CHAPTER

2

STATE OF THE BAY

The Land and the People

The Tillamook Bay estuary is about 60 miles west of Portland and 45 miles south of Astoria on the Oregon Coast. Like other Northwest Coast estuaries, it supports diverse living resources including anadromous fish, shellfish, and birds; some of which have been listed as threatened or endangered species.

Tucked between the rugged Coast Range and the Pacific Ocean, Tillamook Bay drains a 597 mi^2 watershed that includes some of North America's richest timber and dairy land. The Bay supports an oyster aquaculture industry and boasts some of the best salmon fishing on the West Coast. Historically dependent on resource industries, the Tillamook Bay area economy increasingly relies on tourism and transfer payments to support about 25,000 citizens. Yet dairy farming, logging, and fishing continue to define the cultural landscape of the area.

Years of development and change to the landscape created several environmental problems that result in conflicts among the diverse user groups in the Watershed. For example, high bacterial inputs from agricultural and urban sources cause closures of shellfish beds about 90 days per year. In other cases, important fish and wildlife habitat has been modified and simplified to provide for transportation, agriculture, urban development, and forestry.

To address environmental issues in the Bay and Watershed, the 1992 nomination to the National Estuary Program defined three priority problems:

- *pathogen contamination affecting shellfish and water contact use;*
- *sedimentation affecting freshwater and saltwater flows and habitat for bay shellfish and fish; and*
- *changes in living resources in the upper Watershed, particularly due to loss of spawning habitat for anadromous fish.*

After the Flood of 1996, these problems broadened in scope and the Management Committee added a fourth priority problem – flooding:

- *The interaction of human activities with dynamic natural systems has increased the magnitude, frequency, and impacts of flood events.*

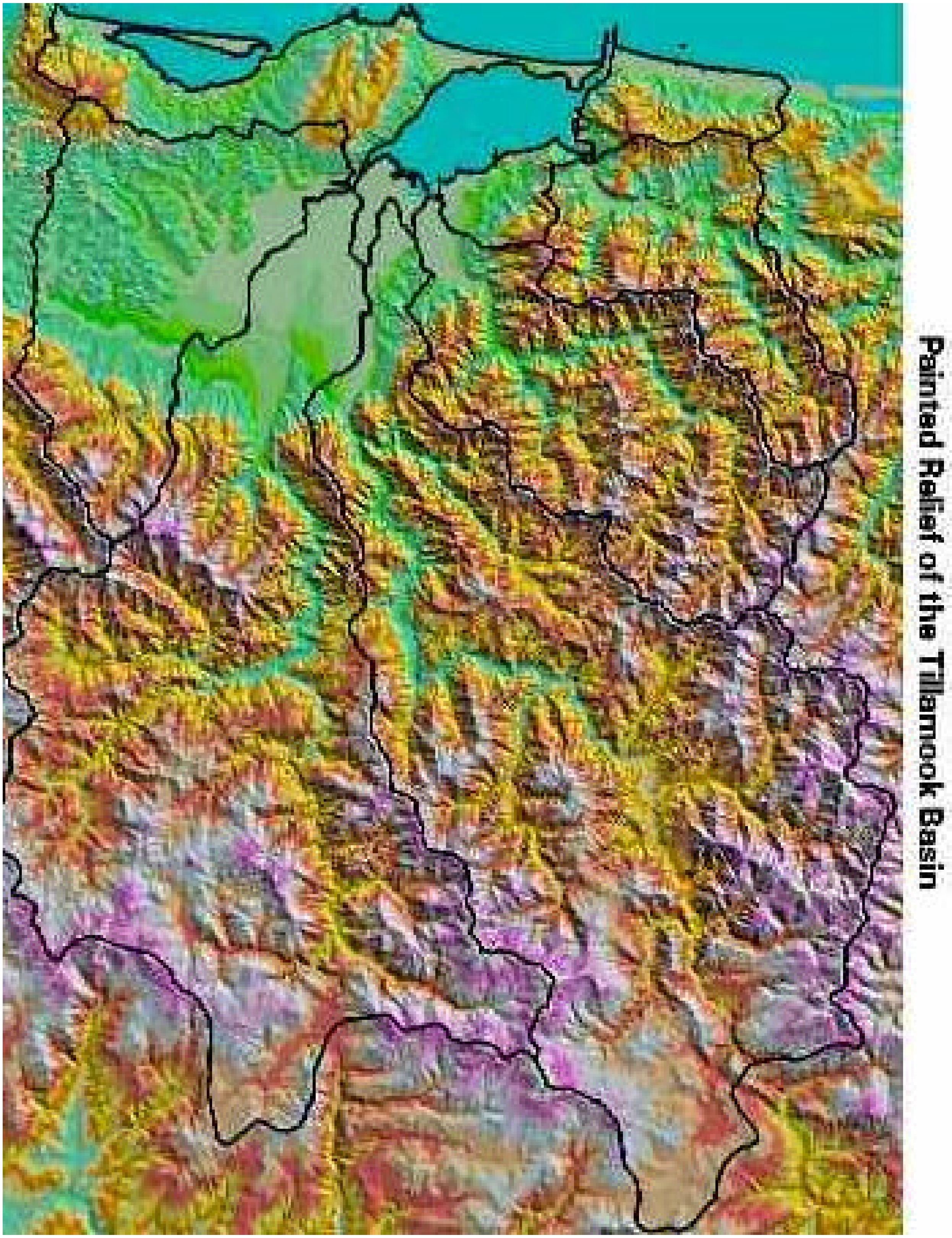


Figure 2-1. Painted relief map of Tillamook Basin.
Source: Larry Reigel, U.S. Fish and Wildlife Service, Oregon State Office.

This chapter provides a brief environmental characterization of the Bay and Watershed. It includes a geographic overview followed by a description of the four priority problems confronting the community. For each problem, the chapter describes the causes of the problem, reviews status and trends of relevant resources and contaminants, and describes goals and objectives to address the problem.

The Bay and the Watershed

Tillamook Bay is a shallow estuary averaging only 6.6 feet (2 m) deep over its 13 square miles (34 km^2). At low tide, about half of the Estuary bottom is exposed as intertidal sand/mud flats, presenting navigational challenges similar to those facing the first known European explorers who entered the Bay in 1797. Today, these intertidal flats provide important growing areas for oyster culture.

Several deep channels, running roughly north-south, represent the geological signatures of river mouths drowned by the rising Pacific Ocean about 9,000 years ago. Boaters and fish, including salmon, depend on these channels. The Oregon Department of Fish and Wildlife (ODFW) rates Tillamook Bay as the State's premier recreational shellfishing area.

The last ocean-bound ship left the town of Tillamook in 1912. Anxious to improve ocean-borne commerce, developers dredged and modified the main navigational channels in the Bay and river mouths. But heavy sediment loads convinced the U.S. Army Corps of Engineers (COE) to stop dredging the main Bay in 1913. The Corps, which last dredged the mouths of the Trask and Wilson Rivers in an attempt to control flooding in 1972, discontinued river dredging primarily due to high costs. Today only the Port of Garibaldi at the northern end of the Bay serves deep-water traffic.

Five rivers enter Tillamook Bay from the south, east, and north. See Figures 1-1 and 2-1. Salmon fishermen still recognize the Bay and its rivers — the Tillamook, Trask, Wilson, Kilchis, and Miami — as some of the West Coast's most productive fish habitats. In 1998, the Wilson River produced more juvenile Chinook salmon than any other monitored river in coastal Oregon (Dalton *et. al.* 1998). See Table 2-1. Yet the current harvest of Chinook, chum, coho, and steelhead pales compared with the bounty of earlier years. In August 1998, the National Marine Fisheries Service (NMFS) listed the North Coast coho salmon as a threatened species and populations of chum and steelhead have been declining. Conditions have been more favorable for Chinook, with very strong runs in recent years. A number of factors have been identified as possible contributors to the decline of salmonids, including: over-harvesting, hatchery practices, loss or simplification of habitat (reducing spawning and rearing success), poor ocean conditions, and reduced water quality.

Table 2-1. Number of juvenile Chinook salmon captured, estimated migrants and migrants per meter of stream length, by age class, for ODFW monitored streams of the Oregon Coast, 1998.

Stream (tributary to)	Length (meters)	Number Captured	Estimated Migrants	Migrants per meter
North Fork Nehalem River	70,675	67,962	984,449	13.929
Little North Fork Wilson River	27,891	204,907	1,223,944	43.883
Little South Fork Kilchis River	11,703	22,347	109,097	9.322
Little Nestucca River	101,122	13,795	98,679	0.799
Siletz Mill Creek	30,907	1	?	?
Bales Creek (upper Yaquina)	7,895	40,937	249,308	31.578
Yaquina Mill Creek	16,862	2,003	7,063	0.419
Cascade Creek	11,465	8	26	0.002
Tenmile Creek (combined) (ocean)	30,971	950	3,396	0.110
West Fork Smith River (Umpqua)	59,716	29,715	127,726	2.139
North Fork Coquille River	51,529	6,481	38,199	0.741

Source: Adapted from Dalton, T. 1998. *Juvenile Salmonid Outmigration in the Little North Fork Wilson and Little South Fork Kilchis Rivers*. Oregon Department of Fish and Wildlife study for the Tillamook Bay National Estuary Project, Garibaldi, OR.

Like most Pacific Northwest estuaries, Tillamook Bay is part of a coastal, temperate rainforest ecosystem. Much of the Tillamook Bay Watershed, especially the uplands (in this document, areas above 500 feet elevation), is rich forest, blanketing the rainy Coast Range. Mean annual precipitation averages 90 inches (229 cm) per year in the lower basin and close to 200 inches (510 cm) per year in the uplands. The Watershed’s coniferous forests – trees such as Douglas fir, true fir, spruce, cedar, and hemlock – cover about 89% of the total land area. Hardwood species such as alder and maple also grow throughout the region. Most of the older trees have been lost to fire and timber harvest. Today, Douglas fir is the dominant species. Foresters describe this environment as “highly productive,” from both biological and commodity perspectives.

In the lower Watershed, forest gives way to rich alluvial plains used primarily for dairy agriculture. Meandering rivers and networks of small channels once provided plentiful fish habitat, large wood, and organic matter. Early settlers recognized the rich agricultural potential of this land and drained it with numerous dikes, levees, and ditches. Today's 40 mi^2 (104 km^2) of agricultural lowland supports about 28,600 dairy cattle[1], producing 95% of Oregon’s cheese. Cattle also produce hundreds of thousands of tons of manure annually and much of the bacteria washing into the Estuary. Urban and rural residential development contributes

[1] Calculated in 1,000-pound units, including calves, heifers, and dry stock
Source: Pedersen, B. pers. com. (1998)

significant fecal bacterial contamination during heavy storms and untreated stormwater carries grease, pesticides, sediment, and animal waste. Development also impairs floodplain function and lowland habitat.

The Estuary

Several deep channels wind through intertidal mud flats that are exposed at low tide. The Bay receives fresh water from five rivers and exchanges ocean water through a single channel in the northwest corner. Despite large freshwater inflows, especially during the rainy winter months, heavy tidal fluxes dominate the system. Extreme diurnal tides can reach 13.5 ft (4.1 m), with a mean tidal range of 5.6 ft (1.7 m) and diurnal range of 7.5 feet (2.3 m). Tidal effects extend various distances up the rivers, ranging from 0.4 miles (0.6 km) for the Miami River, to 6.8 miles (11 km) for the Tillamook River (Komar 1997). The volume of water entering the Bay due to tides has been estimated at 1.63 x 10^9 cubic feet (4.63 x 10^7 cubic meters) (Perch *et al.* 1974). See Table 2-2.

The Bay experiences the full range of estuarine circulation patterns, from well stratified to well mixed, depending on the season and variations in river discharge. During heavy rain winter months, November through March, researchers describe a stratified system, but during low precipitation summer months, the Bay shifts to a well-mixed estuarine system (Komar 1997). Salinity ranges from around 32 ppt near the ocean entrance to around 5 ppt at the upper (southern) end of the Bay near the river mouths. Water temperature ranges from around 47–66^{o}F (8–19^{o}C) over the year. The Estuary maintains relatively high levels of dissolved oxygen (DO) throughout the year and ranges from about 6.0 ppm to 12.0 ppm. Except for some lowland sloughs and tributaries, eutrophication and low DO do not appear to be problems for Tillamook Bay. However the Bay experiences high levels of bacteria, especially after storms and associated agricultural and urban runoff and point source overflow. Chapter 5, Water Quality, discusses water quality problems and the actions proposed to achieve water quality goals.

When rising sea levels drowned the river mouths to create Tillamook Bay about 9,000 years ago (USDA 1978), large amounts of marine sediments entered the Bay until about 6,000 years ago, when the Estuary reached a dynamic equilibrium between sediment deposition and resuspension. (as cited in Coulton *et al.* 1996). A predominant northern longshore drift deposited sands to create the elongated north-south peninsula known today as Bayocean Spit. The spit generally protected the Estuary from ocean intrusion until 1952, when the sea breached the eroding spit and deposited additional marine sediments in the southwestern corner of the Bay. The COE documented a decrease in Bay water volumes from 40,614,928 yd^3

Table 2-2. Comparison of Representative Estuaries in Coast Range Ecoregion

Estuary	Total Area* (Acres)	Drainage Basin (Square Miles)	Intertidal Area (% of Total Area)	Mean Flow (cfs)
Oregon				
Alsea Bay	2,516	474	71	2,070
Chetco River	171	359	11	1,700
Coos Bay	13,300	605	60	2,200
Coquille River	1,083	1,085	56	3,300
Elk River	290	94	NA	610
Necanicum Bay	451	87	60	NA
Nehalem Bay	2,749	855	64	3,600
Nestucca Bay	2,176	322	73	1,540
Netarts Bay	2,743	14	88	N/A
Pistol River	230	106	NA	N/A
Rogue River	880	5,100	35	7,800
Salmon River	438	75	78	538
Siletz River	1,461	373	78	1,930
Siuslaw River	3,060	773	53	3,150
Sixes River	330	129	NA	646
Tillamook	9,216	570**	60	2,164
Winchester Bay	6,543	4,560	43	7,435
Winchuck River	130	70	NA	NA
Yaquina Bay	4,349	253	54	1,078
Washington				
Grays Harbor	58,000	2,550	63	NA
Willapa Bay	79,000	720	50+	NA
California				
Humboldt Bay	NA	220	NA	N/A
Eel River	NA	3,622	NA	9,700
Klamath River	NA	15,480	NA	20,600

*At Mean High Water. **The watersheds of the five rivers only. The total Tillamook Bay Watershed, including the Bay, covers 597 square miles.

Sources: NOAA, 1985; Percy *et al*. 1974, U.S. Army Corps of Engineers 1989.

(31,051,168 m^3) in 1867 to 30,690,992 yd^3 (23,464,061 m^3) in 1954. Bay volume rebounded to 32,475,034 yd^3 (24,828,008 m^3) by 1995.

The estuary provides habitat for numerous fish, shellfish, birds, marine mammals, and sea grasses. See Figure 2-2. A 1974-1976 monthly seine and trawl survey (Bottom and Forsberg 1978) identified 59 species of fish in the Bay at various times of the year. Five species of anadromous salmonids use the estuary at some point in their life cycle. A 1996 TBNEP survey (Golden *et al.* 1998) identified 154 benthic invertebrate species. The prolific benthic community includes rich clam beds dense areas of eelgrass, and abundant burrowing shrimp communities. Clams and Dungeness crabs continue to provide important commercial and recreational fisheries. The Bay also provides important habitat for many birds migrating on the Pacific flyway. After earlier declines, the seal population has grown in recent years due to marine mammal protection laws. Today, groups of these marine mammals can be seen sunning themselves on intertidal sand flats at low tide.

In the tidal and subtidal estuary, eelgrass beds provide important habitat for crabs and fish species such as salmon, herring, northern anchovy, and smelt. Although eelgrass beds show great spatial variability, the Bay currently contains healthy eelgrass beds.

In the intertidal areas, anecdotal evidence suggests increased burrowing shrimp populations. The ghost or sand shrimp, *Neotrypaea californiensis*, and mud shrimp, *Upogebia pugettensis,* both dig burrows 10–20 inches (25.6-51 cm) deep. Undermined by burrowing shrimp, oysters sink into the sediment and suffocate. Scientists and oyster growers speculate over options for controlling burrowing shrimp and reasons for their population growth. However, few solid facts exist regarding the ecological interactions between oysters, eelgrass, and burrowing shrimp. The TBNEP recently began a 4-year study to explore the question.

From a management perspective, the Oregon Department of Land Conservation and Development (DLCD) classifies Tillamook Bay as a "shallow draft development" estuary under Goal 16 of the Statewide Planning Goals. This classification categorizes Tillamook Bay as an "estuary with maintained jetties and a main channel (not entrance channel) maintained by dredging at less that 22 feet (6.7 m); these estuaries have development, conservation, and natural management units." (DLCD 1987).

State and local planners define management units according to biological and physical features and allow particular activities and uses in those areas, while prohibiting others. Portions of the estuary shorelands are zoned for urban, rural, natural, conservation and development use. Special shoreland sites allow for dredging and channel maintenance, water-dependent development, mitigation and restoration sites, and protection of neighboring wetland areas and significant habitat sites.

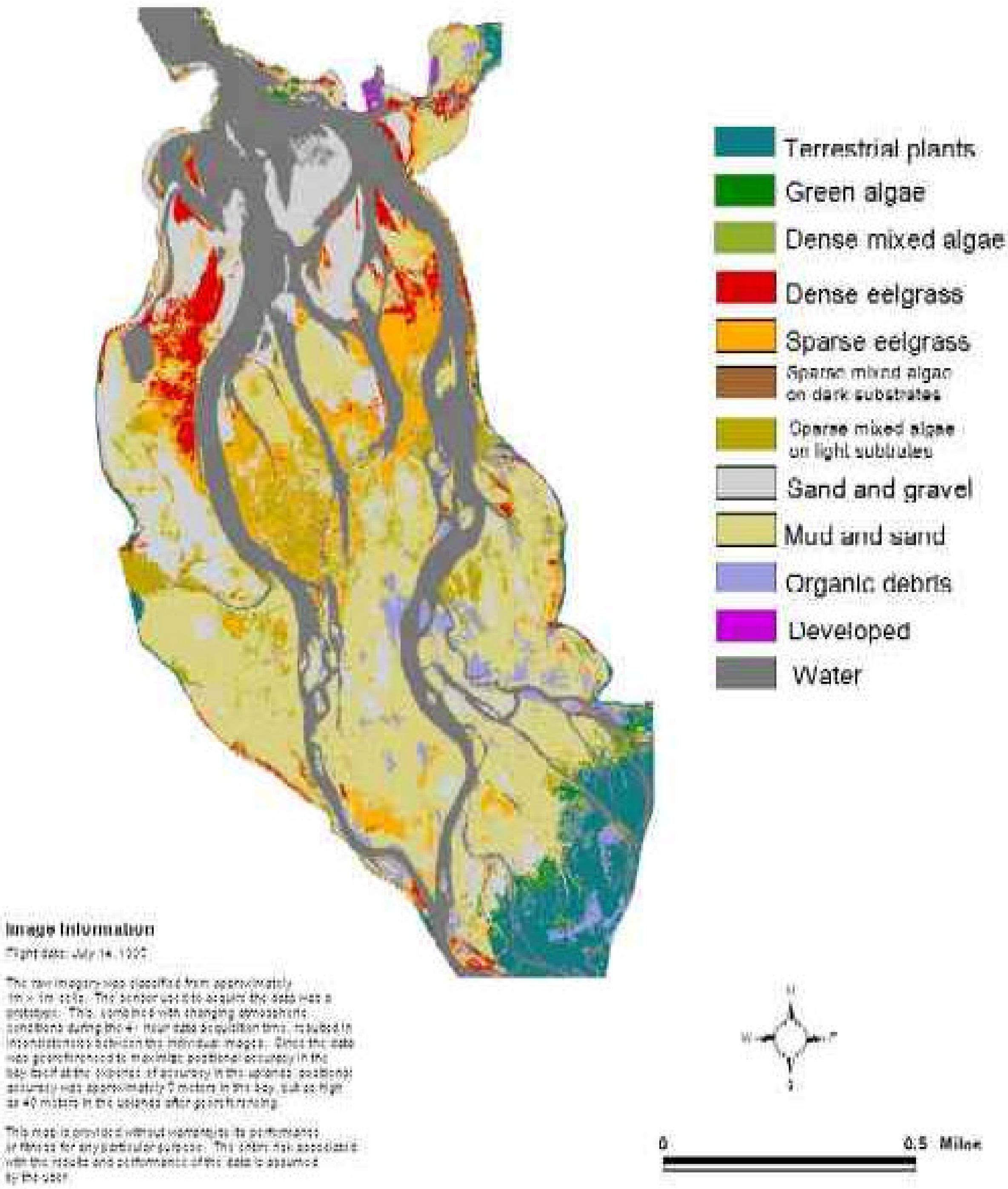


Figure 2-2 shows the diverse benthic habitats of Tillamook Bay. This map shows eelgrass beds that serve as baseline monitoring data.
Source: Strittholt, J., and P. Frost. 1996. Determining Abundance and Distribution of Eelgrass (Zostera spp.) in the Tillamook Bay Estuary, Oregon Using Multispectral Airborne Imagery.

Climate

Tillamook County receives a lot of rain. From 1961 through 1990, The City of Tillamook averaged 90 inches (229 cm) of rain per year with 76% of total precipitation occurring from October through March. The highest precipitation and rainfall events occurred during November, December, and January. Tillamook County averaged more than 23 days per year in which precipitation exceeded 1 inch (2.54 cm). In 1996, however, 126 inches (320 cm) of lowland rain (and very heavy upland rain and snow) led to severe flooding throughout the Basin and caused significant economic and environmental damages. New flooding at the close of 1998 added to the toll. Chapter 7, Flooding, provides an overview of flood problems and trends and proposes actions and goals for reducing flood damage.

The seasonal, episodic nature of precipitation defines the natural system. Fall Chinook migrate upstream with the first heavy rains of autumn. Big storms can cause major landslides in the steeply sloped upland regions. Although heavy storms have characterized the natural system for thousands of years, human activities have exacerbated the impacts and consequences of high rainfall (Coulton *et al.* 1996).

Westerly winds predominate and carry the temperature-moderating effects of the ocean over all of western Oregon. Summers are cool and dry; winters wet and moderate (USDA 1964). Winds blow nearly continuously throughout the year and often reach gale force in the winter. Prevailing winds come from the northwest during the summer and from the south and southwest during the winter.

Temperatures in Tillamook County are moderate. The mean annual temperature is 50.4^{o}F (10.2^{o}C), with yearly mean maximum and mean minimum temperatures documented at 59.3^{o}F (15.1^{o}C) and 41.6^{o}F (5.4^{o}C), respectively. Those 30 years averaged less than one day per year with a temperature over 90^{o}F (32^{o}C). September had the greatest number of extreme temperatures while July and August recorded the highest temperature of 102^{o}F (38.89^{o}C).

Hydrology

As noted above, the Tillamook Watershed receives abundant precipitation. The Tillamook basin drains the west slope of the Coast Range, where precipitation increases with elevation. Due to relatively warm winter temperatures, most precipitation falls as rain. Large rainfall events can produce flood events. However, the rare combination of snowmelt and an influx of warm, wet subtropical moisture cause most of the largest flood events (1964 and February 1996).

Most soils in the Tillamook basin have very high infiltration rates and overland flow is uncommon. Overland flow can occur when soils become saturated during major rainstorms or frozen during unusually cold weather. Land use practices can, to a limited degree, impact soil infiltration rates. Land use practices, such as road building, can also cause subsurface flow to become overland flow. The belief that forests beneficially reduce flooding has been the source of considerable debate. Forest harvesting and roads have been found to modify stream flows in small basins. Results for small basins (Ziemer and Lisle 1998) suggest that timber harvesting can increase summer low flows and average fall peak flow. However, Ziemer and Lisle also found no appreciable increase in peak flows for the largest of floods from timber harvesting in the Pacific Northwest (and elsewhere).

Proponents of the belief that forests can reduce floods have often applied a concept called hydrological maturity. This concept hypothesizes that as the vegetation in a watershed becomes "more mature," the risk of floods diminishes. Interestingly, the average age of the forests in the Tillamook Watershed has increased annually since the great Tillamook Burn fires. Thus, the perception by some that the frequency of flooding has increased over the same time is inconsistent with the change in the "hydrologic maturity" of the basin.

Soils and Geology

Tillamook Bay and its Watershed are situated in typical Pacific Northwest coastal terrain. A relatively straight coastline consists of miles of sandy beaches punctuated with cliffs of igneous rock and small inlets such as the Bay. East of the Pacific Coast, the high, steep ridges of the Coast Range climb up to 3,500 feet (1,064 m). These forested upland areas consist mostly of volcanic basalt base material with moderately deep overlying soils formed from basalt, shale, and sandstone material.

A discontinuous coastal plain separates the coast and the mountains. Derived from basalt and sandstone-shale bedrock, these deep, level floodplain soils have been deposited over thousands of years by the streams and rivers. These soil deposits range in width from a few hundred feet to more than a mile and can extend upstream up to seven miles along broad stream channels. These are among the most fertile soils in the area, but require drainage for maximum productivity. Originally, this land was almost all forested; but most has been cleared and is used for silage and pasture. Most farmers irrigate their land in the dry summer months. Between the bottomland floodplain and the forested regions, extensive alluvial terraces extend up to 80 feet (24 meters). These soils, with high to medium organic content, make up about 50% of the Tillamook Basin=s tillable lands. More detailed soil information appears in the TBNEP *Environmental Characterization Report*, Chapters 1 and 5.

Vegetative Communities

Approximately 89% of the Watershed is forestland, based on geographic imaging. The natural, or potential vegetation of the Tillamook Basin is evenly distributed between the Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) vegetation zones. These two vegetation zones extend from British Columbia to Northern California, running roughly parallel to the coast with the hemlock zone also enclosing the Willamette Valley (Franklin and Dryness 1973). However, disturbance has drastically affected the Tillamook basin's vegetation.

Natural disturbance from fire, flood, windstorm, or large geologic event resets the successional dynamics of the vegetative communities. Disturbance is characterized in part by its frequency and magnitude. For the Tillamook Watershed, a number of disturbance events play important roles in shaping the basin. Historically, the upland forests were likely burned relatively infrequently, but with very high intensity. Winter windstorms may have helped set the stage for the catastrophic fires by creating large areas of blowdown. The lowland forest may have burned somewhat more frequently, due to fires set by Native Americans. Debris flows and (within floodplains) floods disturbed riparian forests fairly often. Historical riparian forests in the Tillamook were often hardwood dominated (*e.g.* alder, cottonwood, willow, crabapple) or mixed hardwood and conifer (Coulton 1996). A series of human-caused forest fires beginning in the 1930s, known as the Tillamook Burn, burned much of the natural vegetation of the mixed conifer upland forests, and most have been replanted in Douglas fir trees. Hardwoods continue to dominate riparian areas.

The spruce zone covers the lower regions of the Watershed and normally occurs at elevations below 450 feet (150 meters). It is a wet zone with annual precipitation ranges between 78 inches (200 cm) and 118 inches (300 cm). The nearby ocean adds frequent summer fogs and moisture to otherwise dry months and distinguishes the spruce zone from the higher elevation hemlock zone. The temperature averages 51^{o}F (10.6^{o}C) annually with an average January minimum of 40^{o}F (4.7^{o}C) and a July maximum of 70^{o}F (20.6^{o}C) at Astoria. The soils are deep, fine textured, typically acid (pH 5.0 to 5.5) and high in organic matter (15–20%).

Dense, tall stands of Sitka spruce, western hemlock, western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), and grand fir (*Abies grandis*) dominate the spruce zone. In dune areas close to the ocean, shore pine (*Pinus contorta contorta*) is locally common. Following disturbance by fire, logging, or windstorm, a dense shrub community often dominates the spruce zone, eventually yielding to either a dense stand of red alder, or a mixture of spruce, hemlock, and Douglas fir. Replacement of the alder stands can be very slow, due to the dense shrub understory. The resulting communities are semi-permanent brush fields, spruce stands, or red cedar and hemlock that grew on downed logs.

The hemlock zone normally extends in elevation between 450 feet (150 meters) and the subalpine zone of the Coast Range. With less ocean influence and summer fog, the upland hemlock zone still receives heavy precipitation. In fact, the upland regions average up to 142 inches (360 cm) of rain each year with very little precipitation in the late spring to fall period. The zone temperature averages 50°F (9.6°C) annually with a January minimum of 30°F (-0.7°C) and a July maximum of 78°F (25.6°C) at Valsetz. The soils are derived from sedimentary and basalt parent materials, of moderate depth and medium acidity, with a high infiltration rate.

In the hemlock zone the dominant vegetation is dense conifer forest. Forest stands are dominated by Douglas fir, western hemlock, and western red cedar, with other conifers mixed in, such as grand fir, Sitka spruce, and Pacific yew (*Taxus brevifolia*). Hardwood species occurring in the hemlock zone include red alder, bigleaf maple, black cottonwood (*Populus trichocarpa*), and Oregon ash (*Fraxinus latifolia*). Following disturbance, these zones generally grow up in first year residual species and invaders of the groundsel *(Senecio)* and willowherb (*Epilobium)* genera. This community is replaced during years two to five by one dominated by fireweed (*Epilobium angustifolium*), thistle (*Cirsium vulgare*), and bracken fern (*Pteridium aquilinum*). Shrubs such as vine maple, Oregon grape, salal, and blackberries (*Rubus* spp.) dominate the next community. Eventually conifers such as Douglas fir overtop the shrubs.

Settlement and Commerce

The Native Americans inhabiting the Tillamook Basin at the time of European contact were known as the Nehalem band of the Killimuck (also known as Tillamook) tribe (Seaburg and Miller 1990). They tapped marine, riverine, estuarine, and terrestrial sources for a broad-ranging diet and stable food supply. The only recorded alteration to the landscape caused by the Killimuck was periodic burning of the lowlands to encourage growth of grains and produce pasturage for horses (Coulton *et al.* 1996). This burning kept some lowlands open and clear of stands of large trees.

The first European-American settler in the region, Joseph Champion, landed a whaling boat on the banks of the Estuary and lived the winter of 1851 in a tree stump. Henry W. Wilson brought the first cattle into the area in 1852 and the population grew to 80 by 1854. Most settlers came to the Watershed to farm, and immediately began clearing, diking, and draining the lowland forest to make more farm land available. They also converted a significant portion of the intertidal and freshwater wetlands to pasture by the early 1900s (Coulton *et al.* 1996). Cheese was the best way to market milk from this remote area, and many small cheese factories opened. Ten smaller cheese producing cooperatives joined forces in 1909 as the Tillamook County Creamery Association. Today, agriculture occupies 6% of the Watershed. See ownership map, figure 2-3.

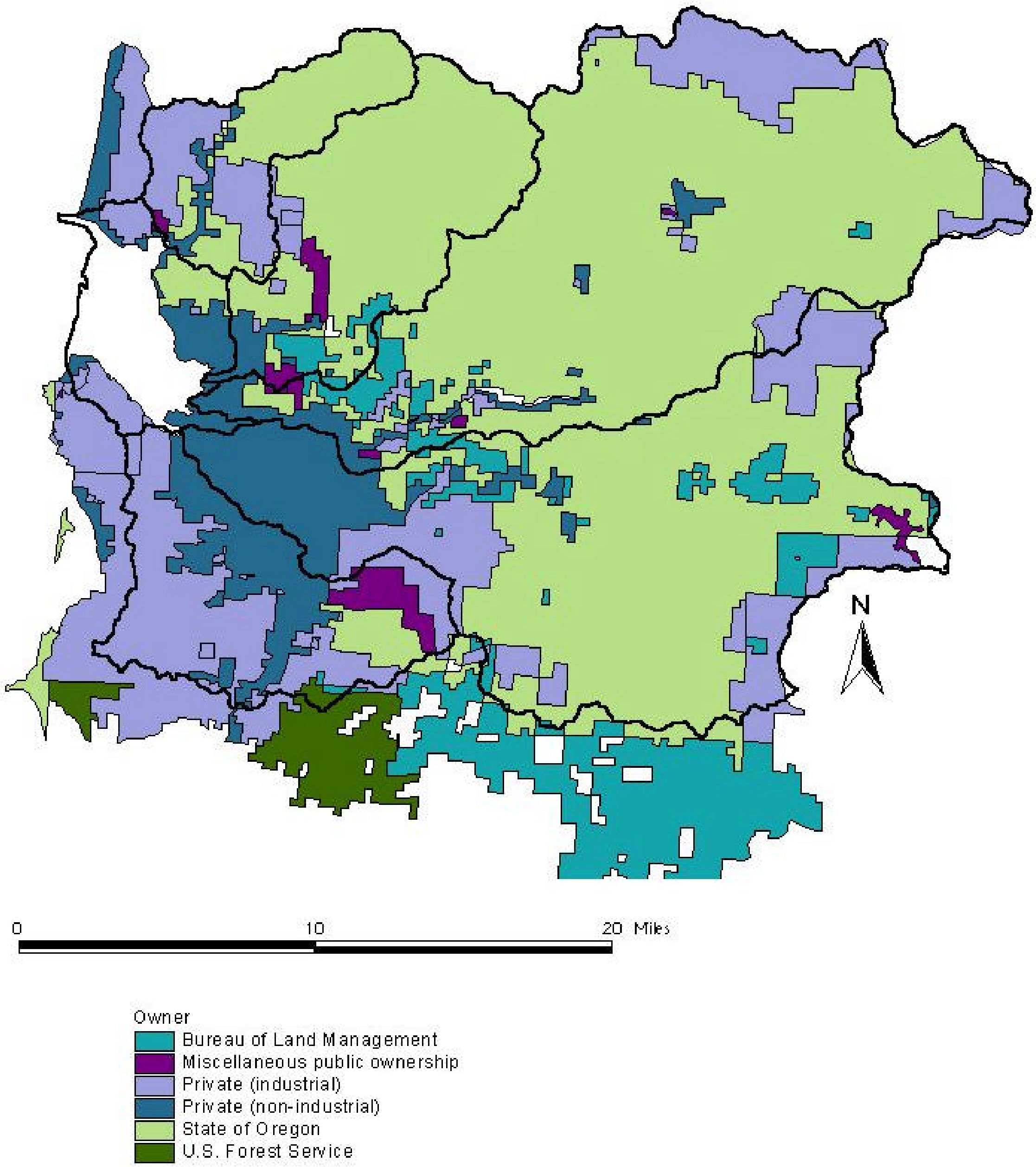


Figure 2-3. Ownership of land in the Tillamook Bay Watershed.
Source: Tillamook Coastal Watershed Resource Center, from TBNEP Geographic Information Systems (GIS) database. Bay City, OR.

Early settlers shipped their products by boat, and port activities (from Tillamook and Garibaldi) such as importing and exporting, shipping, and navigational improvements have long been part of the local economy. Boats needed deepwater channels to transport logs and lumber to West Coast markets (Levesque 1985). The Port of Tillamook maintained a shallow draft channel before 1913 as far as the City of Tillamook for ocean-going ships, and the main navigation channel was dredged regularly, beginning in the late 1880s. Dredging near the City of Tillamook ended in the 1920s. The Corps of Engineers last dredged the mouths of the Wilson and Trask Rivers in 1972 in an attempt to alleviate flooding, but ended dredging due to cost considerations.

The North Jetty, completed in 1918, was intended to aid navigation, but may have had the opposite effect by accelerating sand accretion in the Bay (Coulton *et al.* 1996). Logistical improvements and cost reductions over the past few decades have made road transportation much more viable than marine shipping. The County's main highway link with the Willamette Valley, Highway 6, follows the Wilson River east through the Coast Range. Rail transportation also handles a portion of the County's shipping. The railroad begins at the Port of Tillamook Bay Industrial Park just south of the Trask River and crosses the Trask, Wilson, Kilchis, and Miami Rivers to pass north out of the Tillamook Bay drainage.

Although natural resource extraction industries have historically supported the Tillamook Bay region, the Watershed became a tourist destination around the turn of the century (Coulton *et al.* 1996). Hiking, beach combing, wildlife viewing, sport fishing, off road vehicle use, crabbing, and clamming draw numerous tourists. Many people, especially retirees, are also finding the Tillamook Bay Watershed an attractive place to live. See Figure 2-3. Thus recreational users are competing for natural resources traditionally devoted to farming, fishing, and forestry.

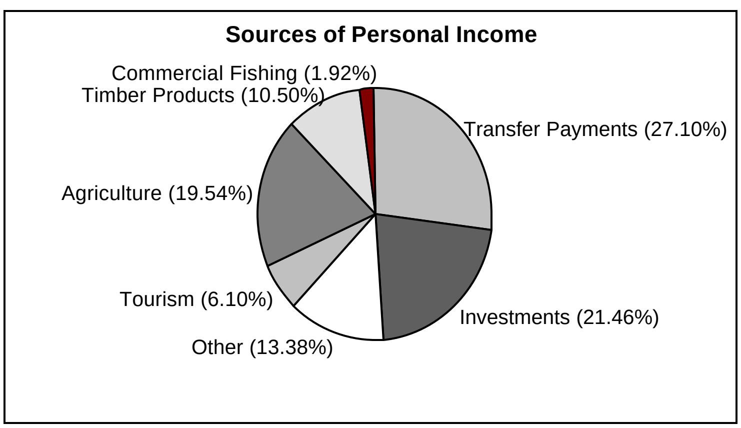


Fig 2-4. Sources of personal income in Tillamook County, 1993.
Source: Radtke, H.D. 1995. Economic trends in the northern coastal regional economy. Report prepared for the Tillamook Bay National Estuary Project, Garibaldi, OR.

The Priority Problems:

Key Habitat Loss and Simplification

Priority Problem

Loss and simplification of key habitat, and past and present fisheries practices, have contributed to declines in salmonids and other aquatic and estuarine associated organisms. Important riparian, instream, freshwater off-channel, tidal slough, and estuarine habitats have been lost or degraded. Fishery practices include management of natural production, hatcheries, and harvest.

Anadromous salmon and trout runs are integral to the economy, ecology, and culture of the Pacific Northwest. Yet these salmonid species are under stress throughout the Coast Range ecoregion. After years of declining populations, the National Marine Fishery Service (NMFS) listed the coho salmon as an endangered species in August, 1998.

Factors contributing to the decline of salmonids include: over-harvesting; hatchery practices; poor ocean conditions; human-caused barriers to fish passage; channel form changes; loss of large wood; and loss or modification of riparian, instream, wetland, estuarine, and tidal habitat. Many of the practices that produced these factors for decline have been modified or eliminated. Nonetheless, the Watershed retains a legacy from these past practices. Other practices contributing to the factors for decline may not yet have been changed to adequately minimize adverse effects.

In the Estuary, sediments from the Watershed and ocean have altered Bay bathymetry and habitats. Many believe the large introduction of marine sediments resulting from an ocean breach of Bayocean Spit in 1952 improved habitat for burrowing shrimp. These species continue to plague oyster growers by loosening sediments and causing oysters and other shellfish to sink or be buried. Heavy sediment loads due to extensive forest fires and past logging activities may have contributed to habitat change around the southern end of the Bay. Changes in estuarine sedimentation patterns may adversely affect ecological interactions among eelgrass, burrowing shrimp, and oysters.

This section documents status and trends of key habitats in the Tillamook Bay Watershed and describes how these changes affect living resources.

Habitat Status and Trends

Lowland/floodplain habitat. Agricultural and urban development in the lowland floodplains altered riparian and instream habitats vital to salmon and other aquatic species. In earlier times, bottom land forest and open grassland covered a rich alluvial plain that regularly flooded in winter. This lowland floodplain's off-channel sloughs, oxbows, and wetlands provided ample habitat for rearing fish. A forest of mixed hardwoods and conifers supplied organic matter and insects to feed fish and support aquatic food webs. Large log jams in the main rivers led to frequent seasonal flooding in the floodplains, regularly depositing sediments to lowland areas and providing large areas of salmonid habitat. Log jams and other large wood also created scour pools in the mainstream channels.

Adequate levels of large wood are an important component of healthy salmonid habitat. It is widely acknowledged, however, that the total amount and distribution of large wood has been greatly reduced over the last century to levels significantly below what existed historically across the landscape. Early developers cut down riparian trees to expedite log drives and cleared logjams to reduce flooding and improve navigation. Around 1900, loggers used splash dams to move logs downstream and subsequently damaged instream and riparian habitat in several river reaches. Prior to the early 1980s, ODFW policy was to clear streams and rivers of wood to enhance fish passage. Such activities - as well as urban development, impervious surfaces, and other land changes - caused changes in the hydrograph, sediment routing and deposition, and channel complexity. Stream habitat survey results in the Oregon Coastal Basin show that large wood levels in streams are lower than desired. The ODFW rates about 40% as "adequate to good" and about 60% as "poor." See Table 2-3. The Oregon Plan for Salmon and Watersheds (OPSW) includes several voluntary measures to improve the recovery rate for large wood,

Table 2-3. Instream habitat quality according to ODFW Aquatic Inventory Project*

	Good (stream miles)	Fair (stream miles)	Poor (stream miles)
Gravel availability	65	122	110
Gravel quality	184	56	57
Large wood key pieces*	9	21	267*
Large wood pieces	61	54	182
Large wood volume	78	19	199
Pool area	50	77	170
Pool frequency	98	83	116
Riparian vegetation (large wood recruitment potential, thermal cover)	85 (Conifer or mixed conifer and deciduous)	195 (Deciduous)	17 (Brush, grass, or bare)

* More stream stretches were selected by agency priority ranking than on a random basis.

** "Key pieces" must be longer than the active channel width; very difficult in many of these streams.

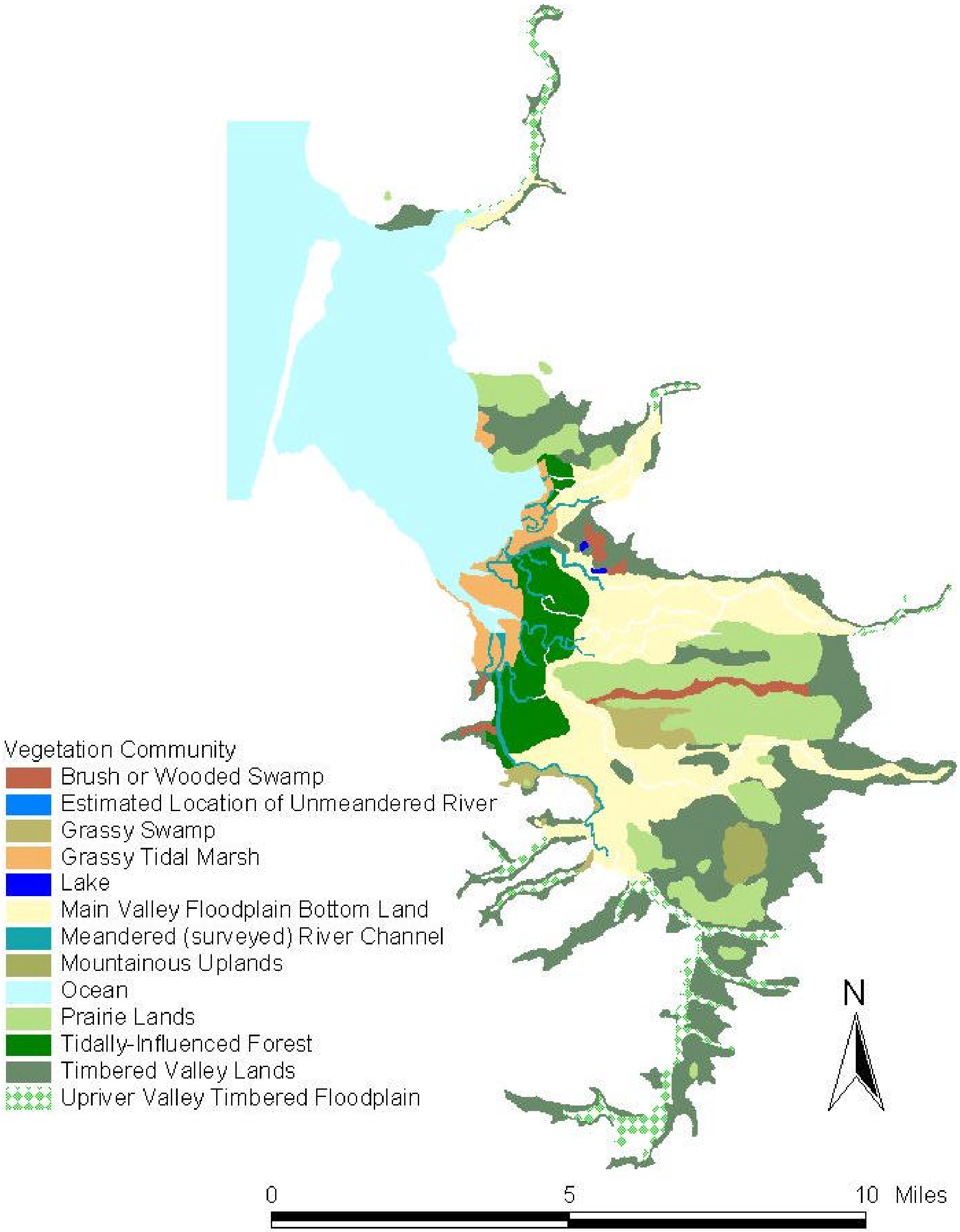


Figure 2-5 Characterization of the Tillamook Bay valley historic landscape, circa 1857.
Source: P. Benner in: Coulton, K., P. Williams, P. Benner and M. Scott. 1996. *Environmental History of the Tillamook Bay Estuary and Watershed*, prepared for the Tillamook Bay National Estuary Project by Philip Williams and Associates, Portland, OR.

Table 2-4: Characteristics of surveyed areas[1]

Parameter	Surveyed Under 500'	Total Under 500'	Surveyed Above 500'	Total Above 500'	Total Surveyed	Total
Stream miles	127	458	170	829.2	297	1287.2
Watershed (mi^2)	89.8	138.8	11.2	458.2	100	597
Uplands (dry)	68		11.4		79.4	
Wetlands:	21.5		.0105		21.5105	
Tidal wetlands	1.6					
- Tidal forest	.02					
Tide flat	8.9					
Freshwater wetlands	5.7		.0105		21.5105	
- Freshwater forested wetland	.5					
Water: (includes Bay and Cape Meares Lake)	5.3					

[1] Compiled by Sean Allen for the Tillamook County Performance Partnership from GIS data: most from 1982 National Wetlands Inventory, except water areas from 1857 survey reconstruction Tillamook Bay outline in Coulton *et al.* 1996.

Table 2-5 Tidal wetland change

Tidal wetland	Total mi^2
Historical amount*	**5.52**
Freshwater today	3.33
Still tidal wetland	0.3
No longer wet	1.89
New** tidal wetland	1.3

* Based on Coquille-Brenner silt loam soils identified in 1964 USDA Soil Survey
** Includes .7 mi^2 designated as water in the 1857 survey (See Coulton *et al.* 1996) and .6 mi^2 which was not included in the 1964 soil survey and can't be determined.

placing pieces in stream channels and relocating in-unit leave trees in core areas to maximize their benefit to salmonids.

The basin has lost most of its floodplain and lowland wetlands. See Figure 2-5 and Tables 2-4 and 2-5. Much of the landscape has been diked, ditched, filled, drained, and cleared, with poorly designed tide gates and culverts cutting off fish access to remaining wetland habitat. Instream habitats have been channelized, straightened, riprapped, and mined. Most lowland riparian areas have been cleared of vegetation, except brush and grass. Livestock have direct access to streambanks and streams in some locations, resulting in crumbling streambanks, trampled vegetation, and disturbed streambeds. Livestock in streams also pose a public health problem by polluting the water with bacteria. Healthy riparian areas still exist in some floodplain and lowland areas, notably along Hoquarten and Squeedunk Sloughs.

Upper watershed habitat. Tillamook County's forestlands have provided timber for wood products industries since the 1880s. While the earliest European American settlers considered the extensive stands of timber a hindrance to farming, the timber industry was the County's most important industry by 1894 (Levesque 1985). As demand for timber products increased and the technology evolved, the number of timber workers and amount of harvested timber increased dramatically. Through the Donation Land Act of 1850, the Homestead Act of 1862, and the Timber and Stone Act of 1878, private timber companies acquired much of the County's valuable timber (Levesque 1985). Large-scale logging began in the early 1900s with no effort to reforest cleared lands.

The Tillamook Burn, a series of forest fires from 1933–1951, profoundly affected the use of forestlands in the region. The fires killed most (about 200,000 acres) of the old-growth timber in the Wilson and Trask river watersheds, burning some areas repeatedly. Roads were then built for salvage logging, fire protection, and replanting (Levesque 1985). Reforestation of the burned acreage began in 1949. Since salvage logging ended in 1959, timber harvesting in the Tillamook Burn area, now the Tillamook State Forest, has been mainly commercial thinning. However, remaining private timberlands have been relatively intensively cut (300 million board feet) in the past 10 years (Labhart, pers. com. 1997).

The huge Tillamook Burn forest fires contributed to relatively high sediment loads during the mid-20th Century. They likely increased surface erosion and were documented to have triggered many debris flows. Moreover, massive salvage logging after the fires left a legacy of poor quality logging roads and skid trails. These changed the frequency and composition of landslides, reducing the supply of large wood, and continue to supply excessive upland forest sediment. Many of these legacy forest roads have poorly designed culverts and road crossings, blocking fish passage (Mills 1997).

Estuarine habitat. Fish and shellfish were historically plentiful in Tillamook Bay and residents quickly began a commercial fishing industry. A small export fish cannery, constructed in Hobsonville in 1885, shipped its products to San Francisco. Commercial gillnet fishing in the Bay began in the late 1800s. Large historic populations of Chinook, coho, and chum salmon in the basin were well documented. Commercial fishing of coho salmon was regulated as early as 1892. Fish hatcheries were established in the early 1900s, with the Trask River hatchery in operation since 1914 (Coulton *et al.* 1996). Tillamook Bay's gillnet fishery closed in 1961, and commercial salmon fishing was limited to the sea (Tillamook System Coho Task Force 1995).

Tillamook Bay still supports a thriving charter fishing service, with paid guides hosting recreational anglers. Despite restrictions on certain species, seafood and fish product processing remains a local industry.

Shellfish harvests before the 1960s were rarely documented, but Tillamook Bay has long been a major clam and oyster producer. Oysters are not native to Tillamook Bay, but were first planted in the Bay in 1928. Conditions in the Bay are very good for oysters and Tillamook Bay dominated Oregon oyster production for many years. Likewise, the Bay has long been a major clam producer, currently producing about 60% of Oregon's clam harvest. More information about harvest levels is in the *TBNEP Environmental Characterization Report*, Chapters 2 and 3.

Dredging and channel control, large wood removal, sedimentation, and the breach of Bayocean Spit have changed the Bay's bathymetry and reduced its complexity. See map, page 2-32. However, diverse species continue to use the Bay. Its tidal channels and sloughs, intertidal sand and mud flats, eelgrass beds, and tidal marsh areas provide structural complexity and a rich source of insects, zooplankton, epibenthic organisms, and other species upon which salmon and other aquatic species depend for food. Juvenile and adult salmonids undergo physiological transition in the sloughs and channels before entering the next phase of their journey.

Tidal sloughs were adversely impacted by adding tide gates, filling channels, and disrupting hydrologic connectivity in the floodplain and wetlands. Water in today's sloughs shows evidence of low dissolved oxygen (DO) and increased turbidity. Water quality behind tide gates can suffer due to long residence times and restricted access to tidal and other water exchange. Poorly functioning tide gates and culverts often block fish passage. The loss of off-channel rearing habitat in tidal and freshwater sloughs and oxbows may be an important factor in the decline of coho salmon.

Key Habitat Goals and Objectives

The CCMP uses mapping and the prioritization process to maximize potential for each unique basin. To address habitat loss in the lowland floodplain area, the CCMP recommends intensive riparian plantings and selective hydrological modifications to protect and enhance fish habitat, improve water quality, mitigate flood damages, and reduce negative impacts of erosion and sedimentation. For upper Watershed riparian areas, the CCMP recommends protection measures and 200 miles of enhancement projects, combined with an action plan to upgrade and maintain forest roads and remove fish passage barriers. Below 500 feet elevation, CCMP objectives include 500 miles of riparian enhancement work (55% of the total riparian area) and 100 acres of freshwater wetland enhancement. To restore estuarine habitat, 750 acres of tidal marsh will be reclaimed, (equal to about 22% of historic marsh lost.) The CCMP outlines actions to restore fish access to tidal sloughs and improve water quality in the important rearing areas for juvenile salmonids. In addition, the CCMP outlines steps to protect eelgrass beds, restore large wood to the Estuary, and maintain intertidal areas for aquaculture. These actions are outlined in Chapter 4, Key Habitat.

Specific key habitat goals and objectives include:

Goal	**Assess, Protect, and Enhance Riparian Habitat**
Objectives	Enhance 200 miles of forested riparian habitat to healthy riparian condition by 2010.
	Enhance 500 miles of riparian habitat in the 0–500' elevation band to healthy riparian condition by 2010.
Goal	**Assess, Protect, and Enhance Instream Habitat**
Objectives	Enhance 100 miles of upland instream habitat by 2010.
	Upgrade 50% of all tide gates by 2010.
Goal	**Assess, Protect, and Enhance Wetland Habitat**
Objectives	Enhance 100 acres of freshwater wetland by 2010
	Enhance 750 acres of tidal wetland by 2010.
Goal	**Assess, Protect, and Enhance Estuary and Tidal Habitats**
Objectives	Enhance 750 acres of tidal wetland by 2010.
	No net decline in eelgrass beds.
Goal	**Enhance Health of Salmonids, Shellfish, and Other Aquatic Species**
Objective	Achieve Oregon Department of Fish and Wildlife (ODFW) wild fish production and escapement goals (See chart on Page 4-2) by 2010.

Water Quality

Priority Problem

Bacteria and other pathogens from both point and non-point sources present a principal water quality problem. Bacterial pollution threatens public health through the ingestion of contaminated shellfish and water, or direct water contact. It also results in frequent closure of commercial shellfish harvesting areas. Many stream reaches do not meet water quality criteria for bacteria or temperature, and exceed recommended concentrations of suspended solids. Dissolved oxygen concentrations meet water quality standards in most areas of the Watershed except in lowland sloughs, where significant oxygen depression has been observed. Nutrient concentrations do not appear to adversely impact water quality except in lowland sloughs. No acute or chronic affects from toxic substances have been observed or monitored.

Tillamook Bay has a long history of bacterial pollution problems. Beginning in the 1970s, scientists measured high levels of bacteria in the Bay and in shellfish meats. To protect consumers from eating contaminated shellfish, the federal government required the State of Oregon to develop a shellfish management plan. The current plan, adopted in 1991, regulates harvest closures based on estimated amounts of bacteria in the water. To control bacteria loads from agricultural sources, the Rural Clean Water Program was implemented locally in 1981. This program was federally funded through the USDA. The NRCS provided the agricultural producer participants with technical assistance in developing their 5 to 10-year Rural Clean Water Conservation Plans and in installing/implementing waste management structures/practices. Along with local cost share, the federal government spent more than $6 million over 15 years to improve manure storage facilities and control runoff around livestock confinement areas in the Tillamook Bay Watershed. (Dorsey-Kramer 1995)

Today, the Bay continues to receive high bacterial loads from diverse sources including livestock operations, wastewater treatment plants, on-site sewage disposal systems (OSDS), and urban runoff. Along with state partners, TBNEP recently estimated the relative ratio of human, dairy, and “other” origin bacteria (Bower and Moore 1999). This CCMP recommends actions to address the problem.

Tillamook Bay has other water quality problems. See Appendix A: 303(d) list and Figure 2-6: 303(d) map. Temperatures in the lower reaches of the Trask, Tillamook, and Wilson rivers exceed water quality standards and may adversely affect salmon habitat during part of the year. Characterized by slow water movement and nearby agricultural and urban activities, lowland sloughs sometimes have low levels of dissolved oxygen (DO). High sediment concentrations and flow modifications also adversely impact instream habitat for salmon and other aquatic species.

Bacteria Status and Trends

Bacterial loading has historically been highest during rainy seasons of the year: fall, winter, and early spring. Seasonal rains wash pollutants off farm fields and from urban areas and can cause sewage treatment plant overflows or bypasses. These pollutants create public health risks associated with water contact and eating raw shellfish. To protect consumers from contaminated oyster meats, ODA regulates shellfish harvesting and closes the Bay after heavy rains or unexpected discharges from sewage treatment plants. Compliance with FDA's standards for shellfish growing waters allows Oregon's shellfish growers to participate in interstate commerce. Figure 2-7 shows the current shellfish management areas for the Bay, which ODA defines as "prohibited," "conditional," and "restricted" to limit human consumers' exposure to water-borne pathogens. These closures represent an important problem for local oyster growers. Although not native to Tillamook Bay, oysters grow well under aquaculture methods and historically provided significant income to the region. Both shellfish harvesters and managers agree that harvest area classifications and closure criteria should be updated when new data trends support changes. The CCMP includes specific action plans that direct the agencies involved to coordinate efforts and use the best available science and information to keep shellfish area classification and harvest management plans current.

Contaminants from Agricultural Lands

During 1979 and 1980, the Department of Environmental Quality (DEQ) sampled the five rivers in the Tillamook Bay watershed and identified potential bacterial sources from livestock operations, wastewater treatment plants, and failing septic tanks. In response to heavy pollutant loads from agricultural sources, the United States Department of Agriculture (USDA) awarded Tillamook County a Rural Clean Water Program (RCWP) in 1979. Through the USDA Farm Services Agency, the federal government contributed more than $6 million to improve manure storage facilities and control runoff around livestock confinement areas. Although a subsequent monitoring program failed to describe a clear statistical trend, most scientists and farmers agree that the RCWP improved water quality in the rivers. Despite these earlier achievements, substantial amounts of bacteria from livestock continue to enter Tillamook Bay and its tributaries. To tackle these problems the CCMP provides an action plan to improve farm management practices, tighten inspections of Confined Animal Feed Operations (CAFOs), and train livestock managers in new methods and technologies that will reduce the impacts of their activities on water and habitat quality.

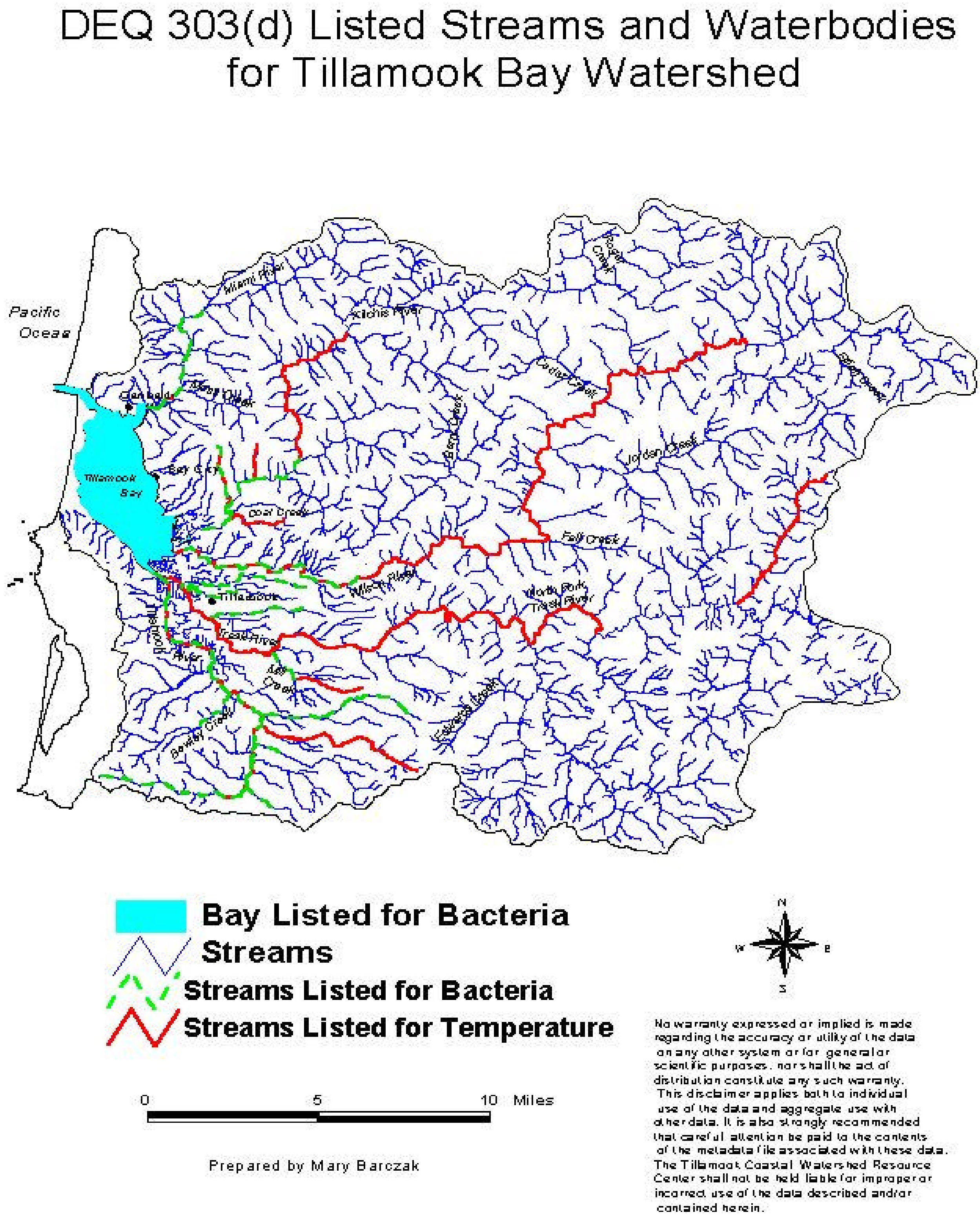
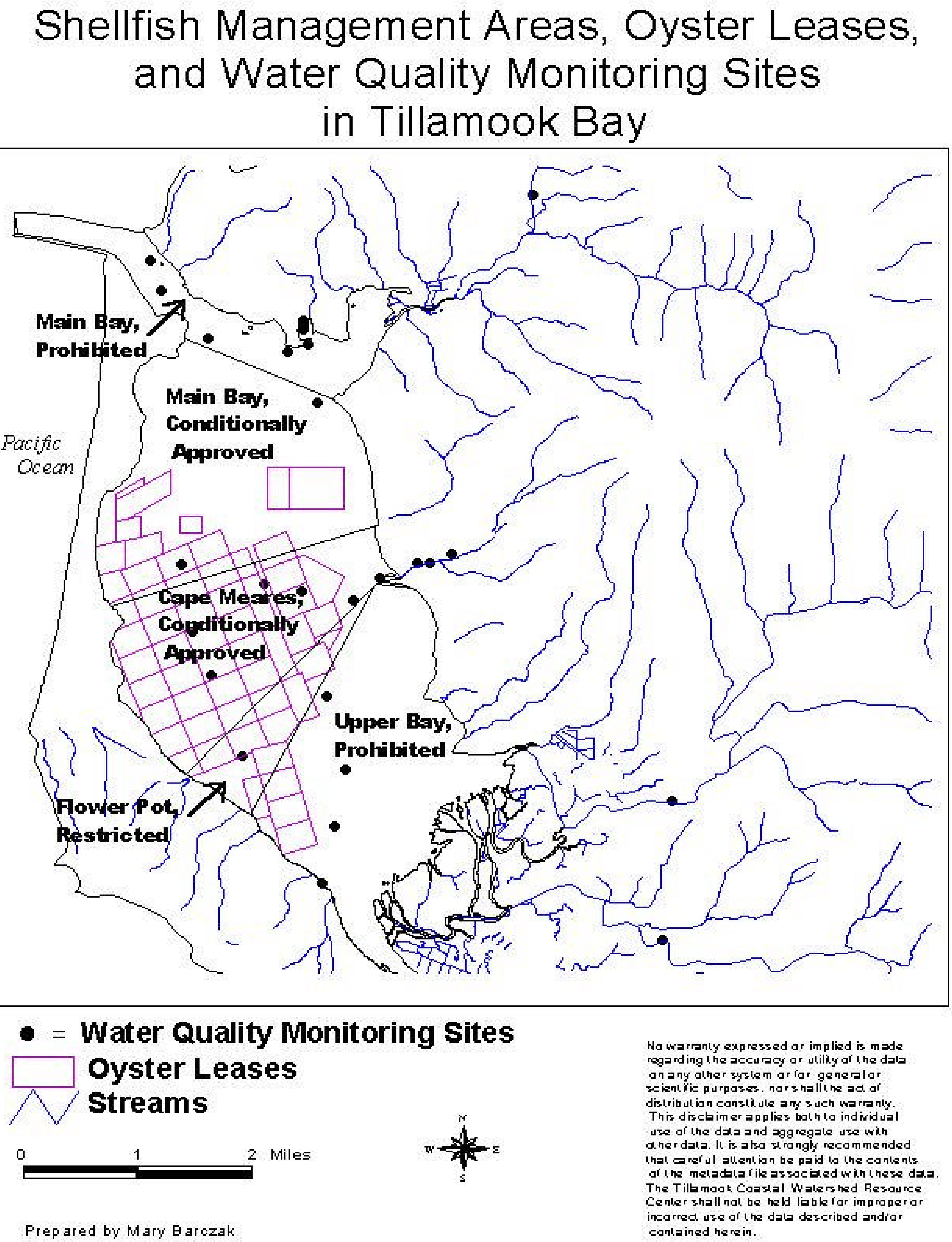


Figure 2-6. 303(d) map for bacteria and temperature. Sites are listed in Appendix A: 303(d) list.



Shellfish Management Areas, Oyster Leases, and Water Quality Monitoring Sites in Tillamook Bay
Main Bay, Prohibited
Main Bay, Conditionally Approved
Pacific Ocean
Cape Meares, Conditionally Approved
Upper Bay, Prohibited
Flower Pot, Restricted
● = Water Quality Monitoring Sites
Oyster Leases
Streams
0
1
2 Miles
N
W
E
S
Prepared by Mary Barczak
No warranty expressed or implied is made regarding the accuracy or utility of the data on any other system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. It is also strongly recommended that careful attention be paid to the contents of the metadata file associated with these data. The Tillamook Coastal Watershed Resource Center shall not be held liable for improper or incorrect use of the data described and/or contained herein.

Figure 2-7.

Contamination from Urban and Residential Areas

Recent studies conducted by TBNEP and its partners suggest that urban and rural residential sources contribute more pathogen contamination than originally suspected. The Watershed contains three incorporated cities (Tillamook, Garibaldi, and Bay City), six wastewater treatment plants, and an uncounted number of household septic systems. Developed areas contribute non-point source pollutants like pathogens, oil and grease, nutrients, and excess heat. On-site sewage disposal systems (OSDS/septic systems) also contribute bacteria and nutrients from homes, trailer parks, and public areas. Although scientists have not precisely quantified the amounts of pollutants from each source, TBNEP studies identified major sources and estimated bacteria loads to the Bay.

Wastewater treatment plants. Wastewater treatment plants in the Tillamook Bay Watershed - operated by the cities of Tillamook, Garibaldi, and Bay City, plus the Port of Tillamook, the Tillamook County Creamery Association (TCCA), and Pacific Campground - are generally in good condition. All plants have been in operation since 1972 or earlier and each has been upgraded at least once since it began operation.

- The City of Tillamook has experienced two bacteria violations in the past five years, but recently upgraded its clarifiers, increasing capacity from 2 million gallons per day (mgd) to 5.6 mgd. The sewer system continues to have problems with infiltration and inflow in winter.
- The Port of Tillamook's wastewater system had extreme infiltration and inflow problems; with as much as 95% of the water treated during winter derived from infiltration. To address the problem, the Port replaced all sewer lines, installed new STEP systems, and repaired the lagoons. The $500,000 project was completed in July 1998.
- Bay City's wastewater treatment plant is two years old, and uses a modern ultra-violet light disinfectant system. An overflow lagoon is available to prevent untreated waters from discharging into the Bay.
- The City of Garibaldi also experiences infiltration and inflow during the winter. Over-capacity flows are by-passed directly to the Bay.
- The TCCA - which spent $3 million to upgrade its wastewater treatment facility in 1989-1992 - currently meets its National Pollution Discharge Elimination System (NPDES) permit requirements at the compliance point of the plant. However, the water has high bacteria counts at the facility's discharge point to the Wilson River. The TCCA currently treats this problem with increased chlorine concentrations in the effluent.
- Pacific Campground uses septic systems during summer and a combination settling and Bio-Pure batch reactor during winter. No major problems have been reported with this system.

Table 2-6. *Draft* Storm Event Bacteria Source Distribution

Date	Location	River Mile	% Dairy	Human	% Wild
	Trask River				
2/28/98	Below trailer park	3.7	65	24	11
"	5th Street boat ramp, above WWT facility	1.5	74	20	6
"	Hospital Hole bridge, below WWT facility	1.2	69	25	6
3/3/98	Below trailer park	3.7	33	67	0
	5th Street boat ramp, above WWT facility	1.5	41	58	1
	Hospital Hole bridge, below WWT facility	1.2	62	33	5
	Tillamook River				
2/28/98	Roadside rest area	8.1	22	50	28
"	Tillamook River Road	4.9	48	35	17
"	Burton Bridge below trailer park	4	41	57	2
"	Netarts highway bridge	0.9	43	57	0
3/3/98	Roadside rest area	8.1	23	73	4
"	Tillamook River Road	4.9	58	42	0
"	Burton Bridge below trailer park	4	42	56	2
"	Netarts highway bridge	0.9	66	28	6
	Bay				
2/28/98	Memaloose	-0.5	74	16	10
3/3/98	Memaloose	-0.5	67	32	1

Source: Bower, R., and Moore, J. 1999. *Identifying Sources of Fecal Coliform Delivered to Tillamook Bay*. OSU. In preparation for Tillamook Bay National Estuary Project, Garibaldi, OR.

The CCMP recommends actions to address problems of long-range treatment capacity and needed sewer upgrades.

Stormwater and septic tanks. In most cases, stormwater receives no treatment before it enters the rivers and Bay from urban sources. Oil, grease, pesticides, sediment, and animal waste are transported directly to the receiving waters via storm drains and street gutters. Recent studies identified significant amounts of human bacteria in the rivers, possibly coming from failing septic tanks. See Table 2-6. The ODA contracts with Tillamook County to survey OSDSs along the shorelines within the drainage basin at least every 12 years. This is part of a required sanitary survey for commercial shellfish growing areas. The CCMP recommends a more frequent inspection process for OSDSs located near waterways to ensure adequate design and function.

Nutrients and Dissolved Oxygen Status and Trends

Plant nutrients, such as nitrogen and phosphorus, can stimulate algal growth and photosynthesis, leading to low levels of dissolved oxygen (DO) in the water. Low DO can be harmful to aquatic or estuarine systems. Streams with low DO no longer provide suitable habitat for rearing, spawning, and migrating salmon. Large inputs of organic wastes, slow water movement, and high temperature can cause low DO. According to surveys by citizen volunteers, TBNEP, and state agencies, the main Bay and rivers generally show healthy nutrient and oxygen levels.

However, initial surveys of lowland sloughs indicate several places where DO drops below the 8.0 mg/L standard[2].

To improve water quality and improve fish habitat, the CCMP recommends reconnecting lowland sloughs to improve water flow and fish access. It also supports riparian restoration and fencing projects in the lowlands. See Chapter 4: Key Habitat. To track trends and detect problems, the CCMP monitoring plan commits to long-term measurements of all major water quality parameters, including bacteria, nutrients, DO, sediments, and others as required by the State. Results from biological monitoring programs such as eelgrass studies or benthic surveys can also identify water quality problems. See Chapter 10: Monitoring and Research Needs for more details.

Temperature Status and Trends

Warm water impairs rearing for juvenile salmonids, inhibits adult migration, and decreases dissolved oxygen levels. After river monitoring in 1995-1998, DEQ listed all or part of all five rivers: Kilchis River from mouth to headwaters, and Murphy Creek from mouth to headwaters; Miami River mouth to Moss Creek; Wilson River mouth to headwaters; Trask River mouth to South Fork of Trask, North Fork mouth to Bark Shanty Creek, North Fork of North Fork mouth to headwaters, and Mill Creek from mouth to headwaters; and Tillamook River mouth to Yellow Fir. See Appendix A: 303(d) List and Figure 2-6: 303(d) List Map.

To develop a temperature TMDL, DEQ conducted baseline monitoring at 40 sites in the Trask, Miami, Tillamook and Wilson Rivers in 1997. Based on these data, DEQ monitored temperature at 60 locations in the Tillamook Bay Watershed in 1998. Additional monitoring is scheduled for 1999.

[2] Ambient Standard: During salmonid spawning periods DO must not be lower than 11 mg/L unless intergravel DO exceeds 8.0 milligram/liter mg/L. If altitude and temperature conditions preclude attainment of the standard, then DO must be at least 95% of saturation. In water bodies that support cold water aquatic species (such as salmonid species), DO must be at least 8 mg/L, or if diurnal monitoring data are available, the minimum shall not fall below 6.5 mg/L. For estuarine waters, DO concentrations must exceed 6.5 mg/L.

Water Quality Goals and Objectives

To address water quality problems in Tillamook Bay, the CCMP supports stronger agricultural pollution control measures and voluntary farm management plans consistent with ODA mandates. It outlines measures to keep manure and other agricultural wastes out of streams and provide the research and training to help local farmers improve their practices. In response to recent scientific findings, the CCMP also calls on the County to ensure that on-site disposal systems (OSDS) function properly. Other actions call for better infrastructure planning to ensure adequate sewer and wastewater treatment facilities. To address water quality problems related to habitat, the CCMP calls for additional watershed-specific temperature and sediment management plans that identify site-specific riparian restoration activities. These actions are detailed in Chapter 5, Water Quality.

Specific water quality goals and objectives include:

Goal	**Promote Beneficial Uses of the Bay and Rivers**
Objectives	Achieve water quality standards for bacteria in the rivers and Bay by 2010.
	Document at least a 25% reduction in bacteria loads to rivers, with apparent trends by 2005 and statistically significant results by 2010.[3]
	Achieve at least a 25% reduction every four years in the number of days that the rivers are not in compliance with water quality standards for bacteria.[3]
Goal	**Reduce Instream Temperatures to Meet Salmonid Requirements**
Objectives	Achieve in-stream temperatures that meet salmonid requirements by 2010.
Goal	**Reduce Instream Suspended Sediments to Meet Salmonid Requirements**
Objectives	Achieve in-stream suspended sediment concentrations that meet salmonid requirements by 2010.
	Document at least a 25% reduction in sediment loads to rivers, with apparent trends by 2005 and statistically significant results by 2010.[3]
Goal	**Improve Farm Management Practices**
Objectives	Achieve Senate Bill 1010 compliance among 100% of livestock operations by 2010.
	Inspect every CAFO annually by 2004.
Goal	**Assess and Upgrade Wastewater Treatment Infrastructure**
Objective	End wastewater treatment plant failures by 2002.
Goal	**Assess and Upgrade Urban Runoff Treatment Infrastructure**
Objective	Control runoff from all construction and development in urban areas by 2003.

[3] Based on 1997-1998 monitoring results.

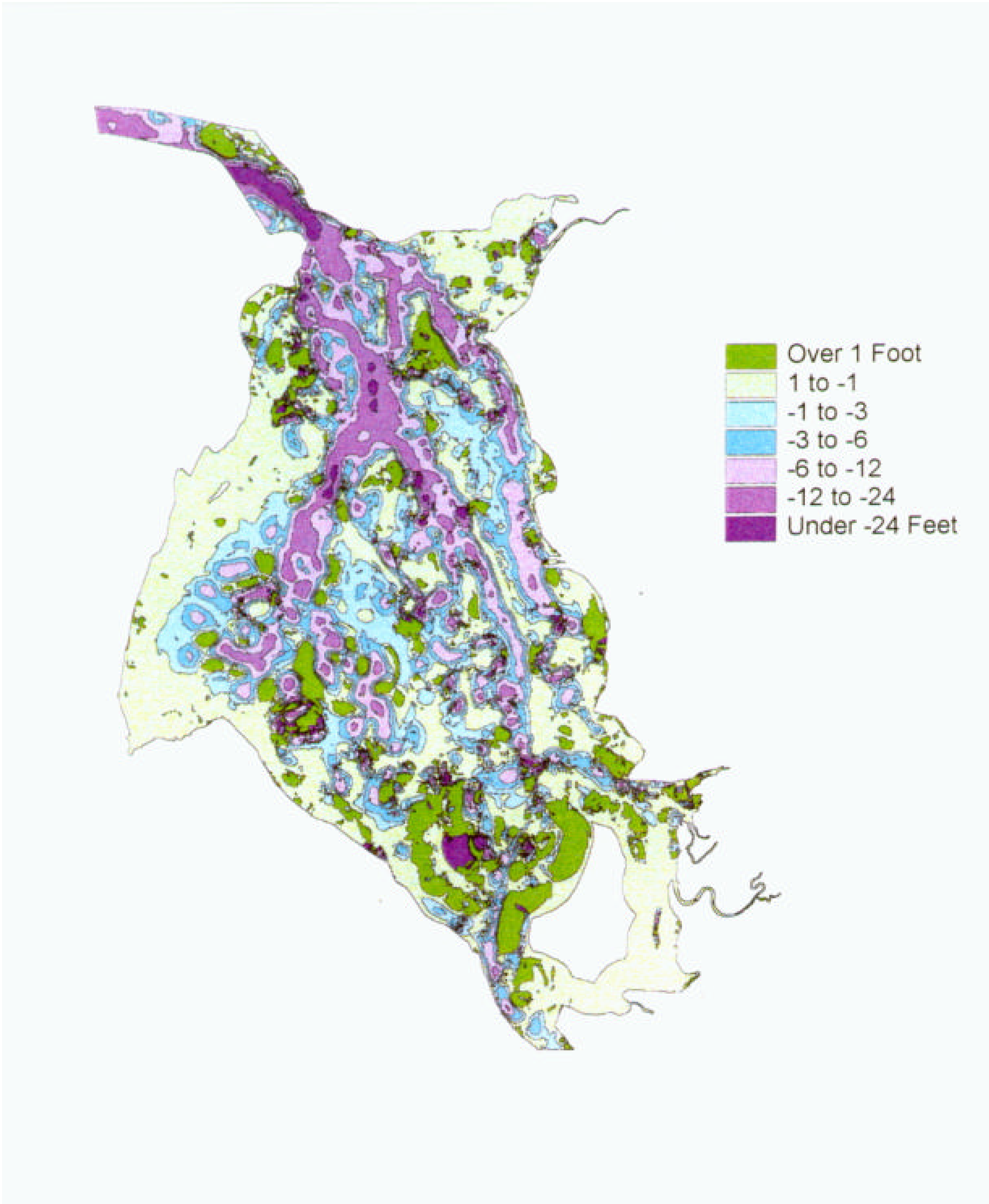


Figure 2-8 Historic bathymetric surface derived for Tillamook Bay from a survey in 1867. Note the large, deep area south of the inlet, and the complexity of the Bay bottom. By 1957 the Bay bottom was greatly simplified and deep areas in the southern half of the Bay were filled in.

Source: Bernert, J., and T. Sullivan. 1998. Bathymetric analysis of Tillamook Bay: Comparison among bathymetric databases collected in 1867, 1957, and 1995. E&S Environmental Chemistry, Corvallis, OR. Prepared for the Tillamook Bay National Estuary Project, Garibaldi, OR.

Erosion and Sedimentation

Priority Problem

Current levels of erosion and sedimentation may adversely impact the human and natural environment. Historic increases in sediment may have caused the loss of spawning and rearing habitat, degradation of estuarine habitats, and changes in the Bay depth, circulation patterns, and response to floods.

Sedimentation has been considered an issue in Tillamook Bay and its surrounding watershed due to changes in Bay bathymetry, along with the filling-in of river mouths, sloughs and ditches. In addition heavy sediment loads can damage Bay ecosystems and salmon habitat and contribute to flooding problems. These problems result from changes in sediment quantity and quality, and in how sediments have moved through the Watershed, as well as into the Bay from the ocean. Solutions to excessive sedimentation depend on understanding the sources of sediments and implementing management actions to minimize their impact on rivers and the Bay.

Erosion and Sedimentation Status and Trends

Recent studies (McManus and Komar *et al.* 1998) completed by the TBNEP indicate that "about 50% of Bay surface sediments are contributed by marine beach sand carried into the Bay by waves, tidal currents and winds, while the remaining 50% is sand, silt, and clay from river sources." Marine sediments enter the Bay through the single opening to the ocean during the daily tidal exchanges. Marine sediments have also entered the Estuary during geological events such as the breaching of Bayocean Spit in 1952 and a tsunami around 1700. River sediments result from natural erosion on the steep slopes of the upper Watershed, along with degraded, eroding streambanks in the lowland floodplains. Earlier studies (Glenn 1978, USDA 1978) estimated about 90% of riverine sediments are derived from upland sources and about 10% from the lowland/floodplain. These source estimates are proportional to basin-scale land use, with about 89% of the Watershed in forested uplands.

Sedimentation in the rivers and Bay is a natural process that can be modified by human actions. Sediment quantity and quality affect habitat quality. Reconciling core analysis and Bay bathymetry, scientists described a heavy rate of sedimentation from 1867 to 1954 (averaging 68 cm/100 years). The period of heavy sedimentation saw four major forest fires, salvage logging, and agricultural, urban, transportation system and other development, along with the breach of Bayocean Spit. During the last four decades, 1954 to 1995, average sedimentation rates (5 cm/100 years) dropped below historic or "background" sedimentation rates (20-40 cm/100 years) (McManus and Komar *et al.* 1998). See Table 2-8.

Table 2-7 Sediment source breakdown for the Kilchis watershed

Source Type	Normal Year	Major Storm	Extreme Storm
Road surface erosion	50-500 yd^3	50-1000 yd^3	1000-5000 yd^3
Road washouts	100 yd^3	2500 yd^3	25,000 yd^3
Road landslides	2000 yd^3	20,000 yd^3	200,000 yd^3
Abandoned road landslides	0 yd^3	5000 yd^3	100,000 yd^3
Background landslides	100-1000 yd^3	1000-100,000 yd^3	100,000-500,000 yd^3

Source: Mills, K. 1997. Forest roads, drainage, and sediment delivery in the Kilchis River watershed. Prepared for the Tillamook Bay National Estuary Project, Garibaldi, OR. 48 pp.

Table 2-8 Modern sedimentation rates in Tillamook Bay

Location	Years	Rates (cm/100 years)
Average Bay	1867-1954	68
(Bathymetry)	1867-1995	48
	1954-1995	5
Western Bay	post-breach	>200*

Source: McManus and Komar *et al*. 1998. The Tillamook Bay National Estuary Project: Sedimentation Study. Final Report, TBNEP, Garibaldi, OR.

Sediment deposition rates in the Bay are now returning to near historic levels. See Table 2-8. However, concern about sediment remains since most sediment is now routed and deposited directly to the estuary, rather than deposited evenly on the lowland floodplain. Loss of instream complexity and floodplain connectivity may speed up the movement of sediment through the system and impact instream habitat value. Levees, roads, and dikes keep the sediment in the channels and move it directly to the lower river channels and Bay.

Historic logging practices and forest fires likely contributed enhanced loads of fine-grained sediments carried by the rivers and subsequent rapid growth of shoreline and tidal flats in the southern (upper) end of the Bay. McManus and Komar *et al.* (1998) state that “clearcutting and forest fires are known to result in an increase in sediment yields, but the increase is temporary, lasting only a few years until vegetative cover is re-established, and it appears to mainly produce fine-grained sediment, clays and silt.” They go on to say, “Although we have seen that this fine sediment is relatively insignificant in producing the general shoaling of Tillamook Bay, since most of it is flushed through to the ocean, its enhanced loads in the rivers might account for the rapid outward growth of the shoreline and expansion of tidal flats. Furthermore, increased concentrations of fine-grained sediment in the rivers are known to be detrimental to fish, as are other water quality factors. Thus, if there are to be changes in the management of Tillamook Bay and its surroundings, the focus should be on human activities in the watersheds of the five major rivers," and practices that can lead to decreased yields of fine-grained sediments."

Studies by ODF to estimate current human-caused sediment sources in the Kilchis Watershed show landslides as the main source of sediment loads to streams. Due to both road fill failures and washouts in major storms, legacy forest roads pose greater landslide risk than roads built with current road construction techniques. See Table 2-7. A 1995-1996 ODF study found that roads built prior to current standards continue to pose risk of increased sediment delivery from the road surface and drainage ditches and from fill material failures (Mills 1997).

Through the Road Erosion and Risk Project, described in Action SED-01, and other OPSW actions, described in Appendix D, state and industrial forest landowners have agreed to identify sediment risks from roads and to address those risks, improving road fills, stream crossings, and drainage and surface problems. ODFW and Forest Practice Rules require that stream crossing structures be designed and constructed to allow for fish passage. State and federal agencies have agreed to comply with structural design standards. The most recent Oregon Plan Watershed Restoration Inventory reports that at least 530 culverts were removed, replaced, upgraded or installed for fish passage in 1996-97, and stakeholders are committed to continuing this effort. Industrial forest landowners estimate they will spend about $13 million a year for the next 10 years on this project for the coastal Evolutionarily Significant Units (ESUs) alone. The Tillamook District of ODF reports spending $4.2 million in 1998 on roads, installing 365 new culverts, building two new bridges, spreading rock, and improving and inventorying roads. State Forest Lands will spend an additional $2.5 million per year for the next two bienniums to improve Tillamook State Forest roads. Action SED-05 calls on owners of non-forest management roads to address their sedimentation and fish passage problems as well.

Lowland sediments result mainly from bank erosion on agricultural lands. The absence of riparian vegetation in the lowlands destabilizes river banks and increases bank erosion. Without fences or other controls, livestock trample streambanks, destroy riparian vegetation, and increase erosion and water quality problems. In addition, stream channel modifications and the use of riprap to stabilize streambanks may increase erosion through changes in river fluvial response.

Erosion and Sedimentation Goals and Objectives

To better address human-caused sediment problems, the CCMP recommends actions to reduce sediment loads from forest roads (built prior to current design standards) and unstable slopes. In the upper Watershed, the plan calls for increased installations of cross-drainage culverts to prevent washouts, and harvest restrictions in sensitive, steep slope areas. It also calls for improved forestland management over the entire landscape, supporting and enhancing existing elements of the Oregon Plan for Salmon and Watersheds related to surveying, prioritizing, and improving forest roads (improving road surfaces and cross-drainage, sidecast pullback, improved stream-crossing structures, etc.) that pose a risk to water quality. In addition, it calls for supporting monitoring to demonstrate the effectiveness of current forest practices and to identify necessary modifications consistent with the Oregon Forest Practices Act to improve the effectiveness or implementation of the practices.

The CCMP also calls for encouraging actions that can help restore more natural sediment storage and routing. Such actions include restoring instream large wood and more functional floodplains, and encouraging the retention of vegetation to someday provide large wood for debris flows that may reach fish-bearing streams. In the lowlands, the CCMP outlines actions to control livestock access to streams, replant riparian vegetation, and stabilize streambanks with alternatives to riprap. It spells out requirements for effective runoff control on construction sites and urban areas, and identifies measures to ensure that road authorities design and maintain roads to minimize erosion and sedimentation. These actions are detailed in Chapter 6, Erosion and Sedimentation.

Specific erosion and sedimentation goals and objectives include:

Goal	**Reduce Sediment Risks from Forest Management Roads**
Objectives	Upgrade 1,400 miles of forest roads on state and private lands by 2010. Decommission 50 miles of unneeded forest management roads by 2010. Conduct regular road maintenance on all 2,000 miles of forest management roads.
Goal	**Reduce the Adverse Impacts of Rapidly Moving Landslides**
Objectives	Upgrade 1,400 miles of forest roads on state and private lands by 2010. Decommission 50 miles of forest management road by 2010. Conduct regular road maintenance on all 2,000 miles of forest management roads.
Goal	**Improve Channel Features to Improve Sediment Storage and Routing**
Objectives	Key Habitat riparian and Water Quality suspended sediments objectives
Goal	**Reduce Adverse Impacts of Erosion and Sedimentation from Developed and Developing Areas**
Objective	Control runoff from all construction and development in urban areas by 2003.
Goal	**Reduce Adverse Impacts of Erosion and Sedimentation from Agricultural Areas**
Objectives	Lowland, freshwater wetland, and tidal marsh Habitat objectives below
Related CCMP Objectives	Enhance 200 miles of forested riparian habitat to healthy riparian condition by 2010. (Key Habitat Objective) Enhance 500 miles of riparian habitat in the 0–500’ elevation band to healthy condition by 2010. (Key Habitat Objective) Enhance 100 miles of upland instream habitat by 2010. (Key Habitat Objective) Enhance 750 acres of tidal wetland by 2010. (Key Habitat Objective) Achieve instream suspended sediment concentrations that meet salmonid requirements by 2010. (Water Quality Objective) Document at least a 25% reduction in total suspended solids loads to rivers, with apparent trends by 2005 and statistically significant results by 2010. (Water Quality Objective)

Figure 2-9. Aerial photograph of flooding on February 10, 1996, at Tillamook, OR, after the floodwaters had begun to recede.
Source: Coulton, K. 1996. Philip Williams and Associates, Aerial reconnaissance of flooding for the Tillamook Bay National Estuary Project, Garibaldi, OR.

Flooding

Priority Problem

The interaction of human activities with dynamic natural systems has increased the magnitude, frequency, and impacts of flood events. These events affect water quality through increased erosion and co-mingling of flood waters with industrial and agricultural products and waste products. Each time a significant flood occurs, water quality and aquatic wildlife are negatively impacted as contaminants enter the system.

Flood Impacts Status and Trends

For all three of the original TBNEP priority problems - fish and wildlife habitat loss, water quality degradation, and erosion and sedimentation - flooding is a unifying natural process, contributing to both the quality and impairment of these ecosystem issues. The Flood of 1996 focused attention on flooding. To resolve the flood problems in the Tillamook Bay area, and also to resolve the original TBNEP priority problems, management efforts will need to satisfy multiple objectives: to reduce flood-related hazards and damages, while minimizing the potential long-term environmental impacts and economic costs of flood control and floodplain management practices.

Tillamook Bay’s uniqueness among Oregon estuaries stems in part from its five tributary rivers. The four southern rivers — Tillamook, Trask, Wilson, and Kilchis — enter the Bay relatively close together, their respective valleys merging into a single, wide floodplain. Fingerlike highlands divide the floodplain. Downtown Tillamook sits upon one of these highlands, adjoining Hoquarten Slough.

Prior to modification of the river channels and sloughs, settlers to Tillamook described “flood lakes,” vast pools of water in the valley of the Wilson and other rivers, during rainy winter months. These lakes could extend to the foothills of the Coast Range. The floodwaters annually deposited thick layers of rich loam on the valley floor, creating prime agricultural land. However, the annual floods also made the land unsuitable for permanent habitation, so it lay unoccupied.

Modification and taming of the floodplain began in the 1850s. Before then, river channels clogged with logs and debris jams easily flooded over their banks. Once the channels were cleared, the lowlands flooded less frequently. Further changes through 1937 reduced channel complexity, allowing the land to drain even faster, with most clearing and draining of the floodplain completed during the 1920s. The addition of riverbank levees eliminated the natural connectivity between river and floodplain through the sloughs. After that, only the highest river flows resulted in floods. The constraining levees kept the water in the channels and quickly moved the sediment, once deposited evenly on the floodplain, to the lower river channels and Bay. Dikes also reduced the extent of freshwater wetland and tidal marsh flooding.

These changes permitted significant agricultural, residential, and commercial development on the Tillamook Bay floodplain. This now interferes with floodplain function and places more people and property in harm's way when flooding does occur. For example, non-farm houses have been built along the Wilson and Trask rivers, quite close to the rivers' normal banks. The Wilson River floodplain has been extensively developed in a narrow corridor along US 101 (North Main Street). Flooding is a persistent problem in all three of these areas and others.

Two consequences of flooding are common in Tillamook County: inundation and erosion. Inundation is the presence of standing or flowing water in places which are normally dry; erosion refers to the physical removal of soil from river banks, or the digging of channels in formerly flat areas due to high flows. The lowland floodplains experience two types of flooding: 1) tidal flooding, which is controlled primarily with dikes; and 2) riverine flooding, controlled with levees. Both types of flooding have varying magnitudes and recurrence intervals and include three conditions or characteristics:

- Riverine bankfull conditions, which occur several times a year.
- First bottomland flooding, which affects lower areas of the floodplain, recurs every 2 to 50 years. Riverbank levees contain smaller first bottomland floods, keeping the water within the main channel.
- Second bottomland flooding, which covers the low and high areas of the floodplain, recurs roughly every 50 to 5,000 years. Despite extensive flood control measures, these floods continue to impact developed areas.

The Wilson River, the river with a continuous height gauge for the longest period of record, reached flood stage (11 feet) 43 times between 1970 and 1996. The highest crest occurred in February 1996 (18.50 feet), nearly two feet higher along North Main Street (Hwy. 101) in Tillamook than the previous high of 16.91 feet in January 1972. Ten other floods over 16 feet also occurred in that time frame: in December 1974, December 1977, January 1980, February 1981, January 1982, December 1982, February 1986, November 1986, December 1987, and January 1990. The average recurrence interval for a 16+ foot flood, since 1970, is 2.25 years.

Prior to 1970, the great flood of 1964 also caused significant impacts to the Tillamook area. In the aftermath of this flood, state and federal agencies conducted significant "clean-up" activities that removed large wood from and straightened many channels.

Work done by OSU scientists in the past decade[4] found that precipitation data used to calculate the original 100-year floodplain used for land use planning purposes in many cases underestimated the actual rainfall amounts or failed to account for higher upland precipitation. This recent information indicates that the 100-year floodplain may need to be recalculated to more reliably locate improvements outside the Tillamook 100-year floodplain.

The great flood of February 1996, which had an estimated recurrence interval exceeding 100 years, was probably of the second bottomland type. The speed of floodwater rise and the duration of flooding are additional concerns. Both of these factors indicate that flood control in Tillamook now involves more than just the maximum floodwater elevation. Both rapidly rising floodwaters and long duration floods increase the risks to life and property out of proportion to the maximum elevation of the flood.

The conflict between human activity and flooding also has serious environmental consequences. More intense land use has increased concern about excess nutrient loading, hydrocarbons, heavy metals, and pesticides, all of which are carried downstream in flowing water and may increase water quality impacts during flood events. Moreover, flooding tends to wash bacterial contaminants from accumulated manure and malfunctioning septic systems off floodplain lands, and may interfere with septic system and sewage treatment facility function. Therefore, flood management solutions must address water quality problems, in addition to floodwater quantity and movement.

[4] Parameter-elevation Regressions on Independent Slopes Model (PRISM) studies, available at WWW.ocs.orst.edu.

Specific flooding goals and objectives include:

Goal **Improve Floodplain Condition**

Objective Complete 20 projects within the two years following adoption of hydrodynamic model which:

- measurably reduce the runoff rate in the Watershed's uplands (increasing interflow and ground water recharge, thereby reducing stream temperatures and increasing summer flows);
- improve drainage characteristics in the Watershed's lowlands (*e.g.*, connect sloughs and rivers for fresh water exchange in sloughs);
- increase floodplain storage capacity in the Watershed's lowlands (*e.g.*, set back levees to increase floodwater capacity, increase riparian area, and create opportunity for sediment deposition); and
- improve the natural environment's capacity to withstand and benefit from flood events.

Goal **Develop and Maintain a Comprehensive Floodplain Management Plan**

Objective Implement a GIS-based, unsteady state hydrodynamic model by year 2001.

Raise at least 60 houses at least 3 feet above the 100-year flood elevation by year 2001, and other houses as resources permit.

Construct 10 livestock and equipment pads in flood-prone areas by 2001 to reduce pollution from petrochemicals and animal wastes during major floods.

Secure and/or remove known hazardous chemicals from areas where they pose a real threat to water quality during flood events by 2005.

Citizen Involvement

Problem

Environmental awareness within the community and sound environmental decision-making by stakeholders depend on focused education programs and progressive community development. Currently, too few educational resources regarding the Tillamook Bay Estuary exist for citizens, watershed council members, resource users, and others involved in or affected by community decisions. Adult education must be strengthened to meet the needs of diverse stakeholder groups. In addition, K–12 programs must connect learning experiences to the environment and the community.

To ensure the success of our efforts to resolve the four priority problems, the Management Conference determined that improved education and institutional infrastructure are required. The Performance Partnership will foster citizen stewardship through public interaction and education, strengthen institutional links, and create and support new institutions needed to carry out the Habitat, Water Quality, Erosion and Sedimentation, and Flooding Action Plans.

Few educational and training resources exist to serve the diverse stakeholder groups involved in community decision-making. Improving adult education regarding Tillamook Bay and Watershed through college classes and community education and outreach will strengthen citizen stewardship and ensure community support for implementing the CCMP.

K-12 education not only brings children and their families into the process for today's actions, but lays the foundation for future efforts. This action plan strengthens teacher training and natural science and outdoor education programs in Tillamook County as part of systemic changes under the Educational Act for the 21^{st} Century.

To build local capacity, foster citizen leadership, and improve community decision-making, Tillamook County requires new and renewed institutions. These must provide better training, greater expertise, and stronger enforcement of local ordinances. State-of-the-art information technologies offered through the Tillamook Coastal Watershed Resource Center will support local infrastructure and nourish community development. The Tillamook Bay Watershed Council will keep citizens engaged as it coordinates restoration and enhancement projects and promotes watershed health and community education. A private non-profit land trust will acquire, conserve and manage lands and receive donations.

Specific citizen involvement goals include:

Goal **Improve Community Education**

Goal **Strengthen K-12 Science and Outdoor Programs**

Goal **Promote Community Development**

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