**Tillamook County, Oregon**

**Tsunami Risk and Vulnerability Assessment**

*This Tsunami Risk and Vulnerability Assessment is part of a   
Tsunami Evacuation and Facilities Improvement Plan that is being   
developed for communities within Tillamook County, Oregon.*

**1st DRAFT  
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**Reviewed and Approved by:**

**Date:**

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# 1 Introduction

Areas within Tillamook County, Oregon are at risk of experiencing a tsunami generated by multiple sources, a distant seismic event (e.g., large earthquake in Japan) or a Cascadia Subduction Zone (CSZ) earthquake. These areas include: Cape Meares, Oceanside, Netarts, Cape Lookout State Park, Sand Lake, Tierra Del Mar, Pacific City/Woods, and Neskowin.

Tillamook County is characterized by above-average populations of residents over 65 years of age and large tourist and visitor populations – during spring and summer months. This risk and vulnerability assessment is designed to identify gaps in preparedness, mitigation, and response efforts required to ensure residents and visitors have feasible means to evacuate prior to a tsunami inundation.

# 2 The Methodology

## 2.1 Document and Data Review

The majority of the findings in this vulnerability assessment were determined based upon the review of existing documents and data. A thorough review of pertinent documents and data was performed to provide a better understanding of the geographies, locations, and populations of concern. The sources utilized and/or referenced in this task include:

* Tillamook County Natural Hazard Mitigation Plan
* U.S. 2010 Census Data
* 2012-2016 American Community Survey (ACS) Data
* DOGAMI Beat the Wave mapping and data
* National Land Cover Database

## 2.2 Stakeholder Feedback

Prior to the development of this vulnerability assessment, an online survey was developed to gather feedback from residents and business owners within each community. The findings have been incorporated into the assessment to document local perception of risk, determine barriers to evacuation, and recommendations for improvement planning provided by the public.

The survey was completed by 177 individuals with homes and businesses within and outside of the inundation zones. 65% of those surveyed indicated their homes were within the inundation zone, 30% were outside of the inundation zone, and 5% were unsure of their proximity to the inundation zone.

## 2.3 GIS Analysis

Urban areas were identified using National Land Cover Database (NLCD 2011) data classified as either Developed Low Density, Developed Medium Density or Developed High Density. These urban areas were then intersected with the 2010 Census Tract population data to refine population estimates across each census tract. Population estimates assume an even distribution of the tract population across the areas identified as developed. These populated areas were then intersected with the XXL tsunami inundation scenario to see where populated areas might be impacted in the event of the XXL scenario. Population estimates are based on the proportionate quantity of people in the geographic portion of the urban area within the inundation zone.

## 2.4 Methodology Constraints

* The conducted survey was completed by a small fraction of residents and the results may not be representative of the community at-large.
* Because population estimates are based on census data, only resident populations are reflected and not transient populations.

# 3 The Risks

For the purposes of this project, a risk assessment was performed to identify considerations related specifically to individuals’ ability to evacuate. Therefore, findings related to tsunami damage were not taken into account. As an example, a risk assessment within a Hazard Mitigation Plan may consider the hazard location as the area in which tsunami inundation is expected. However, this risk assessment identifies location considerations that may adversely affect one’s ability to safely evacuate (e.g., bridges, roadways running parallel to the coastline, etc.).

*Refer to the Tillamook County Natural Hazards Mitigation Plan for additional risk assessment findings.*

## 3.1 Hazard Description

The hazard being addressed by this assessment is a tsunami event that results in the need for community evacuation. A tsunami affecting areas within Tillamook County would be the result of an earthquake from one of two categories:

* **Local Tsunami:** Generated by an earthquake immediately offshore of the Oregon Coast (e.g., a CSZ earthquake) and would result in a tsunami coming onshore within 20 to 40 minutes following the earthquake, based on specific locations. *Refer to Wave Arrival Time Maps in Appendix B for additional information.*
* **Distant Tsunami:** Generated by a distant earthquake (e.g., large event occurring off a distant coastline such as Japan) and would result in a tsunami coming onshore 4 hours or more following an earthquake.

## 3.2 Cascading Hazards

A local earthquake resulting in a tsunami is likely to generate additional hazards that may further hinder an individual’s ability to evacuate and may increase the time needed to evacuate. Such examples include:

* **Damage to buildings:** Severe shaking, especially in areas of unconsolidated soils, will damage buildings, making it difficult to evacuate. Homes built before 1974 may not be tied to foundations and can shift off foundations. Unreinforced masonry buildings and under-reinforced concrete buildings will be severely damaged or collapsed. Furnishings and equipment not securely fastened can cause injuries. In addition, manufactured homes may slide off their foundation following an earthquake. This will cause obvious damage to the structure but may also pose egress concerns if the structure falls into a street.
* **Damage to infrastructure:** Severe shaking and areas of poor soils will result in infrastructure failures. Infrastructure systems that may cause barriers to evacuation are water, wastewater, and stormwater facilities; liquid fuel and natural gas tanks and lines; electrical systems; bridges; and embankments and roads. Shaking damage may result in fallen electrical lines, damaged gas lines, tank and pipeline failures and leaks, and bridge failures, as well as physical interruptions in the surface transportation system due to slope failures and ground failures.
* **Landslides:** Landslides and ground movement may present added barriers to evacuation resulting in blocked roads, bridges, and walking trails.
* **Fires:** Fires from damaged electrical lines or propane may result in injuries that hinder an individual’s ability to evacuate.
* **Liquefaction:** Similar to landslides, liquefied soils may result in damaged and unstable roads, bridges, and walking trails that present added barriers to an individual’s ability to evacuate, especially those who experience access and functional needs.
* **Vehicular accidents and traffic jams:** Individuals may attempt to evacuate in personal vehicles en masse and push their vehicles to cover unusual terrain either due to damaged infrastructure or in an attempt to bypass typical infrastructure to save time. This may result in accidents and traffic jams that prevent individuals from reaching higher ground. Vehicular evacuation is not recommended and likely will not be possible following a local earthquake and tsunami event.

## 3.3 Geography

Low-lying areas are inherently at a greater risk of experiencing tsunami inundation and a hindered ability for individuals to evacuate prior to a tsunami arrival. The following characteristics of Tillamook County’s geography increase the risk of evacuation-related concerns.

DOGAMI Beat the Wave maps indicate the following locations and the surrounding area may be required to be evacuated following a CSZ event:

* **Cape Meares** – The vast majority of the Cape Meares community is within the XXL BTW model. This also includes Bayocean Dike, with the exception of high ground in the central area of the spit.
* **Oceanside and Netarts** – Large swaths of Oceanside and Netarts are within the inundation zone, but high ground is easily accessible throughout the communities.
* **Cape Lookout State Park** – The entirety of Cape Lookout State Park is within the inundation zone, with high ground present along Netarts Bay Road.
* **Sand Lake** – The Sand Lake vicinity is largely within the inundation zone including large swaths of Sand Lake Recreation Area. Sandbeach Campground, and Whalen Island.
* **Tierra Del Mar** – The Tierra Del Mar community is entirely within the inundation zone east of Sandlake Road, with ample high ground to the eastern extent of east-west oriented streets.
* **Pacific City/Woods** – Large swaths of Pacific City/Woods are within the inundation zone with pockets of high ground located at Cape Kiwanda State Park, Hill Road, areas north of Sand Creek, and areas east of Brooten Road south of the bridge near Fisher Road.
* **Neskowin –** The Neskowin community is entirely within the inundation zone west of Highway 101.

*Refer to Appendix C for Beat the Wave maps.*

* **Buildings:** The XXL model indicates that 5,167 buildings are exposed. Totals within the following communities represented the largest exposure risk:
  + **Oceanside and Netarts** – 326 buildings (18% of total stock) are within the tsunami inundation zone.
  + **Pacific City/Woods** – 1,355 (74% of total stock) buildings are within the tsunami inundation zone.
  + **Neskowin** - 508 buildings (77% of total stock) are within the tsunami inundation zone.
* **Bridges:** A CSZ earthquake may lead to damaged or collapsed bridges, leading to the creation of transportation “islands”.
  + **Oceanside and Netarts** – bridges out at Rice Creek, Whiskey Creek, and foot bridges within the RV park pose little added difficulty in finding high ground.
  + **Cape Lookout State Park** – bridges out at the logging road at park entrance, Cape Lookout trail, and the campground shortcut pose significant added difficulty in reaching high ground.
  + **Neskowin** – the geographic complexity of Neskowin presents evacuation difficulty from a number of bridges and it is anticipated that Neskowin may anticipate four separate “island” regions following a CSZ earthquake: South Beach, the Village, North Neskowin, and Winema. Key bridges of concern include: Neskowin Creek on South Beach Road, Kiwanda Creek at Salem Avenue, Hawk Street, and the Tsunami Trail.
* **Hilly terrain:** Numerous locations throughout the project area are characterized by hilly terrain that may present challenges for those who experience access and functional needs during an evacuation situation.

*Walking Pace:*

*1.4 to 2.7   
miles per hour*

* + **Cape Meares –** Hilly terrain is of minimal concern in the Cape Meares vicinity, as the topography is charaterized by only slight climbs out of the inundation zone. An exception may be noted north of Bayocean Dike, but this terrain may actually be adventageous to seeking high ground.
  + **Oceanside and Netarts –** While Oceanside and Netarts are characterized by steep slopes, the terrain does not pose additional risk to reaching high ground, as ample high ground can be reached via existing road networks.
  + **Cape Lookout State Park –** Hilly terrain is a prominent feature of the land east of Netarts Bay Road/Whiskey Creek Road. High ground exists to the southeast of the park, but the terrain may lead to confusion that evacuees must climb the vegetative hillside.
  + **Sand Lake –** Sand Lake is largely characterized by its lowland features, but high ground along Galloway Road may be difficult to reach as the vegetative hillside contains numerous steep slopes.
  + **Tierra Del Mar –** Hilly terrain is of minimal concern in the Tierra Del Mar vicinity, as high ground is accessible on numerous paved roads.
  + **Pacific City/Woods –** While high ground is relatively ample throughout Pacific City/Woods, numerous areas do contain hilly terrain that may make evacuation more difficult. These locations include Cape Kiwanda State Natural Area, Sandlake Road near Sand Creek, and access roads to high ground along Hill Road.
  + **Neskowin –** Hilly terrain is a prominent feature of the land east of Highway 101 and may present difficulty in identifying adequate high ground for communities surrounding Neskowin. In addition, preferred evacuation routes in the community surrounding South Beach Road require navigating steep roads along Nescove Drive.

## 3.4 Critical/Essential Facilities

The following critical/essential facilities are within the XXL model:

* Public facilities and infrastructure
  + General facilities
    - Rockaway Beach City Hall and Public Works
  + Law Enforcement
    - Coast Guard Station – Tillamook
    - Rockaway Beach Police Department
  + Fire Services
    - Nestucca RFPD Neskowin #84
    - Nestucca RFPD Pacific City Station #82
    - Nehalem Volunteer Fire Department/City Hall
  + Water treatment
    - Bay City Water Treatment
    - Rockaway Beach Water Treatment Plant
  + Major transportation facilities
    - Bay City Public Works

Because population estimates are based on census data, only resident populations are reflected and not transient populations (e.g., snow birds, recreational vehicle [RV] parks).

# 4 The People

Tsunami evacuation is of greatest concern to populations residing or working within the inundation zone. The following table illustrates the estimated populations within the inundation zone.

| **Community** | **Total Population** | **Population  within XXL** | **Population over 65** |
| --- | --- | --- | --- |
| Bay City | 1,590 | 291 | 64 |
| Bayside Gardens | 739 | 404 | 110 |
| Cape Meares\* | 115 | 81 | 36 |
| Garibaldi | 833 | 317 | 80 |
| Idaville | 296 | 116 | 41 |
| Manzanita | 263 | 375 | 150 |
| Neahkahnie | 72 | 53 | 25 |
| Nehalem | 463 | 65 | 8 |
| Neskowin\* | 193 | 120 | 49 |
| Netarts\* | 881 | 193 | 64 |
| Oceanside\* | 330 | 15 | 7 |
| Pacific City\* | 964 | 656 | 195 |
| Rockaway Beach | 1,303 | 1,220 | 378 |
| Tillamook | 5,078 | 976 | 163 |
| Tillamook County | 343 | 2,112 | 567 |
| Wheeler | 1,590 | 58 | 12 |
| \*Communities included in this TEFIP. | | | |

## 4.1 Access and Functional Needs Populations

Access and functional needs populations (also referred to as vulnerable populations and special needs populations) are members of the community who experience physical, mental, or medical care needs and who may require assistance before, during, and after an emergency incident after exhausting their usual resources and support network. In the case of evacuations, examples of individuals who have access and functional needs that may make evacuation challenging include, but are not limited to:

* Individuals who experience mobility challenges (e.g., those with physical disabilities, the elderly, children)
* Individuals who are blind or have low vision
* Individuals with limited-English proficiency
* Individuals who are deaf or hard of hearing

Tsunami evacuation requires the ability to move from the inundation zone to high ground (or safety) in a timely matter. Due to this short onset time, individuals who experience access and functional needs may lack the resources to travel such distances. Due to recent best practices in zoning regulations, the vast majority of access and functional needs facilities are located outside of the inundation zone. Nonetheless, the location of these facilities can only serve as a proxy for the presence of access and functional needs populations. It is highly probable that access and functional needs populations live and work within the inundation zone.

### 4.1.1 Mobility Challenges

Within mobility disabilities, there are several subcategories that should be taken into account when planning for tsunami evacuations including:

* **Wheelchair Users:** challenges include needing adequate spaces to maneuver wheelchair, steep paths, rough or uneven surfaces, and negotiating steps.

*According to the 2010 U.S. Census, 14.6% of Tillamook County residents under 65 years of age have a disability.*

* **Ambulatory Mobility Disabilities:** this includes people who can walk, but with difficulty as well as individuals who lack coordination, or use additional support such as crutches, canes, walkers, braces, etc. These individuals may experience difficulty climbing steps, walking, or standing for long periods of time. Elderly populations are of significant concern and according to the 2010 U.S. Census, 25.1% of Tillamook County residents are over 65 years of age. This is significantly higher than the 17.1% of Oregon residents over 65 years of age.
* **Respiratory Issues:** challenges include dizziness, nausea, breathing difficulties, and concentration issues. These individuals may require rest breaks during evacuation.
* **Young Children:** challenges may include difficulty walking far distances and inability to evacuate without adult support. According to the 2010 U.S. Census, 5.1% of Tillamook County residents are under 5 years of age. This is slightly lower than the 5.7% of Oregon residents under 5 years of age.

### 4.1.2 Vision Impairment

Individuals who experience partial or total vision loss, including night vision challenges, rely on their sense of touch and hearing to perceive their environment. After a CSZ event, when physical obstructions such as debris, road or sidewalk damage, and liquefaction changes the lay of the land, those who experience vision impairment may find it difficult to navigate to a location outside the tsunami zone without assistance.

### 4.1.3 Limited-English Proficiency

Key to an individual’s ability to evacuate is access to information. Individuals with limited English proficiency may require additional guidance in their native language. Approximately 7.5% of Tillamook County households speak a language other than English in their homes, indicating a relatively small vulnerable population.

### 4.1.4 Deaf or Hard of Hearing

Individuals who are deaf or hard of hearing may not respond to verbal direction or hear warning sirens. Though the numbers of those who are deaf or hard of hearing in Tillamook County are not available, according to the National Institute of Deafness and Other Communication Disorders (NIDCD), 14% of adults aged 20 to 69 have hearing loss (2011-2012)[[1]](#footnote-1)

## 4.2 Using Key Locations as a Proxy

Specific information about where or how many access and functional needs individuals would need assistance in an evacuation is not available, however, by identifying key locations that can be used as a proxy for access and functional needs populations, we can extrapolate where those individuals may be in a CSZ event.

### 4.2.1 Schools, Youth Organizations, and Childcare Facilities

Schools, youth organizations, and childcare facilities are used as a proxy for the location of children. No locations are within the XXL model.

### 4.2.2 Hospitals and Medical Centers

Hospitals and medical centers are used as a proxy for the location of medically-fragile individuals. No locations are within the XXL model.

### 4.2.3 Senior Facilities

Senior Centers and Assisted Living Centers are used as a proxy for the location of the elderly. No locations are within the XXL model.

### 4.2.4 Impoverished/Homeless Facilities

Outreach services are used as a proxy for the location of individuals who experience poverty or homelessness. No locations are within the XXL model.

### 4.2.5 Hotels and Rental Homes

Out of area visitors and tourists represent a potentially highly vulnerable population that may lack an awareness of the risk of tsunamis and access to evacuation information. Vacation rental data is not entirely accessible due to the wide variety of options on the market (e.g., Airbnb, VRBO), but it is estimated that 7-12% of residential buildings in Tillamook County’s coastal communities are vacation rentals. However, it has been determined that the following high-density visitor locations (e.g., hotels) are located within the inundation zone.

| **Location Name** | **Address** | **Estimated Number**  **of Units** |
| --- | --- | --- |
| Anchorage Motel | 6585 Pacific Ave, Pacific City, OR 97135 | 10 |
| Surf and Sand Inn | 35215 Brooten Rd, Pacific City, OR 97135 | 239 |
| Pacific City Inn | 35280 Brooten Rd, Pacific City, OR 97135 | 16 |
| Headlands Coastal Lodge and Spa | 33000 Cape Kiwanda Dr, Pacific City, OR 97135 | 35 |
| Inn at Cape Kiwanda | 33105 Cape Kiwanda Dr, Pacific City, OR 97135 | Unknown |
| Cape Kiwanda RV Park | 33305 Cape Kiwanda Dr, Pacific City, OR 97135 | 152 |
| Cape Lookout State Park Campground | 13000 Whiskey Creek Rd, Tillamook, OR 97141 | 229 |
| Sandbeach | Galloway Road, Cloverdale, OR 97112 | 81 |
| East Dunes Campground | Galloway Road, Cloverdale, OR 97112 | 61 |
| Whalen Island County Park | Whalen Island Rd, Cloverdale, OR 97112 | 33 |
| Netarts Surf Inn | 4951 Netarts Hwy W, Tillamook, OR 97141 | 8 |
| Terimore Motel Lodging By the Sea | 5105 Crab Ave W, Tillamook, OR 97141 | 28 |
| Proposal Rock Inn | 48988 Hwy. U.S. 101 S, Neskowin, OR 97149 | 59 |
| Barview Jetty Park | 8000 Cedar Ave, Rockaway Beach, OR 97136 | 606 |
| Shorewood RV Park | 17600 Ocean Blvd, Rockaway Beach, OR 97136 | 126 |
| Twin Rocks Motel | 7925 S Minnehaha St, Rockaway Beach, OR 97136 | 5 |
| Camp Magruder – United Methodists | 17450 Old Pacific Hwy, Rockaway Beach, OR 97136 | 275 |

*Source: American Hotel and Lodging Association.* [*https://www.ahla.com/sites/default/files/Lodging\_Industry\_Trends\_2015.pdf*](https://www.ahla.com/sites/default/files/Lodging_Industry_Trends_2015.pdf) *Estimated number of people based on lodging trends from 2014 in which 0.96 individuals occupied each available guestroom at surveyed properties.*

In addition, the County has identified short-term rental locations throughout the area. *Refer to Appendix D for mapped locations of known short-term rentals.*

# 5 The Communication

Individuals rely upon timely information to respond to the impacts of impending hazards. This information is ideally provided pre-incident (e.g., evacuation mapping, personal preparedness materials), but also must include post-incident guidance (e.g., tsunami sirens, road signage, media reports). The following table identifies potential sources of public information in the Tillamook area.

| **Source** | **Service Provider** | **Setting** |
| --- | --- | --- |
| Radio | * KCST (106.9 FM) – Coast Radio * KTCB (89.5 FM) – Coast Community Radio * K282BV (104.3 FM) – Coast Community Radio | ✓ Pre-Incident  ✓ Post-Incident |
| Television | * Standard television stations (PBS, ABC, CBS, NBC, FOX) | ✓ Pre-Incident  ✓ Post-Incident |
| Newspaper | * Tillamook Headlight Herald (weekly) | ✓ Pre-Incident |
| Websites and Social Media | * Tillamook County Website and Social Media * Tillamook County Pioneer (daily news) | ✓ Pre-Incident  ✓ Post-Incident |
| Community Boards | * Post Office * Public Library * Events Center * Justice Center * City Hall | ✓ Pre-Incident  ✓ Post-Incident |

### 5.1 News

Within the conducted survey, respondents were asked to identify sources used to access news on a daily basis. Over 55% of respondents indicated the relied upon television, 30% on Facebook, 38% on radio, and 27% on newspapers. All three sources may be used for pre-incident information sharing, while Facebook and radio may be the best sources for post-incident guidance. In a CSZ event, widespread electrical interruptions are expected which will limit the ability to communicate and spread news in a timely fashion.

### 5.2 Evacuation Signage

Effective signage is critical to saving the lives of visitors and tourists, but it is equally important for the awareness of residents in a crisis. *See the TEFIP for a list of existing signage.*

Within the conducted survey, respondents were asked a variety of questions to determine their knowledge of existing signage. The following table indicates various measures of this knowledge.

| **Survey Question** | **Percentage Responding  with Uncertainty** |
| --- | --- |
| What is the nearest Assembly Point to your home? | 29% (I’m not sure) |
| Do you feel that the current tsunami escape route signage is sufficient in the daytime? | 51% (No) |
| Do you feel that the current tsunami escape route signage is sufficiently visible at night? | 73% (No) |

# 6 The Community’s Awareness

The following information reiterates the importance of public information and education in the communities.

## 6.1 Awareness of the Inundation Zone

Within the conducted survey, participants were asked questions about their awareness of their risk in Tsunami:

* 5% did not know if their home was located in a tsunami inundation zone.
* 11% did not know where the nearest high ground was to evacuate to after an earthquake and said that they would not know what to tell friends and family who were visiting from out of town.

## 6.2 Self-Assessment of Time to Evacuate

Within the conducted survey, 61% of those surveyed indicated they could reach high ground in under 20 minutes, 17% indicated they could reach high ground in 20-30 minutes, and 16% were unsure of how much time would be needed to evacuate.

*See the Beat the Wave for more detailed evacuation times for specific locations.*

## 6.3 Personal Preparedness

Only 45% of the individuals surveyed have a tsunami backpack ready to take with them in the event of an evacuation.

# 7 The Findings and Areas of Concern

The following areas of concern were identified through the Risk and Vulnerability Assessment:

* Evacuation awareness of existing residents (e.g., high ground, assembly points)
* Communicating pre-incident information to visitors
* Visibility, quantity, and quality of existing tsunami evacuation signage (e.g., daytime, nighttime, vision impairment, clear understanding by non-English speakers)
* Individuals who experience mobility challenges
* Gaps in available tsunami evacuation routes (e.g., lack of east-west running streets, lack of traditional grid street layout, cascading hazards)

## Appendix A Survey #1 Results

## Appendix B Wave Arrival Times

## Appendix C Beat the Wave Maps

## Appendix D Short-Term Rental Locations

1. https://www.nidcd.nih.gov/sites/default/files/Documents/health/hearing/NewHearingLossStudy\_Infographic\_12\_13\_16.pdf [↑](#footnote-ref-1)