).

## Ring of Fire

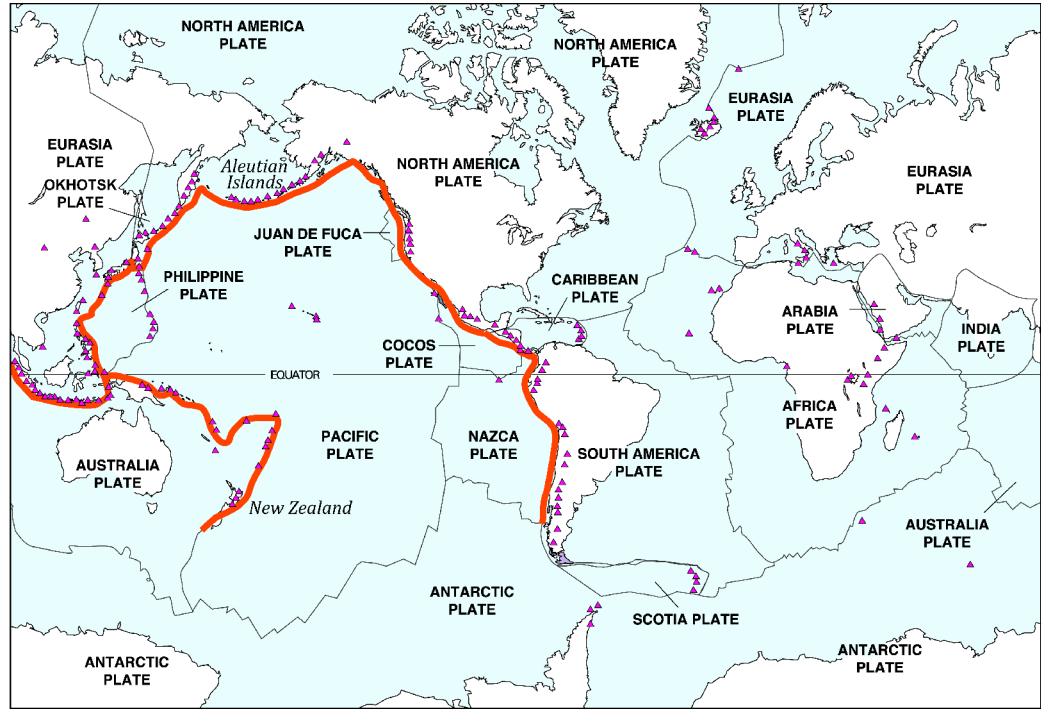


Figure 1: The "Ring of Fire" is a zone of active earthquakes and volcanoes that ring much of the Pacific Ocean, including the Oregon coast. Volcanoes and earthquakes on this ring are caused by the movements of tectonic plates. One type of movement is called subduction -- when thin oceanic plates, such as those that compose the rock beneath the Pacific Ocean, sink beneath thicker, lighter plates that make up continental plates. Earthquakes that occur as a result of subduction can trigger tsunamis.

## Prince William Sound 1964 M9.2 Earthquake and Tsunami Travel Time Map

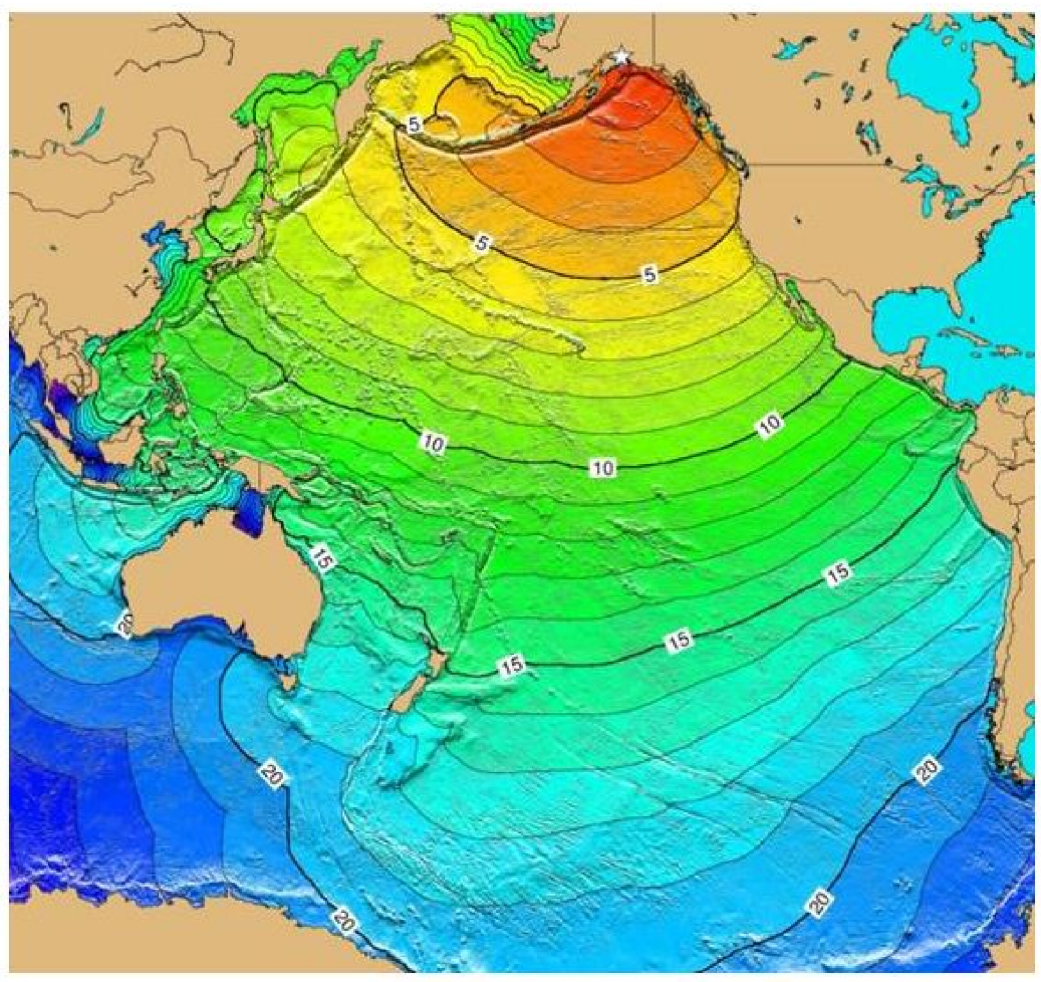


Figure 2: This image depicts the actual initial tsunami arrival times, in hours, around the Pacific Rim from the 1964 Prince William Sound earthquake. This magnitude 9.2 earthquake and resulting tsunami caused 125 deaths and \$51 million in property loss. \$64 million and 106 deaths in Alaska (NCEM/USCG). The tsunami devastated many towns along the Gulf of Alaska, left serious damage in British Columbia, Hawaii, and along the west coast of the United States, and was recorded on tide gauges in Cuba and Puerto Rico.

## Buildings within Tsunami Inundation Zones

|                                                  | Entire Map Area | City of Nehalem | City of Wheeler | Unincorporated Areas |
|--------------------------------------------------|-----------------|-----------------|-----------------|----------------------|
| <b>Total Buildings</b>                           | 967             | 45              | 118             | 804                  |
| <b>Buildings Within Tsunami Zones*</b>           |                 |                 |                 |                      |
| Alaska M9.2 (1964)                               | 1               | 0               | 0               | 1                    |
| Alaska Maximum                                   | 1               | 0               | 0               | 1                    |
| <b>Percent of Buildings Within Tsunami Zones</b> |                 |                 |                 |                      |
| Alaska M9.2 (1964)                               | 0.1%            | 0.0%            | 0.0%            | 0.1%                 |
| Alaska Maximum                                   | 0.1%            | 0.0%            | 0.0%            | 0.1%                 |

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



Figure 3: The table and chart show the number of buildings inundated for the Alaska M9.2 (1964) and the Alaska Maximum tsunami scenarios for cities and unincorporated portions of the map.

## Estimated Tsunami Wave Height through Time for Simulated Gauge Station

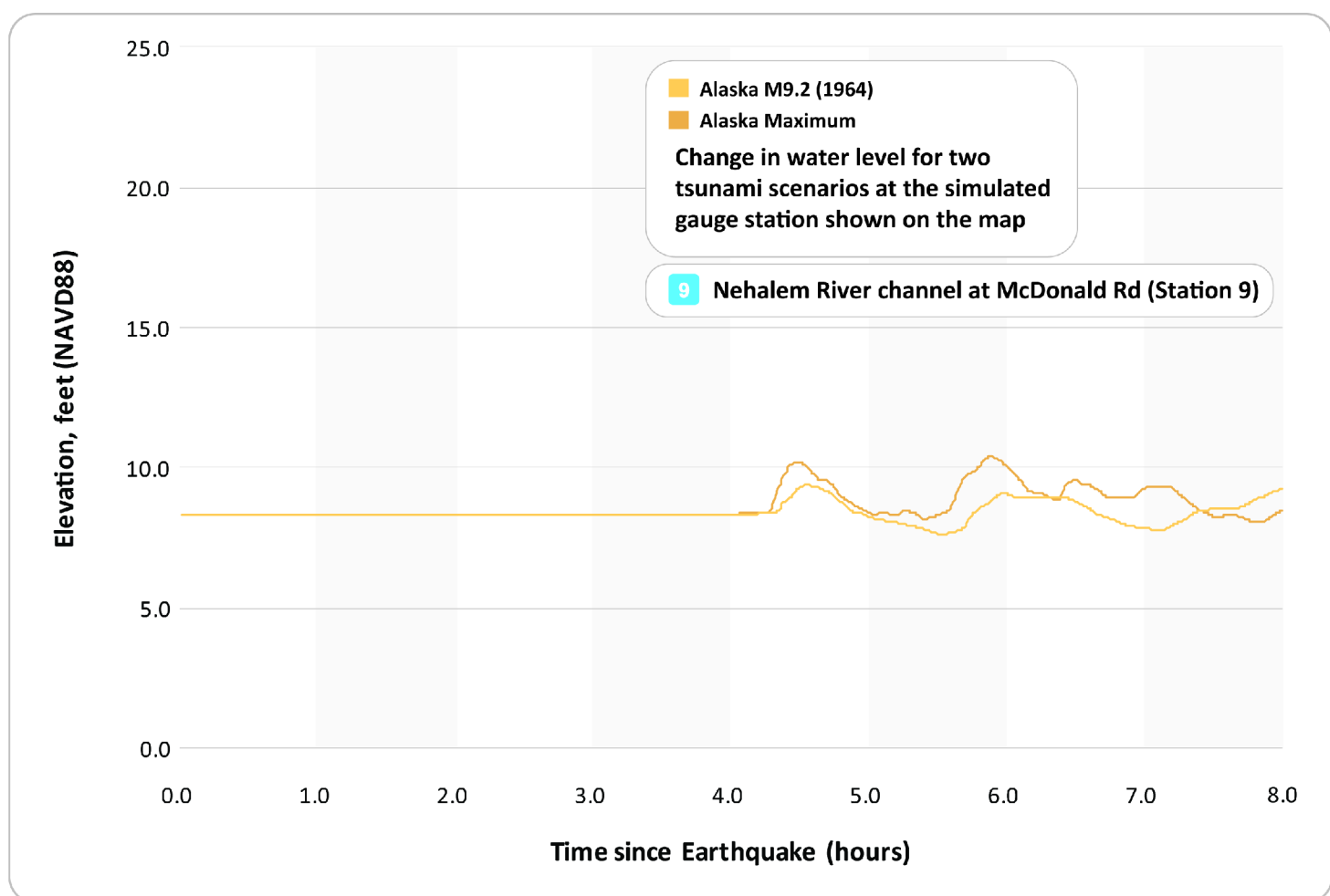


Figure 4: This chart depicts the tsunami waves as they arrive at the selected reference point (simulated gauge station). It shows the change in wave heights for the two Alaska tsunami scenarios over an 8-hour period. Wave heights vary through time, and the first wave will not necessarily be the largest as waves reflect and reflect off local topography and bathymetry. (Chart revised 07/12/2012)

## Maximum Wave Elevation Profile

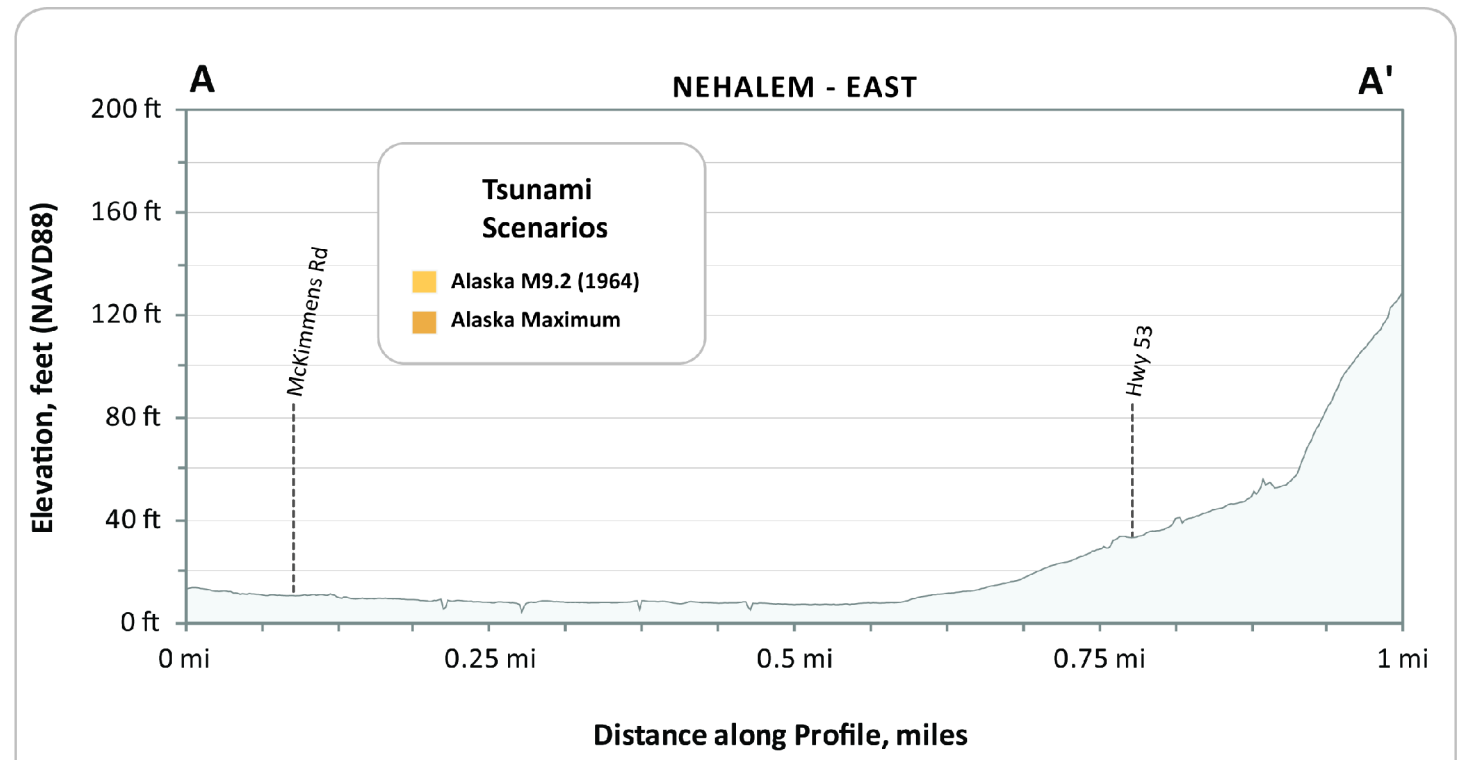
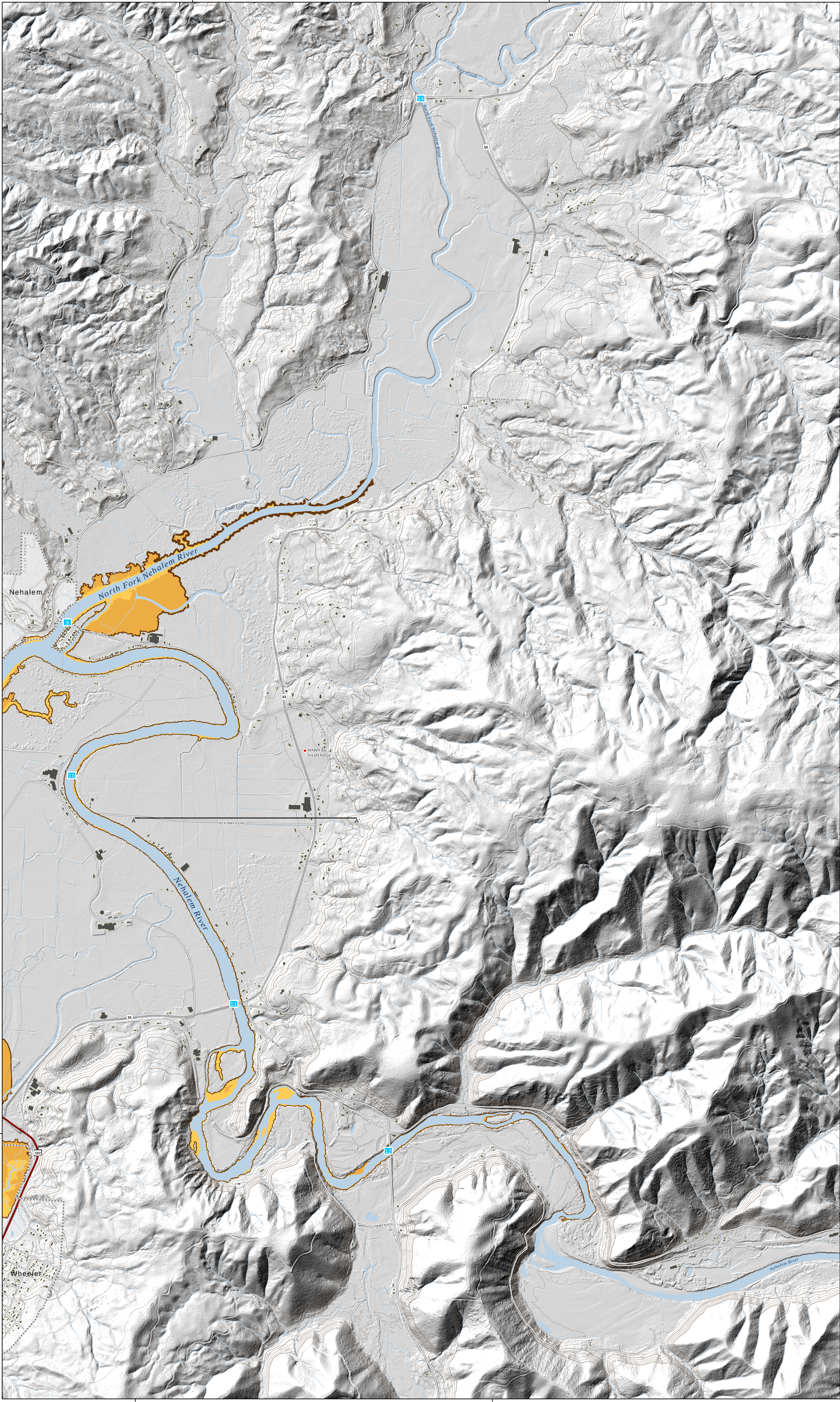


Figure 5: This profile depicts the expected maximum tsunami wave elevation for the two Alaska tsunami scenarios along line A-A'. The tsunami scenarios are modeled as water at static (no flow) tide and equal to the Mean Higher High Water (MHHW) tide.

# Distant Source (Alaska-Aleutian Subduction Zone) Tsunami Inundation Map Nehalem East, Oregon

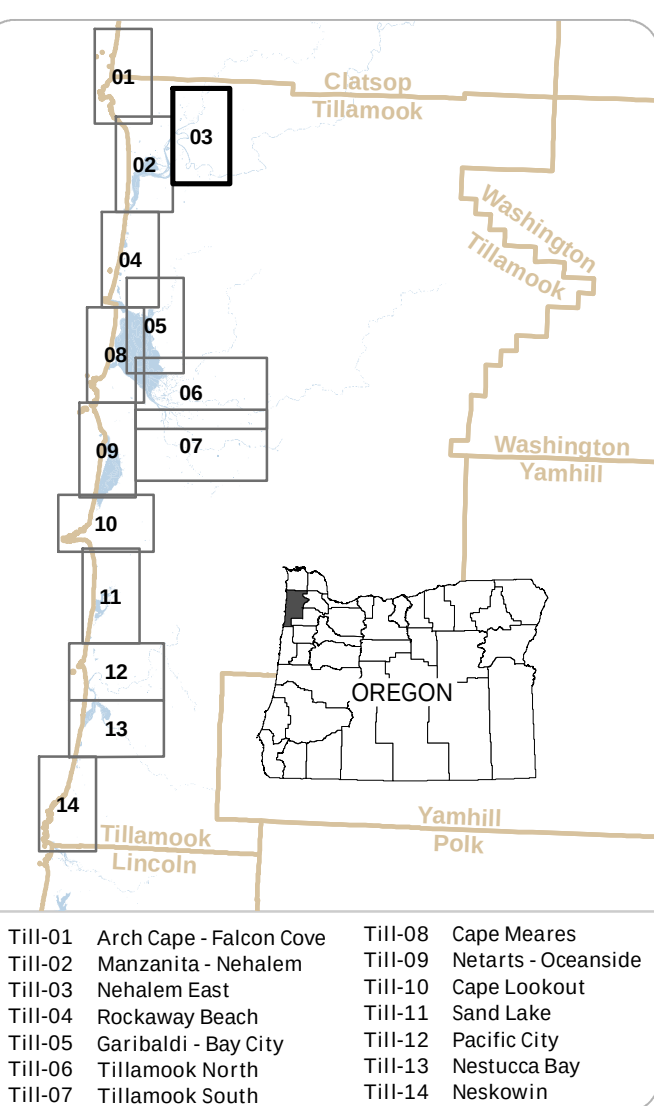
2012



## Legend

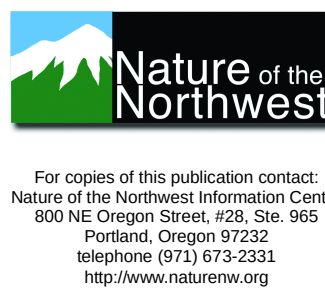
| Earthquake Size                                  | Slip / Deformation                                                                | Earthquake Magnitude |
|--------------------------------------------------|-----------------------------------------------------------------------------------|----------------------|
| Alaska M9.2 (1964)                               | Vertical seafloor deformation estimate                                            | -9.2                 |
| Alaska Maximum                                   | Uniform slip on 12 subfaults with each assigned values ranging from 49 to 98 feet | -9.2                 |
| Alaska Maximum 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                                                                      |                      |
| Elevation Contour (25 ft intervals up to 200 ft) | State Highway                                                                     |                      |
|                                                  | Improved Road                                                                     |                      |

## Tsunami Inundation Map Index



## Data References

**Source data:**  
This map is based on hydrodynamic tsunami modeling by Joseph Zhang, Oregon Health and Science University Portland, Oregon. Model data input were created by John T. English and George R. Priest, Department of Geology and Mineral Industries (DOGAMI), Portland, Oregon.  
  
Hydrology data, contours, critical facilities, and building footprints were created by DOGAMI. Senate Bill 379 line data were reprojected by Rachel R. Lyles Smith and Sean G. Pickner, DOGAMI, in 2011 (GIS file set, in press, 2012).  
  
Urban growth boundaries (2010) were provided by the Oregon Department of Land Conservation and Development (DLCD).  
  
Transportation data (2011) were provided by Tillamook County.  
  
Lidar data are from DOGAMI. Lidar Data Quadrangles LID-2011-45123-67-Nehalem, LID-2011-45123-68-Nehalem, LID-2011-45123-67-Southern, and LID-2011-45123-68-Nehalem.  
  
Coordinate System: Oregon Statewide Lambert Conformal Conic, Unit: International Feet, Horizontal Datum: NAD 1983 HARN, Vertical Datum: NAVD 1983. Graticule shown with geographic coordinates (latitude/longitude).  
  
References:  
National Geophysical Data Center / World Data Center (NGDC/WDC) Global Historic Tsunami Database, Boulder, CO, USA. ([http://www.ngdc.noaa.gov/hazard/tvu\\_db.shtml](http://www.ngdc.noaa.gov/hazard/tvu_db.shtml))  
  
Priest, G. R., 1996. Explanation of mapping methods and use of the tsunami hazard maps of the Oregon coast. Oregon Department of Geology and Mineral Industries Open-File Report O-95-67, 95 p.  
  
Tsunami Pilot Study Working Group (1994), 2006. Seaside, Oregon tsunami pilot study -- reproduction of FEMA flood hazard maps. U.S. Geological Survey Open-File Report 2006-1234, 90 p. + 7 apps. (<http://pubs.usgs.gov/of/2006/1234/>)  
  
Witter, R.C., Zhang, Y., Wang, K., Priest, G.R., Goldfinger, C., Stensley, L.L., English, J.T., and Ferro, P.A., 2011. Simulating tsunami inundation at Seaside, Clatsop County, Oregon, using hypothetical Cascadia and Alaska earthquake scenarios. Oregon Department of Geology and Mineral Industries Special Paper 43, 57 p.  
  
Software: Esri ArcGIS 10.0, Microsoft Excel, and Adobe Illustrator 9.  
  
Funding: This map was funded under award #NA00RW5670014 by the National Oceanic and Atmospheric Administration (NOAA) through the National Tsunami Hazard Mitigation Program.  
  
Map Data Creation/Development:  
Tsunami Inundation Scenario: George R. Priest, Laura L. Stensley, Daniel E. Cox, Paul A. Ferro, Sean G. Pickner, Rachel R. Lyles Smith, Benjamin Davis, Robert L.B. Hughes, Sean G. Pickner.  
  
Map Production:  
Cartography: Katherine L.B. Hughes, Sean G. Pickner, Taylor B. Witter.  
Text: Don W.T. Lewis, Rachel R. Lyles Smith.  
Editing: Don W.T. Lewis, Rachel R. Lyles Smith.  
Publication: Deborah A. Schuetler.  
Map Date: 07/12/2012.



For copies of this publication contact:  
Nature of the Northwest  
300 NE Oregon Street, 4th, Ste. 905  
Portland, Oregon 97232  
Telephone (503) 473-2353  
Web: <http://www.natureofnw.org>

Tsunami Inundation Map Till-03

Tsunami Inundation Maps for Nehalem East,  
Tillamook County, Oregon

Plate 2