HAZARDS

(Goal 7)

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(Goal 7)

1. OVERVIEW

The demand for land in Tillamook County is increasing rapidly and problems related to developing these lands are mounting. Because of the tractable ground already in use, new developments are being directed toward areas that were previously passed over. Unfortunately, many of the new areas are subject to some type of natural hazard such as landsliding, flooding, erosion, ground instability, or other geologic condition, unknown to the citizen who plans to occupy this ground.

The purpose of addressing hazards then, is not meant to restrict properties from development, but rather to institute policies concerning potential problems, so that they can be considered before financial losses and possible injury may be avoided by the application of the policies formulated in the Comprehensive Plan.

Goal 7, Areas Subject to Natural Disasters and Hazards, reads:

> "To protect life and property from natural disasters and hazards, developments subject to damage or that could result in loss of life shall not be planned nor located in known areas of natural disasters and hazards without appropriate safeguards. Plans shall be based on an inventory of known areas of natural disaster and hazard."

Hazards listed include: ocean and stream flooding, groundwater, erosion and deposition, landslides, earthquakes, weak foundation soils, and other unique local hazards.

1.1 State Planning Requirements

a. Planning guidelines specify that:

1. Developments should be keyed to the degree of hazard present;

2. Plans for flood areas should prefer uses that do not require structural protection;

3. Low density and open space uses should be preferred in floodplains, and especially in floodways;

4. Land conservation and development actions should not exceed resource carrying capacities; and,

5. Planning for known areas of natural hazards and disasters should include an evaluation of the beneficial impact on natural resources and the environment from letting such events naturally re-occur.

b. Implementation guidelines specify:

1. Cities and counties not already enrolled should qualify for inclusion in the National Flood Insurance Program;

2. Density of development should be limited by degree of natural hazard

present;

3. The potential impacts of both regulatory programs and engineering projects should be considered; and,

4. The possible creation of new natural hazards by proposed developments should be considered, evaluated, and provided for.

c. Definitions for planning purposes are:

ACTIVE LANDSLIDE: These are areas where ground movement is continuous or periodic or areas in which historic (within about 100 years) movement has taken place. The areas indicated include debris and rockfalls on the headlands, shallow slump failures along terraces fronting the ocean and bays, and areas of local slump in upland areas.

BASALT: A dark, fine-grained volcanic rock composed primarily of calcic plagioclase and pyroxene, occurs in flows, dikes, and sills.

DEBRIS SLIDE: Rapid downslope movement of unconsolidated earth and debris which has no planar slide plane and which is characterized by a hummocky topography.

EARTHFLOW: The downslope movement of unconsolidated earth or fragmented rock debris in a manner which resembles the flow of a highly viscous fluid.

LANDSLIDE: In this report, the term LANDSLIDE is restricted to downslope movement of a rapid nature.

MANTLE CREEP: Mantle creep (also soil creep) is the slow movement of earth material downslope over prolonged periods of time.

It generally is restricted to moderate slopes varying between approximately 10 percent and 25 percent, but also occurs in association with active and historic landslides on steeper slopes. Mantle creep is similar to landsliding in most respects except for a much slower rate of movement. It may involve soil, weathered bedrock, or both. Diagnostic features are the same as those for landslides, but are much more subtle in their development, owing to the lesser rates of movement. Irregularities of slope, drainage, soil distribution, and vegetative cover are the main criteria for recognition.

MASS WASTING: Downslope movement of earth material under the influence of gravity without the aid of running water.

MUDFLOW: Downslope movement of a wet, viscous mud and rock mixture.

ROCKFALL: The free fall of a newly detached segment of bedrock from a cliff or steep slope.

ROCKSLIDE: Perceptible downslope movement of rocky material down moderate to steep slopes.

SEDIMENTARY ROCKS: Rocks formed by the deposition of individual grains from a transporting medium, as opposed to igneous and metamorphic rocks.

SLUMP: The downward movement of unconsolidated material in response to gravity characterized by backward rotation of the moving material and by movement along a curved basal slip plane.

SOIL CREEP: Slow particle-by-particle downslope movement of unconsolidated material with no well-defined basal slip plane and no backward rotation of the slide mass.

TERRACE DEPOSIT: A bench topped by marine sediments or alluvium. Represents the eroded remnant of a former beach or floodplain before uplift or lowering of sea level.

1.2 Information Base

Data for identifying potential hazard areas were drawn from the following state publications. The maps following are illustrative of these data.

a. Oregon Department of Geology and Mineral Industries. "Environmental Geology of Inland Tillamook and Clatsop Counties, Oregon". Portland, Oregon. 1972. 65 pp.

b. Oregon Department of Geology and Mineral Industries. "Environmental Geology of the Coastal Region of Tillamook and Clatsop Counties, Oregon". Portland, Oregon. 1972. 164 pp.

c. Oregon Department of Geology and Mineral Industries. "Geologic Hazards Inventory of the Oregon Coastal Zone". Portland, Oregon. 94 pp.

d. Oregon State Soil and Water Conservation Commission. "Streambank Erosion in Oregon". Salem, Oregon. 151 pp.

Additional information sources for the Natural Hazards element are the following:

Information Source	Description	Author/ Agency	Date
Appraisal of Chronic Hazard Alleviation Techniques, with Special Reference to the Oregon Coast	Hazards management. Describes geomorphic, oceanic and human factors affecting shoreline stability, then discusses approaches for identifying and evaluating hazard avoidance technique options. Contains brief section relating the above to the specific context of the Oregon Coast.	Report to DLCD, from Oregon Coastal Zone Management Association, prepared by Shoreland Solutions	December 1994
Inventory of Critical and Essential Facilities Vulnerable to Earthquake or Tsunami Hazards on the Oregon Coast	Quantification of risk faced by facilities(such as hospitals, fire stations, communications centers, etc.) in Tillamook County, in the event of earthquake or tsunami. Database file (included on disk) lists these facilities, their location, data used in assessing risk, the risk determination, and other data.	Oregon Dept. of Geology and Mineral Industries (DOGAMI)	January 1995
A Unified National Program for Floodplain Management	Broad scale policy direction pamphlet (43 pages) describing floodplain management in theory, the history of floodplain management, a discussion of the Unified National Program and its implementation, including goals for the next 30 years.	Federal Interagency Floodplain Management Task Force	1994
Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials	Identifies types of flood hazards, describes regulatory approaches for addressing specific types of flood hazards, provides examples of innovative community programs, and provides a bibliography of more-detailed information sources. Arranged by type of flood hazard.	Prepared by The Association of State Floodplain Managers, for The Federal Emergency Management Agency	1985
Managing Floodplain Development in Approximate Zone A Areas – A Guide for Obtaining and Developing Base (100-Year) Flood Elevations	Includes computer program (diskette) for computing water surface elevations in open channels.	Federal Emergency Management Agency (FEMA-265)	July 1995

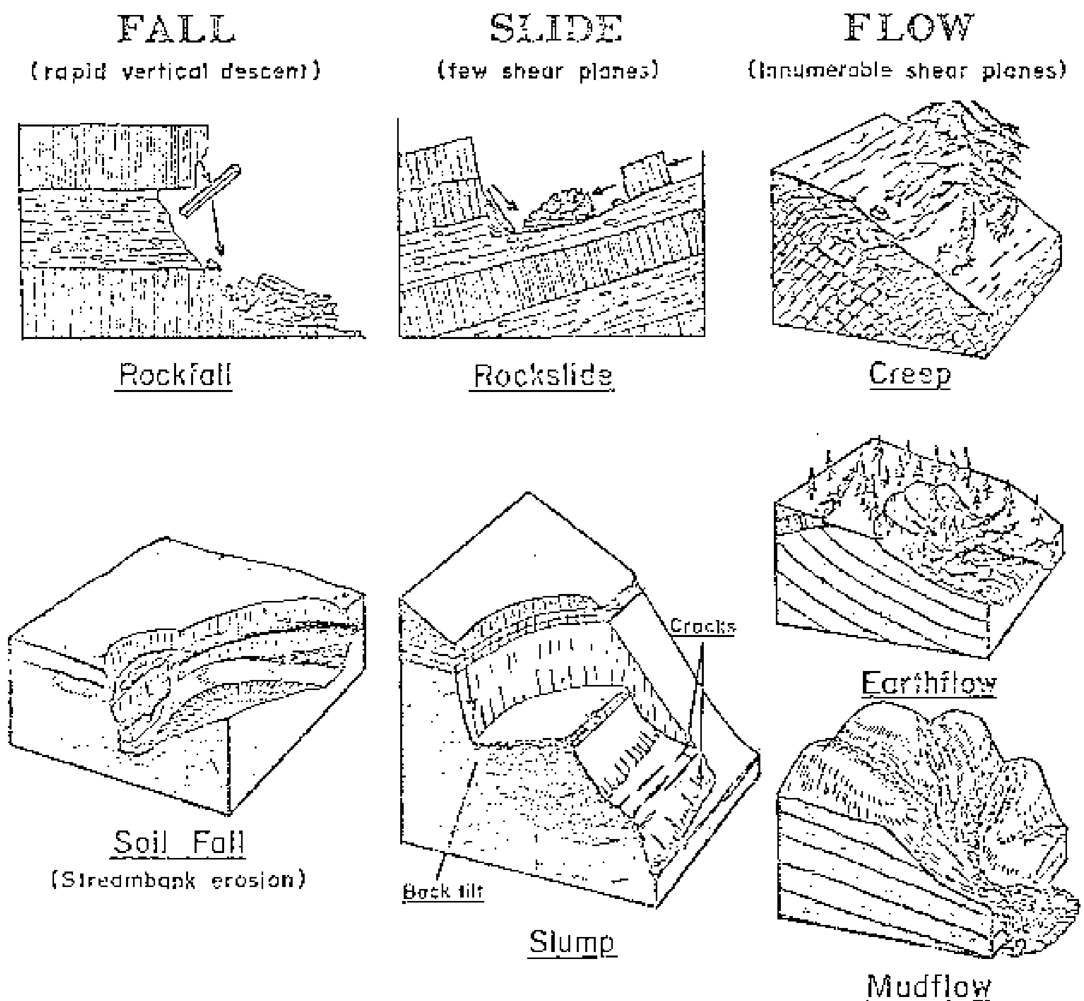
Also included is a chart prepared by RNKR Associates of Corvallis illustrating potential relationships between land uses and geologic hazards. Additional charts are also available from the firm covering more detailed aspects of potential county response to development problems caused by geologic hazards.

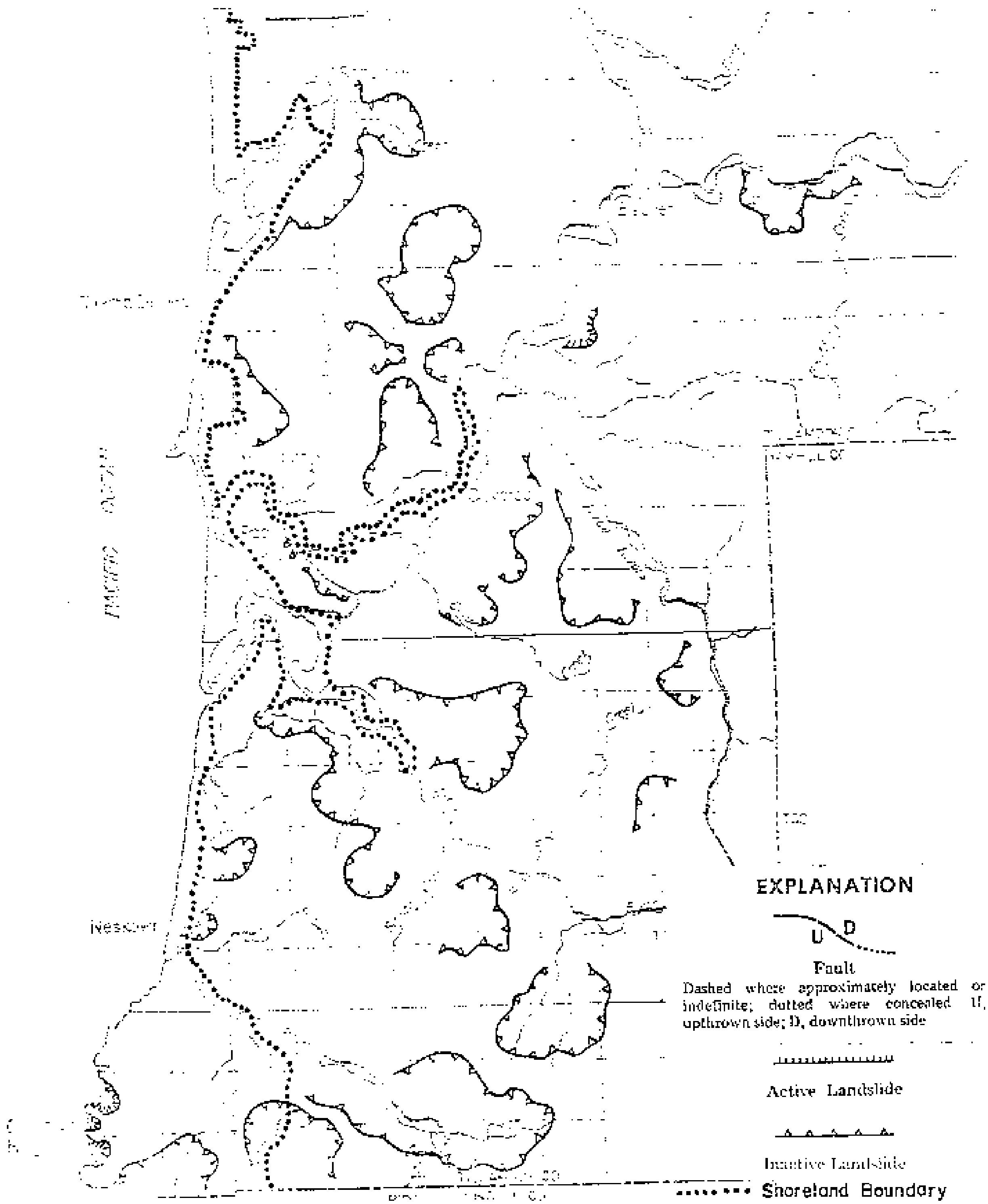
Although the groundwater resource and groundwater quality are covered to some degree in the Goal 5, Goal 6 and Goal 18 elements of this plan, they are also included in this element because of their fundamental relationship to the geology of the County.

INLAND TILLAMOOK COUNTY

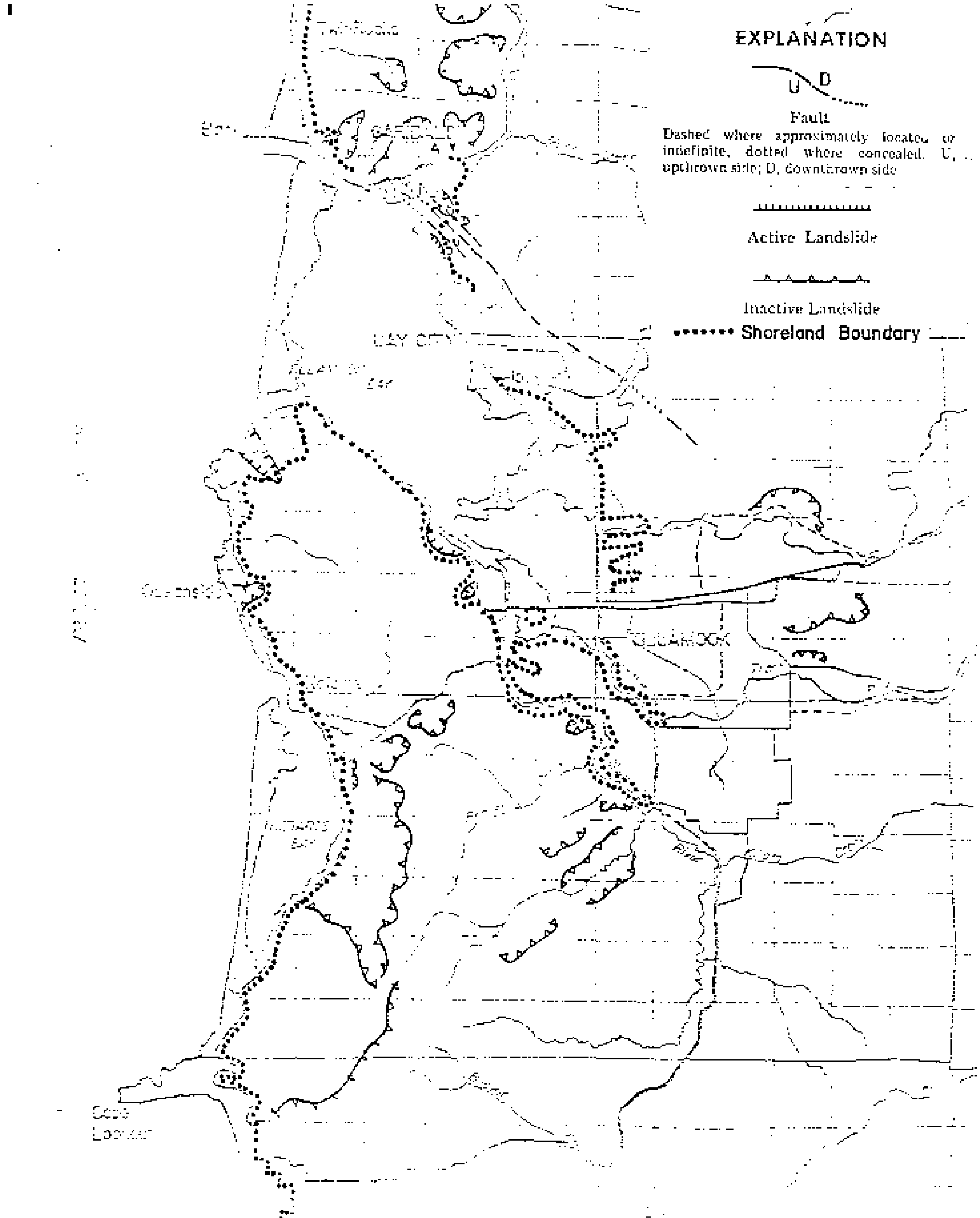
MASS MOVEMENT

(downslope movement of earth material)




EXPLANATION
U D
Fault
Dashed where approximately located or indefinite; dotted where concealed U, upthrown side; D, downthrown side
Active Landslide
Inactive Landslide
Shoreland Boundary

VII - 8 -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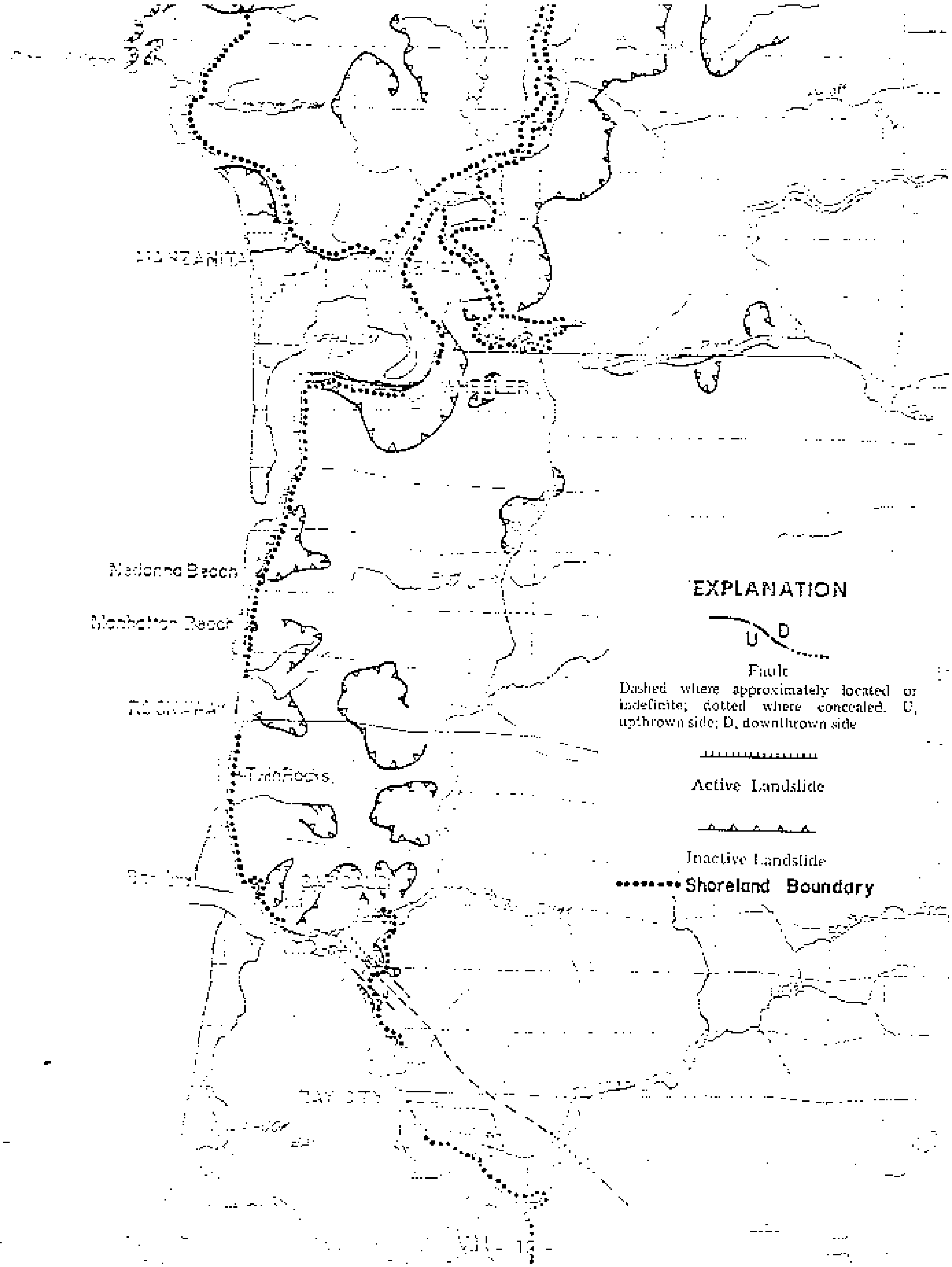
Active Landslide
Inactive Landslide
Shoreland Boundary

VII - 9 -



Madonna Beach
EXPLANATION
U D
Fault
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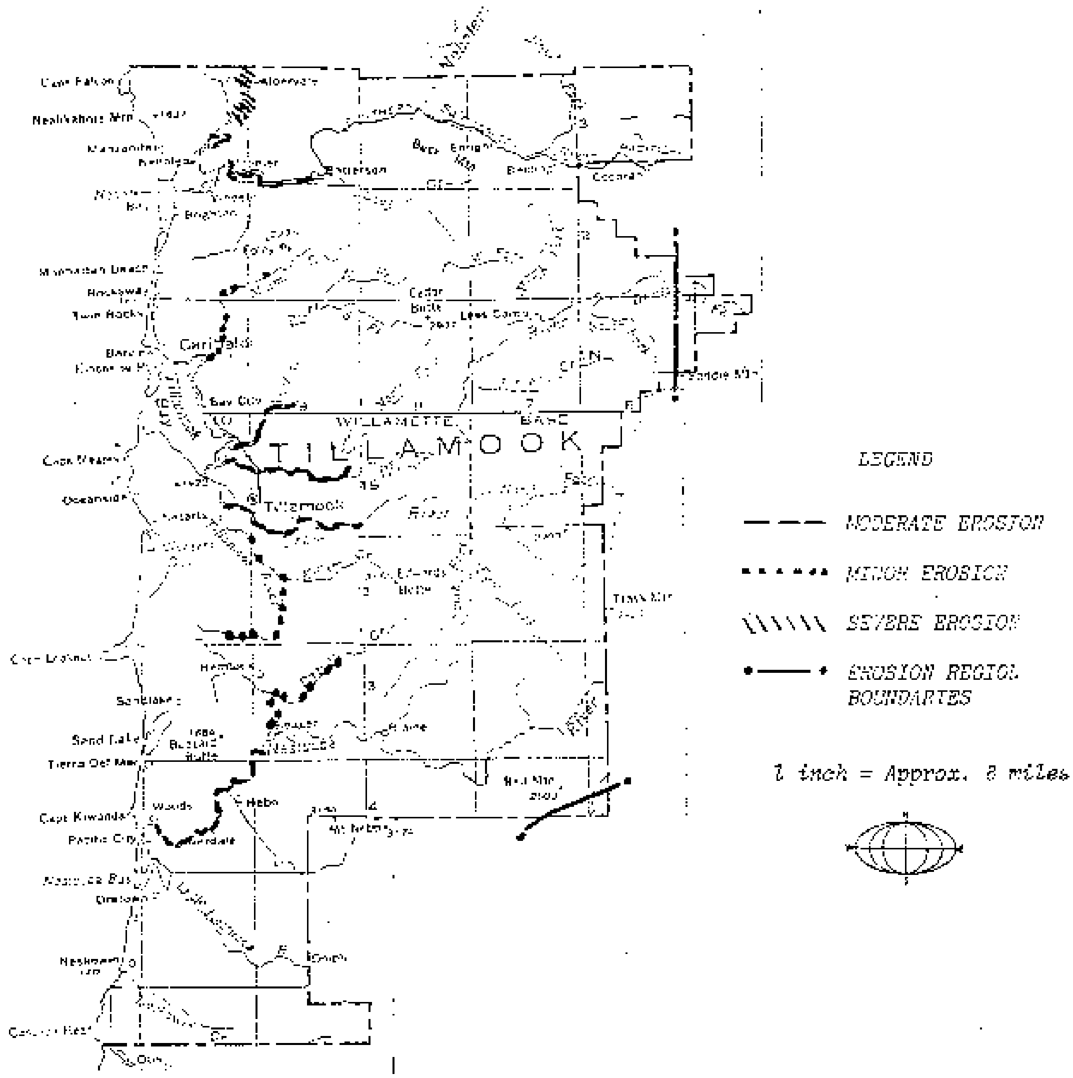
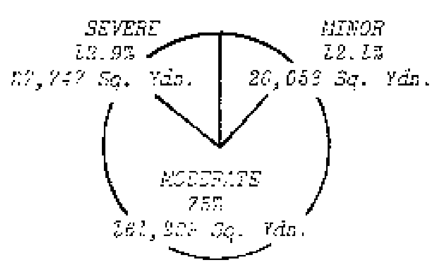
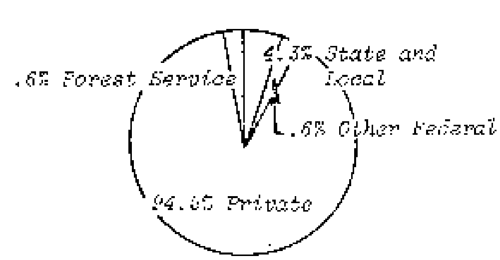
Active Landslide
Inactive Landslide
Shoreland Boundary



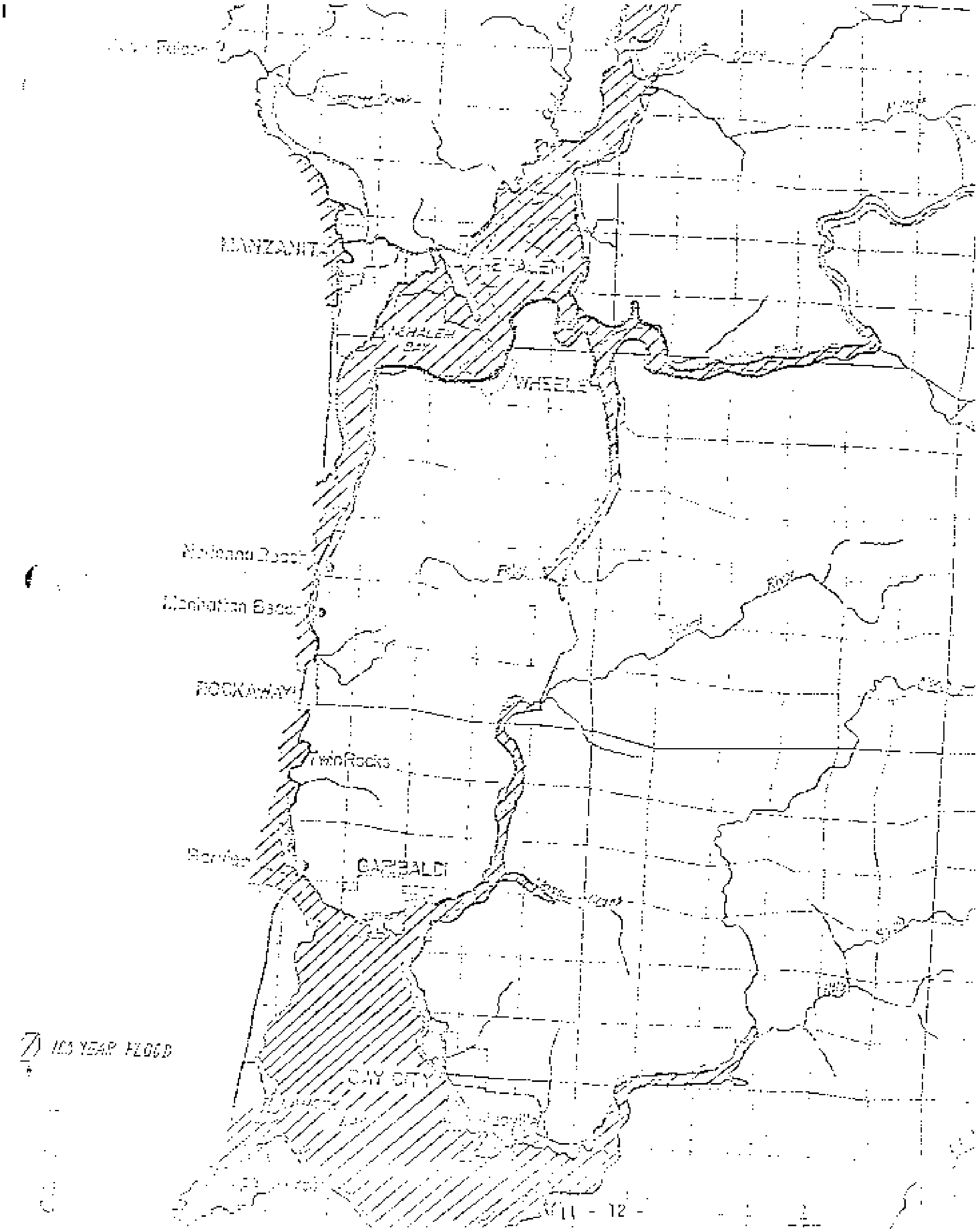
Severity of Erosion



Ownership of Lands Affected



SOURCE. SWCC "Streambank Erosion in Oregon", 1973, p. 14,90 and Plate 27.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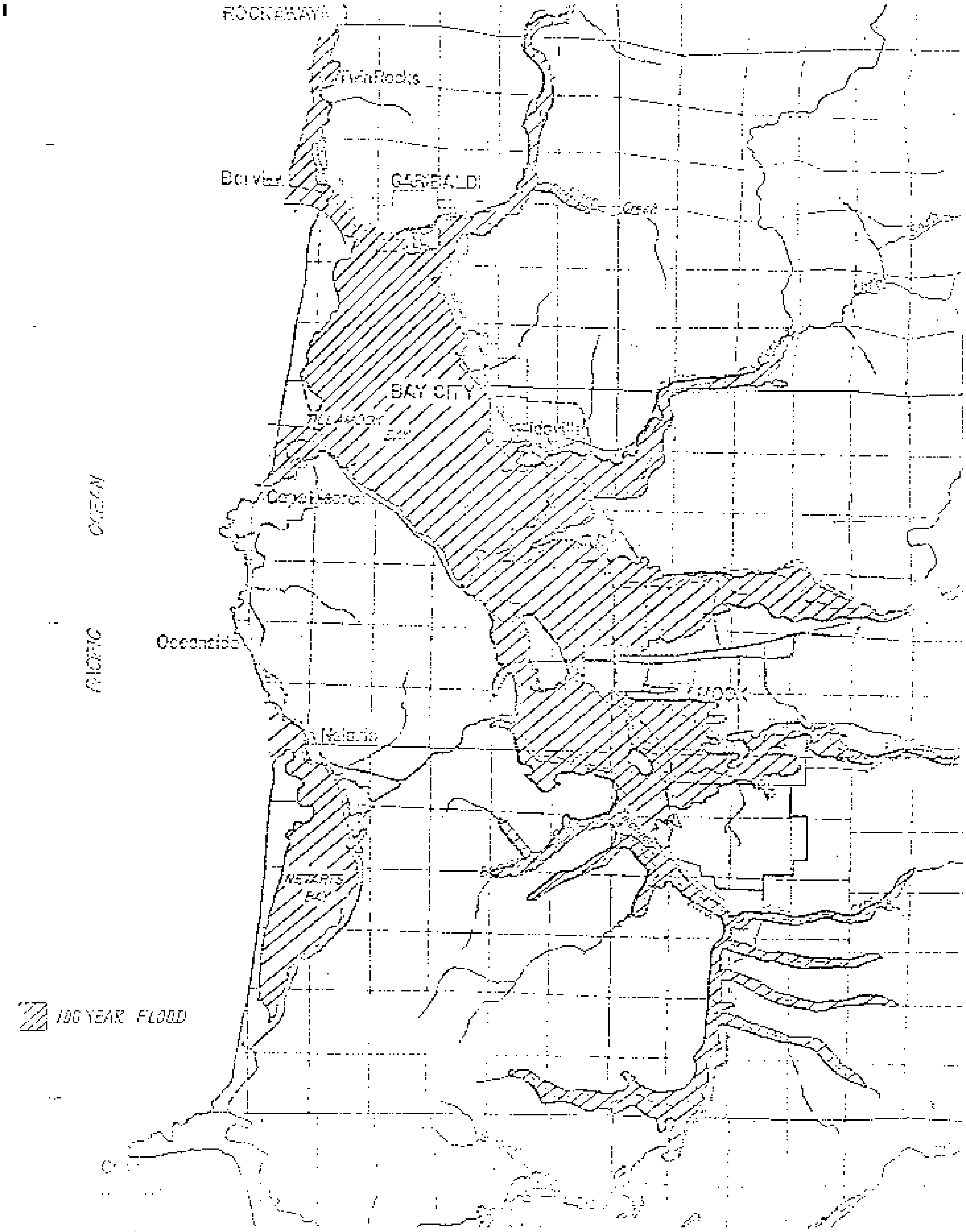
WHEELER
ROCKAWAY
Twin Rocks
GARIBALDI
BAY CITY
100 YEAR FLOOD


ROCKAWAY
TwinRocks
GARIBALDI
BAY CITY
Oceanside
100 YEAR FLOOD

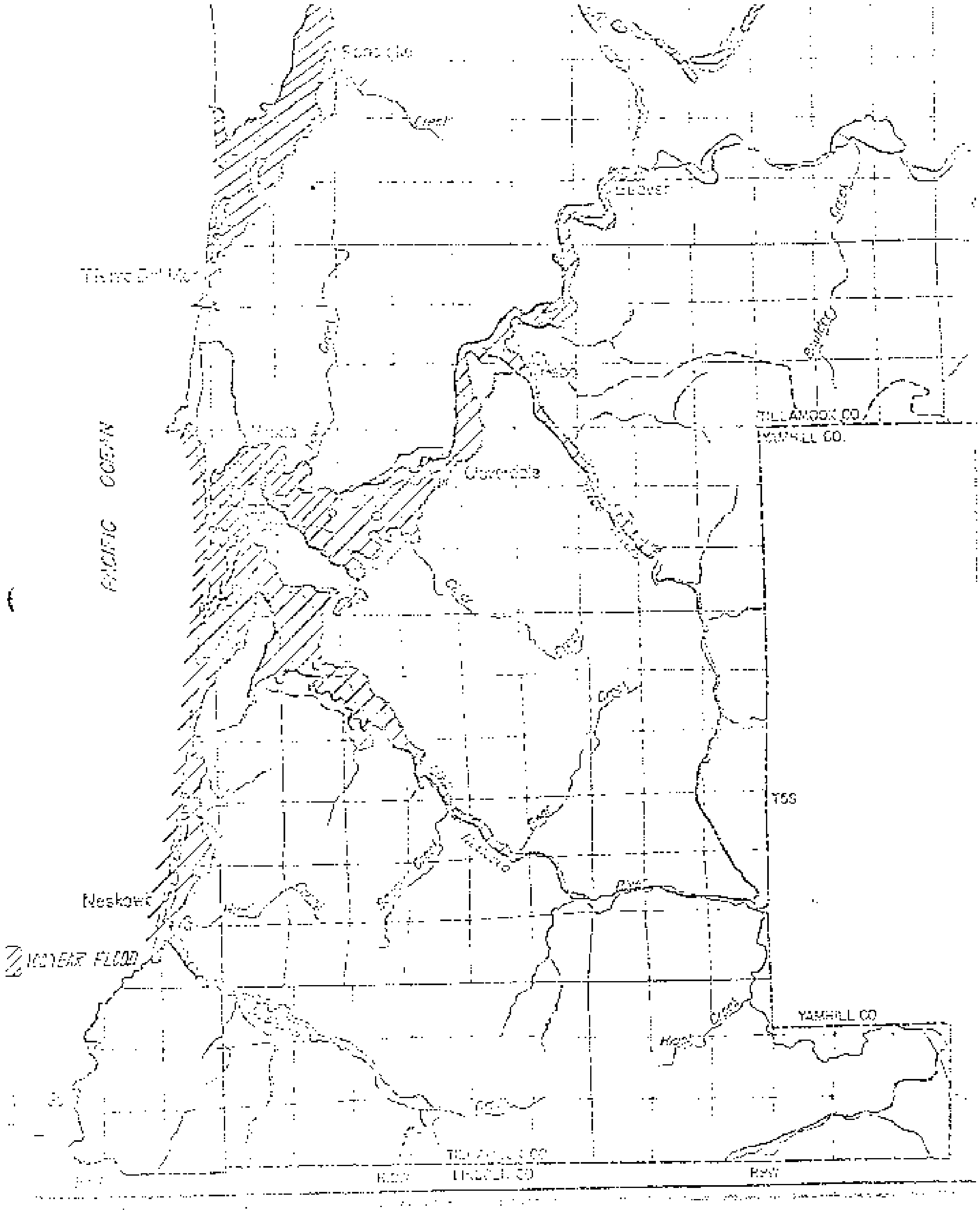

PACIFIC OCEAN
Neskowin
100 YEAR FLOOD
TILLAMOOK CO.
YAMHILL CO.
T5S
YAMHILL CO

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TABLE 1
TILLAMOOK COUNTY

River/Stream	Eroded Length (Miles)	Total Erosion in County (Square Yards)	Erosion In Region Per Mile of Eroded Length (Square Yards)	Severity By Region
Beaver Creek	.4	1,462	3,655	Minor
East Beaver Creek	1.1	1,584	1,742	Minor
Bible Creek	.4	704	1,760	Minor
Boulder Creek	.3	468	1,560	Minor
Clear Creek	.2	820	4,100	Moderate
Edwards Creek	1.2	1,404	1,170	Minor
Fawcett Creek	1.4	3,801	2,715	Minor
Kilchis River	1.6	25,669	16,039	Moderate
Little South Fork Kilchis River	.3	1,056	3,520	Minor
Miami River	1.3	4,744	3,880	Minor
Moon Creek	.2	584	2,920	Minor
Nehalem River**	3.2	22,205	6,939	Moderate
	1.4	38,846	27,747	Severe
	4.6	61,051		
Big Nestucca River	5.7	49,801	8,719	Moderate
Little Nestucca River	.3	468	1,560	Minor
South Fork Trask River	1.0	3,520	3,520	Minor
Trask River	3.6	24,552	6,823	Moderate
Wilson River	3.5	26,664	7,618	Moderate
Total	27.1	215,041		

** This stream falls within two or more erosion regions.

LAND USE VS. GEOLOGIC HAZARD

GEOLOGIC HAZARD \ LAND USE	High Density Housing	Low Density Housing	Heavy Foundation Loads	Roads and Streets	Drainfield Disposal	Landfill	Basements	Underground Fuel Storage	Underground Utilities
Landslide	High	High	High	High	High	High	Moderate	High	High
Steep Slope	High	Moderate	High	Moderate	High	High	Low	Low	Moderate
Rock Fall	High	High	NA	High	NA	NA	NA	NA	NA
High Water Table	Moderate	Moderate	Low	Moderate	High	Low	High	High	Low
Ponding	High	Moderate	Low	Low	High	Moderate	Moderate	Moderate	Low
Weak Foundation Soil	Moderate	Moderate	High	High	Moderate	High	Moderate	Moderate	Moderate
Heavy Clay Soil	Moderate	Moderate	Moderate	Moderate	High	Moderate	Low	Low	Low
Erosion	Moderate	Low	Low	Moderate	Low	High	NA	Low	Low
Near Surface Bedrock	Moderate	Moderate	Low	Low	High	Low	High	High	High
Pollution	High	Moderate	NA	NA	High	High	NA	Low	Low
Eventual Slope Failure	High	Low	Moderate	Moderate	High	High	Low	NA	Low
Marine Erosion	High	High	High	High	High	NA	NA	NA	Low
Flooding	High	High	Low	High	High	High	High	Moderate	Moderate

HIGH POTENTIAL FOR PROBLEMS (High)
MODERATE POTENTIAL FOR PROBLEMS (Moderate)
LOW POTENTIAL FOR PROBLEMS (Low)
NOT APPLICABLE NA

2. FINDINGS AND POLICIES

2.1 Landslides

Findings

a. In Tillamook County, approximately 70% of the upland area has undergone some type of downslope movement. At present, these areas of old landslides remain in various stages of instability, ranging from active movement locally to temporarily stable conditions in which changes of slope or drainage could reactivate movement (Bulletin 74, p. 75).

b. Massive land failure is caused primarily by the high winter rainfall (80-150 inches per year) which saturates the weathered and soft sedimentary rocks underlying much of the area (Bulletin 74, p. 77).

c. One of the major causes of slope failure along the coast is wave erosion on the headlands and terraces. Sea stacks adjacent to the larger headlands testify to the former position of the coastline and to the erosive force of the sea. At present, the ocean is undercutting headlands and terraces, causing continual retreat of the shoreline (Bulletin 74, p. 77).

d. Many areas along the coast from Tillamook Head to Cascade Head exhibit active landslide movement. Slides occur on basalt headlands, marine bedrock, marine terrace deposits, and dune sands. Debris slides and rockfalls are characteristic of the basalt headlands, whereas slump failure and slope retreat are typical of marine bedrock, terrace deposits, and dune sand (Bulletin 74, p. 77).

e. Active slides can be generated by acts of man which alter the balance of nature. Excavations, cuts, fills, and drainage modifications may decrease the stability of an area and initiate sliding. Water introduced into the subsurface by drainfields, septic tanks, and improper handling of runoff may also initiate slides (Geologic Hazards Inventory, p. 23).

f. Piecemeal hillside development will eventually reach a density of housing sufficient to create instability and slope failure (Bulletin 74, p. 130).

g. Cape Falcon is a basalt headland with extensive rockfalls from Falcon Cove to Short Sands Beach. On the south side of Cape Falcon, large blocks of sandstone are sliding over the south-dipping beds of Astoria formation to the beach (Bulletin 74, p. 80).

h. A cross section of the Neahkahnie hillside on the north shows vegetation and soil creep on the upper hillside, debris slump or shift in the middle, and block slide on the headland area is eroded by block falling. Near Neahkahnie Beach there is a vegetated remnant of an old debris shift consisting of Astoria rocks or terrace deposits (Bulletin 74, p. 80).

i. Just south of the Neahkahnie headland, active wave erosion is causing slope retreat and slump movement in a marine bedrock slope that has undergone landslide movement in the past. The slopes above the beach are crudely terraced in landslide slump blocks, some of which appear to be unstable (Bulletin 74, p. 80). Some sliding has occurred in the Neahkahnie area as a result of residential development in the recent past.

j. A major landslide is located on the north side of Cape Meares. The slide is more than 3000 feet long and averages 1000 feet wide; the elevation of the head of the slide is about 400 feet above mean sea level. The toe of the landslide is on the beach and erosion of the toe is rapid and continual (Bulletin 74, p. 80).

k. Between Oceanside and Netarts, dune sand and marine terrace deposits are eroding in many places. South from Netarts to Cape Lookout the elevated marine terraces along the east shore of Netarts Bay are extensively slumped. On Cape Lookout erosion takes place by rockfall directly into the ocean. A large slump block occurs immediately south of the headland and minor slope failures occur in the dune sand south about as far as Chamberlain Lake (Bulletin 74, p.80).

l. Mass movement in the middle reaches of the Wilson River varies from rockfall and rockslide along the volcanic ridge crests to earthflow and slump in isolated patches of unsupported sedimentary rocks on the lower slopes. Sheets of talus are draped over bedrock in many areas, and thick vegetative cover blankets much of the terrain. Although much of the area is known to be unstable owing to the moderate to steep slopes, more precise analysis is difficult (Bulletin 79, p. 34).

m. Many of the streams draining into the Trask occupy short steep channels in bedrock. As is true of the Wilson River, such channels have a potential for mudflow activity. Owing to the relative lack of soil and sedimentary rock, however, flash flooding is the most immediate danger. This is discussed in a later section (Bulletin 79, p. 34).

n. Slumping has occurred in weathered siltstone an eighth of a mile south of Sears Lake. Numerous small scarps are exposed upslope from the highway cut, and sliding extends west to the beach. At Cape Kiwanda rockfall occurs on the south side of the Cape (Bulletin 74, p. 80).

o. South of Neskowin on U. S. Highway 101 near the Tillamook-Lincoln County border, an active landslide extends along the west side of the highway for more than 1000 feet. The landslide is a deep failure in siltstone of the Eocene sedimentary rock unit. Previous attempts to stabilize the landslide have not been successful (Bulletin 74, p. 80).

Policies

a. Development shall not be allowed in areas of active sliding.

b. Zoning regulations should incorporate the grading requirements as stipulated under Chapter 70 of the Uniform Building Code.

c. Standards of the Uniform Building Code and the density and nature of developments should be keyed to slide potential.

d. All excavations, fills and drainage changes, and vegetation removal programs in areas of mass movement topography shall be engineered to minimize the possibility of sliding.

e. Any development on the headlands shall consider the degree of safety which exists in terms of ground stability and the rate of beachfront erosion.

f. Where strata slope toward cuts, slides are easily initiated, and excavation in areas with such unfavorable bedrock conditions should be properly excavated.

g. Projects involving modifications of established drainage patterns should be evaluated in terms of the effect these changes would have on drainage and slope stability.

h. Projects which include plans for modifying the topography of sloping areas should be evaluated in terms of the effect these changes would have on drainage and slope stability.

i. Projects or long-range plans involving urbanization of given areas should be evaluated in terms of the long-range influence the proposed land use would have on land stability; drainage is particularly critical.

j. Closely spaced drainfields and septic tanks should be restricted from moderate to steeply sloping areas because of the potential for sliding.

k. Proposed development in close proximity to active or inactive landslides shall require site investigation.

2.2 Weak Bearing Soils

Findings

a. Compressible soils are soils which undergo a significant decrease in volume when subject to loading. They commonly contain types of clay or organic matter which release water under pressure. Compressible soils are associated with marshland, tidal flats, estuaries, lake margins, and interdune areas (Geologic Hazards Inventory of the Oregon Coastal Zone, p. 30).

b. Construction on compressible soils can result in differential settling of a wide variety of structures including large buildings, homes, roads, railroads, airport runways, and pipelines (Geologic Hazards Inventory of the Oregon Coastal Zone, p. 31).

c. The moisture content of the soil at time of test is basically important. For instance, a clay soil having a moisture content below the shrinkage limit may be almost as hard as kiln-dried brick and have a very high supporting power; yet when it has a moisture content near the liquid limit it is almost a liquid and has very low supporting power (Bulletin 74, p. 163).

Policies

Proper engineering investigations should precede all medium to large construction in regions of possible compressible soils. Engineering solutions include excavation and backfilling with more suitable material, preloading, and the use of piling, or spread footings, depending upon the nature of the specific structure being considered and the degree of severity of the hazard.

2.3 Earthquakes

Findings

a. In general, earthquake activity is important to the area only insofar as it may trigger mass wasting in previously unstable areas. Earthquake activity is just one of many factors which may initiate sliding, and it should be regarded as a hazard of secondary importance (Bulletin 74, p. 107).

b. A few faults have been indicated on the geologic maps for the Tillamook area, but no attempt was made to conduct detailed mapping of rock structure (Bulletin 74, p. 107).

c. Most of the Oregon Coast is categorized as a zone of minor potential damage for which quakes of Mercalli Intensity V-VI may occur. Moderate quakes (Intensity VIII) are accompanied by general alarm, the cracking of walls, and the falling of plaster in a wide variety of structures. Minor quakes (Intensity V-VI) are associated with swaying trees and the overturning of loose objects (Geologic Hazards Inventory of the Oregon Coast, p. 41).

d. On November 16, 1957 an earthquake of Intensity VI (Modified Mercalli Scale) occurred near Beaver (12 miles south of Tillamook) and was felt over a total area of 4,500 square miles. As far away as Salem, household furnishings shifted location and some objects were broken.

Policies

Care shall be taken when reviewing development proposals to insure that development does not take place on faults which are highly susceptible to earthquakes.

2.4 Erosion

Findings

a. Erosion is the loss of land by stream, ocean, wind, or other hydraulic action and includes streambank erosion, channel scour, and gullying (Geologic Hazards Inventory of the Oregon Coastal Zone, p. 15).

b. Causes of erosion include rapid precipitation, lack of vegetation, steep to moderate and sometimes gentle slopes, low infiltration rates, and erodibility of bedrock or soil. Because land use can affect slope, vegetative cover, infiltration rate, and degree of consolidation, it is a primary factor in gullying in areas of development (Geologic Hazards Inventory of the Oregon Coast, p. 15).

c. The impacts of erosion may include the undercutting of structures of all sizes, the interruption of linear developments such as highways, railroads, and pipelines, the loss of topsoil in forestry and agricultural areas, increased sediment load, degradation of water quality, and the destruction of spawning grounds (Geologic Hazards Inventory of the Oregon coast, p. 15).

d. Slopes in excess of 15% are highly susceptible to erosion.

Policies

a. Prevention or remedial action shall include any or all of the following:

   1. Maintenance of existing vegetation in critical areas;

   2. Rapid revegetation of exposed areas following construction;

   3. The stabilization of shorelines and stream banks with vegetation and/or riprap;

   4. Maintenance of riparian buffer strips;

5. Structural accommodation of increased runoff in areas of development;

6. Seasonal restriction of construction in critical areas;

7. Set-back requirements for construction or structures near slope edge, stream banks, etc.; and,

8. Any other measures deemed appropriate to deal with site specific problems.

b. Development on slopes of 15% or greater shall require the submission of topography and other information to show that no significant detrimental effects will occur.

2.5 Flooding

Findings

a. Flooding of streams in Tillamook is an annual winter occurrence and some streams may overflow their banks several times a year. This condition is due to various combinations of heavy rainfall, steep topography, low bedrock permeability, extensive flood plains, log jams, gravel- and silt-clogged rivers and bays, high tides, and strong westerly winds from storms at sea (Bulletin 74, p. 91).

b. Stream flooding is most likely to occur during December and January, although a combination of stream and tidal flooding can also be expected throughout the November-February period. Coastal streams respond quickly to rapid runoff from higher elevations experiencing heavy rainfall or melting snow, or combination of both (Bulletin 74, p. 91).

c. Preliminary investigation reveals that clogging of the lower streams and the bays by silt is not the primary cause of flooding in the floodplain areas. The effect of the high ocean tides driven farther ashore by gale winds is far greater. Consequently, any advantage in getting stream flood waters to sea as quickly as possible by dredging would depend on the simultaneous occurrence of flooding conditions and ebb and slack tides. Such an occurrence would be purely coincidental and could not be depended upon. Commonly the high ocean flood tides would combine with the stream flooding to overflow the deepened channelways regardless of dredging (Bulletin 74, p. 91).

d. In general, precipitation ranges from 80 to 110 inches with up to 150 inches in the headwaters of the Kilchis to 89 inches at Tillamook (Bulletin 74, p. 91).

e. Flooding by streams constitutes one of the major hazards to Tillamook County with damage to developments through the effects of moving water, standing water, erosion, and siltation. Commercial establishments, homes, and other structures can experience considerable structural damage and transportation by highways and roads can be severed or impeded.

f. The major problem associated with flooding in the Nehalem River basin is stream-bank erosion. The terraces are composed of unconsolidated sand and silt, and the main channel follows a sinuous course through the terraced valley. Lateral erosion is characterized mainly by slump and may be a potential threat to highways where abrupt turns in the river are situated very near the roads (Bulletin 79, p. 41).

g. The major hazard throughout much of the Wilson River drainage basin is flash flooding. In its lower reaches, Deadman Creek, Negro Jack Creek, Smith Creek, Slide Creek, and Fern Creek exhibit potential for flash flooding. Because of the primary governing factors, which include steep slope, impermeability, and heavy rainfall, are beyond human control; prevention of flash floods is not possible. During the floods of 1972 and 1977 torrents from side channels swept over the Wilson river Highway in dozens of places causing major damage at several localities (Bulletin 79, p. 43).

h. Mudflows are an additional hazard, especially in the lower reaches. The actual channel of the river is scoured in bedrock throughout its entirety and lateral migration under natural conditions is minimal. However, bank erosion in areas of fill constitutes a hazard. In addition, floodwaters laden with logs can inflict considerable damage on man-made structures extending into the river (Bulletin 79, p. 43).

i. In terms of flooding, the major hazards along the Trask River are landslide damming in the upper reaches and flash flooding of the side channels in the upper and lower reaches. In the valley bottom, terrace levels are fairly high and bedrock is near or at the surface. Danger of appreciable streambank erosion in the main channel is minimal. Streambank erosion of some of the tributaries and parts of the upper main channel, however, is significant.

   Flash flooding due to steep slopes, impermeable bedrock, and intense winter rains is a hazard along many of the short streams in the lower Trask drainage including Cedar Creek, Panther Creek, Burton Creek, and others. In 1972, considerable upstream flash flood damage was done to the main road one mile south of Trask House, where a short unnamed stream washed out the road (Bulletin 79, p. 43).

j. The upper Nestucca river basin is characterized by gentle relief, more vegetative cover, and longer side channels than the more hazardous parts of either the Wilson or the Trask Rivers. The dangers of flash flooding are correspondingly diminished. Terraces are relatively high west of Blaine, and the stream channel is scoured out of bedrock east of Blaine. Stream-bank erosion, although still a hazard, is not extreme. No stream-flow data are available for the study area (Bulletin 79, p. 44).

Policies

a. Tillamook County's flood control regulations as stipulated under the "F-H" Flood Hazard Zone shall apply to all areas designated as flood areas on the County's Flood Insurance Rate Maps.

b. The County shall continue cooperation with other local governmental units to seek out and implement solutions to flooding problems in the Lower Wilson River area.

c. Roads crossing channels subject to flash flooding shall be founded on culverts of adequate size to accommodate maximum runoff.

d. Permanent structures shall not be placed in channels subject to flash flooding.

e. Where development within floodplains is allowed, the developer shall provide appropriate safeguards to insure public safety and protect individuals residing in the flood zone.

f. All new construction and substantial improvements shall be constructed by methods and practices that minimize flood damage (floodproofing).

g. Flood zone regulations shall be based on the most current and reliable flood plain data and meet the minimum requirements established by the Federal Insurance Administration.

h. Development within the regulatory flood way shall meet minimum Federal requirements.

i. Protective measures shall be taken to insure that the cumulative effect of a proposed development or fill, when combined with all other development or previous placement of fill, will not increase the water surface elevation above a specified level.

2.6 Tsunamis (Seismic Waves)

Description of the Hazard:

The Oregon coast is well known for its spectacular scenery and natural resources. However, because the coast lies at the interface between land and the Pacific Ocean, it also is a zone of great instability and vulnerability. Over time, we have gained a greater awareness of our coast's geologic hazards and its risks to people and property.

Coastal Oregon is not only vulnerable to chronic coastal hazards such as coastal erosion from winter storms and sea level rise, but it is also subject to the potentially catastrophic effects of a Cascadia earthquake event and related tsunami. These types of powerful and devastating earthquakes of magnitude 9+ are generated at the Cascadia Subduction Zone where the eastward-moving Juan de Fuca tectonic plate dives under the westward-moving North American plate just off the Oregon coast.
These large earthquakes will occur under the ocean just offshore of our coast and will produce extremely destructive tsunamis that can strike the coast as soon as 15 minutes after the earthquake, leaving devastation in their path. It is likely that in most Oregon coast communities, including Tillamook County, the only warning of an approaching tsunami will be the earthquake itself.

The geologic record shows that the largest of these large Cascadia Subduction Zone earthquakes and accompanying tsunamis occur about every 500 years, plus or minus 200 years. The last such earthquake and tsunami occurred over 300 years ago, on the evening of January 26th, 1700. This means that we are in the time window where a destructive Cascadia earthquake and tsunami could occur and the probability of that occurrence will continue to increase over time. This time the stakes are much higher as the great earthquake and catastrophic tsunami could occur when tens of thousands of Oregonians and visitors are enjoying coastal beaches and towns. To address this increasing risk and substantially increase resilience within our community, Tillamook County is proactively addressing tsunami preparedness and mitigation within its land use program. Land use planning that addresses tsunami risk is an essential tool to help increase resilience to a potentially catastrophic tsunami event within Tillamook County.

Tsunami Hazard Maps:

The Department of Geology and Mineral Industries (DOGAMI) has developed Tsunami Inundation Maps (TIMs) which provide the essential information for defining tsunami risk along the Oregon coast. Tillamook County has adopted the TIM's applicable to its coastal unincorporated areas as a part of its comprehensive plan hazard inventory. These maps are also referenced within this natural hazards element of the comprehensive plan and are the basis for establishing the boundaries of Tillamook County's Tsunami Hazard Overlay Zone. The TIMs are referenced in the tsunami related plan policies and within the overlay zone for purposes of differentiating between areas of higher versus lower risk.

Tsunami Related Policies:

Tillamook County has adopted a set of comprehensive plan policies related to tsunami preparedness and recovery that are included within this and other applicable sections of the comprehensive plan. These policies have been developed to address the resilience goals of the County. They are designed to support the County's resilience efforts within the comprehensive plan and implementing codes.

Zoning:

Tsunami Hazard Overlay Zone (THO): Tillamook County has adopted an overlay zone which utilizes the applicable DOGAMI Tsunami Inundation Maps (TIMs). The overlay zone includes all areas identified as subject to inundation by the largest (XXL) local source tsunami event which ensures that life safety and evacuation route planning and development are adequately addressed. Other land use resilience strategies and requirements included within the overlay zone, which are not life safety or evacuation related, are applied within a subset of the overlay to smaller inundation scenario areas. These measures are included within the overlay zone provisions and reflect the community's risk tolerance and application of mitigation measures. The overlay zone boundary has been adopted as an amendment to the official zoning map for Tillamook County.

Tsunami Evacuation Facilities Improvement Plan Maps: The County, as part of its land use program for tsunami preparedness, is in process of completing a comprehensive Tsunami Evacuation Facilities Improvement Plan in coordination with affected communities and stakeholders. The Tsunami Evacuation Facilities Improvement Plan identifies designated evacuation routes, assembly areas and other components of the local evacuation system. The plan is a key component of the County's efforts to reduce risk to life safety by planning for a comprehensive evacuation system and developing the detailed information necessary to establish land use requirements to implement evacuation measures and improvements.

General Policies

To protect life, minimize damage and facilitate rapid recovery from a local source Cascadia Subduction Zone earthquake and tsunami, the County will:

1. Support tsunami preparedness and related resilience efforts.
2. Take reasonable measures to protect life and property to the fullest extent feasible, from the impact of a local source Cascadia tsunami.
3. Use the Oregon Department of Geology and Mineral Industries (DOGAMI) Tsunami Inundation Maps applicable to the County to develop tsunami hazard resiliency measures.
4. Adopt a Tsunami Hazard Overlay Zone for identified tsunami hazard areas to implement land use measures addressing tsunami risk.
5. Enact design or performance implementing code components in identified tsunami hazard areas.

Evacuation Policies

To facilitate the orderly and expedient evacuation of residents and visitors in a tsunami event, the County will:

1. Develop a Tsunami Evacuation Facilities Improvement Plan that identifies current and projected evacuation needs, designates routes and assembly areas, establishes system standards, and identifies needed improvements to the local evacuation system.
2. Identify and secure the use of appropriate land above a tsunami inundation zone for evacuation, assembly, and emergency response.
3. Ensure zoning allows for adequate storage and shelter facilities.
4. Allow for needed evacuation route improvements, including improvements to route demarcation (way finding in all weather and lighting conditions) and vegetation management, for new development and substantial redevelopment in tsunami hazard areas.
5. Work with neighboring jurisdictions to identify inter-jurisdictional evacuation routes and assembly areas where necessary.

6. Allow for the development of vertical evacuation structures in areas where reaching high ground is impractical.
7. Evaluate multi-use paths and transportation policies for tsunami evacuation route planning.
8. Encourage suitable structures to incorporate vertical evacuation capacity in areas where evacuation to high ground is impractical.
9. Install signs to clearly mark evacuation routes and implement other way finding technologies (e.g. painting on pavement, power poles and other prominent features) to ensure that routes can be easily followed day or night and in all weather conditions.
10. Prepare informational materials related to tsunami evacuation routes and make them easily available to the public.

Policies Related to Reducing Development Risk in High Tsunami Risk Areas

The County will:

1. Prohibit comprehensive plan or zone map amendments that would result in increased residential densities or more intensive uses in tsunami hazard areas unless adequate mitigation is implemented. Mitigation measures should focus on life safety and tsunami resistant structure design and construction.
2. Encourage open space, public and private recreation and other minimally developed uses within the tsunami inundation zone area.
3. Prohibit the development of those essential facilities and special occupancy structures within the **LARGE (L)** tsunami inundation area, unless a "Use Exception" has been granted.
4. Protect and enhance existing dune features and coastal vegetation to promote natural buffers and reduce erosion.

Hazard Mitigation Planning

The County will:

1. Address tsunami hazards and associated resilience strategies within the community's FEMA approved hazard mitigation plan.
2. Incorporate and adopt relevant sections of the hazard mitigation plan by reference into the comprehensive plan.

Tsunami Awareness Education and Outreach

The County will:

1. Encourage and support tsunami education and outreach, training, and practice.
2. Implement a comprehensive and ongoing tsunami preparedness community education and outreach program.
3. Collaborate with local, state and federal planners and emergency managers for the purpose of developing a culture of preparedness supporting evacuation route planning and other land use measures that minimize risk and maximize resilience from tsunami events.

Debris Management

The County will:

1. Identify and work to secure the use of suitable areas within the Tsunami Inundation Zone for short and long-term, post-disaster debris storage, sorting and management.
2. Work with other public and private entities to establish mutual aid agreements for post-disaster debris removal and otherwise plan for needed heavy equipment in areas which may become isolated due to earthquake and tsunami damage.

Hazardous Materials

The County will:

1. Limit or prohibit new hazardous facilities within tsunami inundation zones. Where limiting or prohibiting

such facilities is not practical, require adequate mitigation measures consistent with state and federal requirements.

Goal 11: Public Facility and Services

The County will:

1. Consider and address tsunami risks and evacuation routes and signage when planning, developing, improving, or replacing public facilities and services.

Goal 12: Transportation

The County will:

1. Develop multi-use paths that both enhance community livability and serve as tsunami evacuation routes.
2. Coordinate evacuation route and signage planning in conjunction with existing or proposed transportation system plan pedestrian and bicycle route planning efforts.
3. Locate new transportation facilities outside the tsunami inundation zones where feasible.
4. Where feasible design and construct new transportation facilities to withstand a Cascadia event earthquake and be resistant to the associated tsunami.

Goal 14: Urbanization

The County will:

1. Limit the allowable uses on property in the tsunami hazard area vacated as the result of a community growth boundary expansion to relocate existing development. Such limitations shall include permitting only low risk uses, or requiring uses which implement adequate protection or mitigation measures for seismic and tsunami hazards.
2. Plan for the location or relocation of critical facilities outside of tsunami hazard area when conducting the land needs analysis.

Map Amendments

a. *DOGAMI Tsunami Inundation Map (TIM): Communities should adopt the map, or maps in the DOGAMI Tsunami Inundation Map (TIM) Series applicable to their jurisdiction as a part of the comprehensive plan inventory, as they provide the essential information for defining tsunami risk. The TIMs include five inundation scenario areas including small, medium, large, extra-large, and extra extra-large tsunami events. The TIMs will typically be referenced in the natural hazards element of the comprehensive plan, and will also be used as the basis for establishing the boundaries of a Tsunami Hazard Overlay zone. The TIMs may also be referenced in plan policies and/or the overlay zone for purposes of differentiating between areas of higher versus lower risk.*

b. *Tsunami Hazard Overlay Zone Map (THO): The overlay zone map(s) should be developed using the applicable DOGAMI Tsunami Inundation Maps or TIMs. In developing the overlay map it is recommended that the overlay area include all five inundation scenarios identified on the TIMs (S, M, L, XL, and XXL) which would ensure that life/safety and evacuation route planning and development are adequately addressed. Other land use resilience strategies and requirements included within the overlay zone, which are not life safety or evacuation related, may be applied within a subset of the overlay to smaller inundation scenario areas subject to the community's risk tolerance and application of mitigation measures. The map(s) should be adopted in the form of an amendment to the official zoning map for the community.*

c. *Tsunami Evacuation Facilities Improvement Plan Maps: The Tsunami Evacuation Facilities Improvement Plan will typically include a map or maps that identify designated evacuation routes, assembly areas and other components of the local evacuation system. This map would be included in the adoption of the overall Tsunami Evacuation Facilities Improvement Plan. The Tsunami Evacuation Facilities Improvement Plan should, in turn, be incorporated into the community's comprehensive plan or transportation system plan, as appropriate.*

2.7 Groundwater

Findings

a. Groundwater pollution is technically not a geologic hazard in that the main cause of the problem lies in the activities of man rather than acts of nature. Because an understanding of geologic conditions is fundamental to the prevention or treatment of groundwater pollution, however, it is included here (Geologic Hazards Inventory of the Oregon Coastal Zone, p. 29).

b. The study area is characterized by heavy winter rains, dry summers, impermeable bedrock, variable vegetative cover, and gentle to steep slopes. Relatively little water is retained by the ground. Total runoff amounts to approximately three-fourths of the annual precipitation and it is concentrated in the winter months (Bulletin 79, p. 52).

c. Bedrock consists of “tight" volcanic and sedimentary rocks in the Nestucca, Trask, and Wilson River drainages and in the lower Nehalem Basin. Bedrock in the upper Nehalem Basin consists of impermeable clay siltstone and minor sandstone (Bulletin79, p. 52).

d. The lack of consolidation and the flat topography expression of the terrace deposits in the upper Nehalem River Basin apparently favor the storage of groundwater and the overall well production there is significantly higher than in the valleys to the south (Bulletin 79, p. 52).

e. In the upland areas water wells are basically restricted to valley and canyon bottoms. Because stream flow is so low in the dry summer months and runoff is so abrupt following winter storms, it can be inferred that infiltration on the mountain slopes is minimal and water potential away from the major valleys is very low. Almost all producing wells are drilled in sedimentary rock (Bulletin 79, p. 52).

f. Static water level is 50 feet or less in most wells of the Nehalem River Valley and it is 30 feet or less in most of the wells of Tillamook County. Total depth of producing wells is generally less than 200 feet. Water production is erratic even within small areas (Bulletin 79, p. 52).

g. Most of the producing wells yield approximately 10 gallons per minute in inland Tillamook County. However, the Tillamook Valley is underlain by extensive alluvial sand and gravel layers which locally can produce large volumes from high-yield wells. The total potential sustained yield of the area has not been determined, but it undoubtedly is much greater than is presently produced. Individual large-diameter wells in Tillamook Valley can produce more than 1000 gallons per minute (Bulletin 74, p. 133).

Policies

a. Measures shall be recognized that assure the protection of recharge areas of groundwater aquifers that have immediate or future potential use.

b. Future planning for the uplands shall consider the restrictions inherent in the low groundwater potential of the area.

c. Buoyant structures such as basements, buried gas tanks, and swimming pools shall not be permitted in areas of high groundwater table.