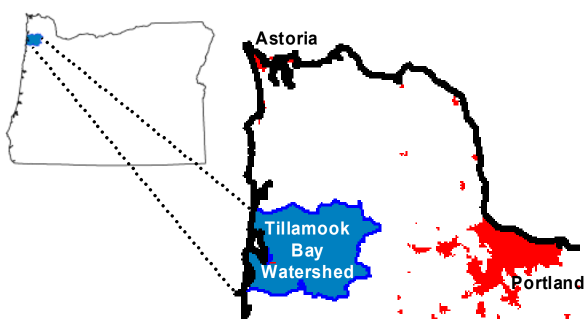
Tillamook Bay Watershed
Total Maximum Daily Load (TMDL)



Prepared by,
Oregon Department of Environmental Quality
June, 2001

Draft Tillamook Bay Watershed Total Maximum Daily Load (TMDL)

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EXECUTIVE SUMMARY

Introduction

The following document contains the required components for a Total Maximum Daily Load (TMDL) as described by the USEPA (EPA) for compliance with the Federal Clean Water Act. As well, the document and its appendices provide a thorough analysis of pollutant sources and accumulation processes in the Tillamook Bay Watershed. The analyses and modeling that followed are in many cases complex. Every attempt has been made to thoroughly describe and explain assumptions and methods and to make the results as clear as possible. In this spirit, we are providing this summary to provide the essential results that the reader and land managers will see “on the ground.”

Water Quality Summary

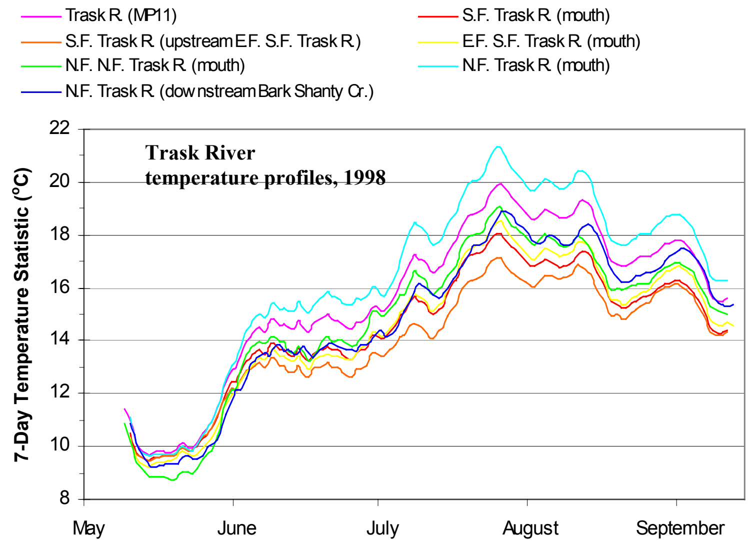
Legal Requirements

Under Section 303(d) of the Clean Water Act, the EPA or its state delegates are required to develop a list of the surface waters in each state that do not meet Water Quality Standards (WQS). These standards are developed by each of the states to protect “beneficial uses” and must be approved by EPA. The resulting “303(d) list” is based on the best available data and , in most cases, must be revised every 2 years. The list submitted by the State of Oregon in 1998 and approved by the EPA is the most recent source of this information. Water bodies that are listed as impaired must have Total Maximum Daily Loads (TMDL) developed for each pollutant for which that waterbody is “listed.” There may be waterbodies that are listed for “pollution” (e.g., habitat modification, flow modification). These waterbodies do not require a TMDL.

Listed Parameters

The Tillamook Bay Watershed includes 5 major drainages (rivers) that discharge to Tillamook Bay – the Miami, Kilchis, Wilson, Trask, and Tillamook Rivers. Each of these drainages provide beneficial uses of their own as well as being sources of pollutants to the Bay. The beneficial uses that are affected by pollutant loads are cold water aquatic life and water contact recreation in the rivers, and shellfish harvesting in the Bay. As required by law, the most sensitive beneficial uses were considered for listing. In the Rivers, the migration, rearing and spawning of salmonid fish are put at risk by high water temperatures (those that exceed 64°F for migration and rearing, or 55°F for spawning) in the summer. The Rivers are also impaired for water contact recreation at times throughout the year resulting from high concentrations of fecal bacteria (indicators of fecal waste, may be Fecal Coliform group or *E. coli*). These bacteria are also the source of the impairment of Bay waters, which support commercial shellfish harvesting. Shellfish harvesting is dependent on waters with minimal concentrations of fecal bacteria, and is currently restricted from commercial shellfish harvesting whenever flow in the Wilson River exceeds 2500 cfs (or a stage of 7 feet) due to the risk of bacterial contamination. The TMDLs are developed for these parameters to protect the salmonid fish, and recreational use in the rivers, and commercial shellfish harvesting in the Bay.

Temperature



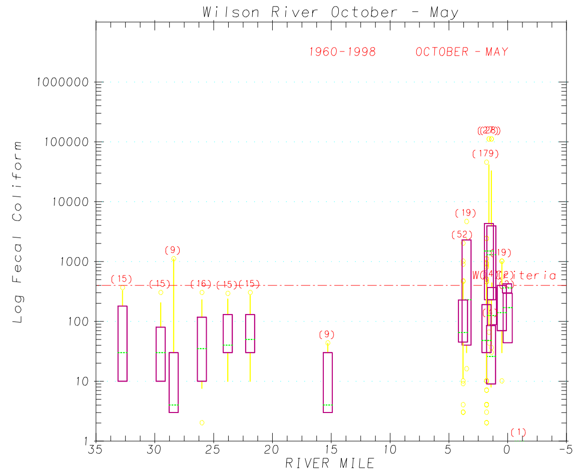
The temperature of surface waters commonly exceeds the WQS for migration and rearing of salmonid fishes [64°F (17.8°C) as a 7-day average of daily maximum temperatures] in the mainstems of all of the Rivers and many of their tributaries during summer months. Temperatures increase with distance from the headwaters of each river, and show the influence of warm or cold water from various tributaries. DEQ has determined that the source of stream heating derives from the combined effects of ongoing and past removal of riparian vegetation and the subsequent widening of streams. These combined landscape changes from what the streams would reflect without human intervention result in reduced effectiveness of shade from natural vegetation and local topography. Although topography cannot be controlled, presence of riparian vegetation can be managed to provide necessary shade and result in stabilized channels that will become narrower over time. The narrowing of streams will increase the effectiveness of riparian vegetation in shading streams and reducing incident solar radiation. Contributions from point source discharges will also be regulated under the terms of discharge permits.

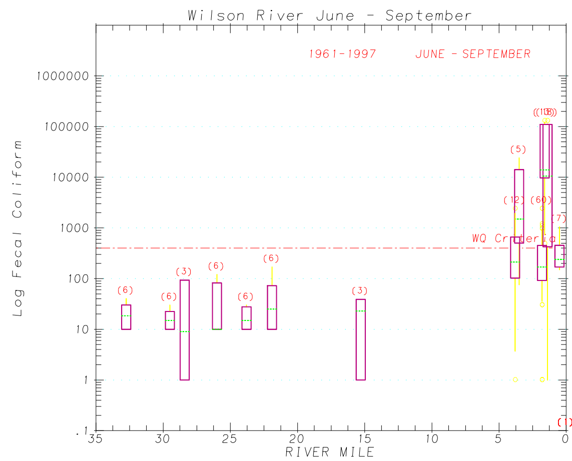
Bacteria

Routinely collected water quality data from DEQ's ambient monitoring program show violations of the bacteria criteria occur in the 5 major rivers and in several creeks in the basin. Concentrations are particularly high during storms and tend to be highest in the lower elevations of each of the basins; the areas associated with the greatest concentrations of agriculture, urban development, and roads.

Waters of the Bay are routinely sampled by the Oregon Department. of Agriculture. Concentrations in the Bay are also commonly elevated above the WQS in the Bay, especially when river flows increase in response to rainfall and runoff.

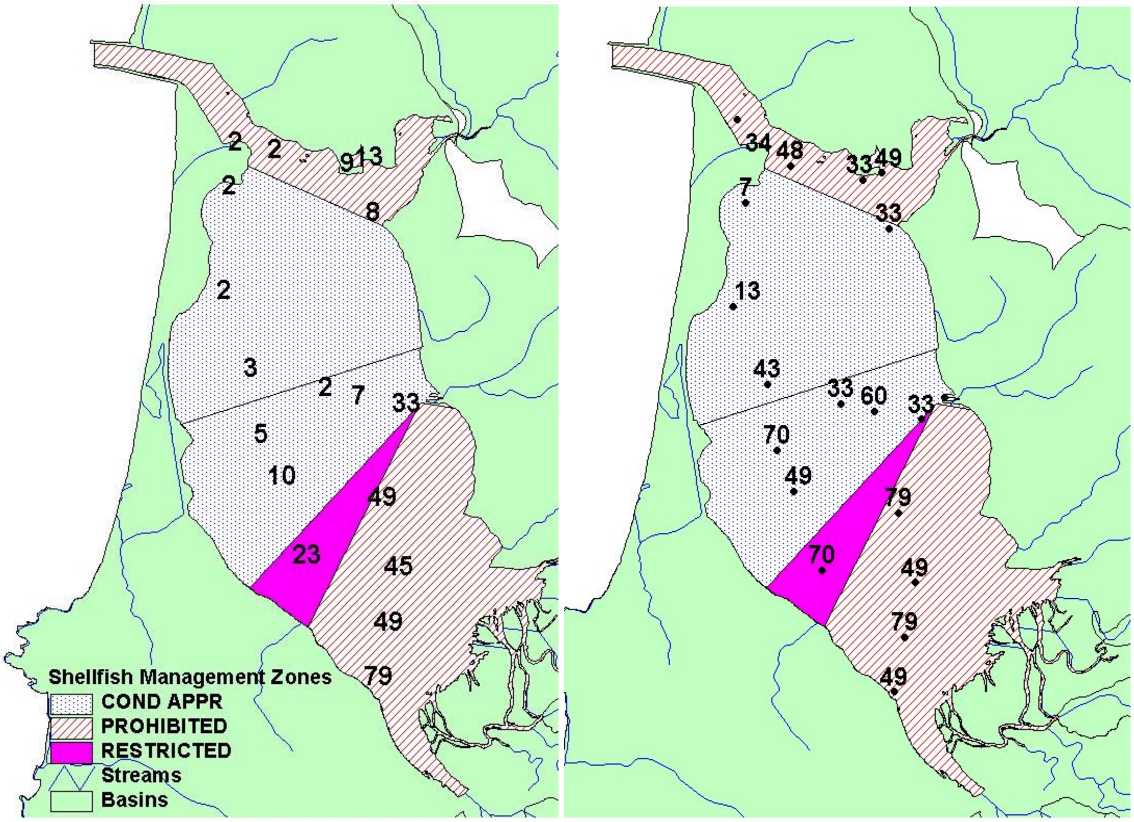
Elevated concentrations of bacteria in rivers can affect water contact recreational use of the rivers for swimming and result in large loads of fecal bacteria entering the Bay. Concentrations in the Bay that exceed a median of 14 MPN/100 ml limit its use for shellfish harvesting. As a result, harvesting is prohibited in much of the Bay near the mouths of the Rivers and near wastewater discharges. Sources of bacteria in the watershed include rural and urban residential development (homes in some areas have failing septic systems), urban stormwater runoff, livestock management and other agricultural activities, and several wastewater treatment plants that discharge either to the Rivers or the Bay.





Median concentrations of bacteria commonly exceed one or more of the Water Quality Standards for protection of recreational use in the Rivers.

Based on the association of high bacterial concentrations during high-flow storm events, the conditionally approved harvesting areas are closed when river flow or rainfall increase beyond limits specified in the Tillamook Management Plan for Commercial Shellfish Harvesting (Appendix E). Data support the closure of these areas during high flow events, as concentrations during closures typically exceed the standard and are higher than during open periods. ODA must react to changes into an area's compliance with the fecal coliform standard for shellfish growing waters. Reactions may include temporary closures or bay management plan changes requiring closures for predictable increases in fecal coliform levels.



Median Fecal Coliform Concentrations when Tillamook Bay is Open (left) and Closed (right) to shellfish harvesting (1991-98).

Allocations

Load Allocations were developed for each of the parameters for non-point sources (NPS) and Wasteload Allocations were developed for point sources. NPS sources are land uses that contribute pollutants from diffuse areas. These include forestry, agriculture, and rural residential and urban development. Point sources discharge directly to waterbodies and their contributions are controlled through limits set in National Pollutant Discharge Elimination System (NPDES) permits. These include sewage treatment plants and industrial sources such as the Tillamook Creamery.

Temperature

Load Allocations for non-point sources are aimed at controlling heat from solar radiation and are expressed in terms of system potential effective shade and channel width. Effective shade is the most straightforward parameter to measure and is easily translated into quantifiable water management objectives. System potential was determined through analysis of shade from topography, potential tree heights and densities, and narrowed channel widths relative to existing conditions in all basins. System potential conditions are the most protective allocation and rely on the environment to provide as much natural effective shade as possible. By simulating these system potential conditions in each of the basins, potential temperatures were calculated for the mainstems of each of the 5 rivers. Overall, under system potential conditions, 74% of these river miles along mainstem reaches are expected to achieve temperatures less than the standard of 64°F (17.8°C), and none of the rivers would be expected to have segments with temperatures in excess of 68°F (20°C).

Wasteload Allocations for point sources assume that effluent will not cause an increase in ambient temperature outside a defined "mixing zone." Mixing zones have been defined for some sources but are generally a corridor no wider than 25% of the river. The allowable effluent temperature is a function of the flow rate of the river, the flow rate of the discharge and the system potential temperature of the water at the point of discharge. In general, the discharges are located near the mouths of the Rivers, where temperatures will be the highest. Wasteload allocations will have different limits depending on the time of year. The facilities that discharge during the critical period (low flow) will have to meet the 64°F (migration and rearing) criterion from June through September, and the 55°F (spawning) criterion from October through May. The spawning criterion reflects the use of the lower reaches of the rivers by chum salmon. Some have slightly higher temperature allocations because sufficient information exists to calculate the facility's wasteload allocation.

Bacteria

Bacterial and flow accumulation rates were analyzed with an event-based unit-load model. The model uses estimated peak flow, runoff concentrations of bacteria for various land uses, and bacteria die off rates to predict total bacteria concentrations and loads in streams. This model was calibrated with flow and bacterial data from recent storms. The dilution of the rivers with saltwater as they enter the bay was determined through analysis of salinity gradients between the river mouth and shellfish harvesting sites in the bay, resulting in a dilution ratio of 2:1. Therefore to achieve the bacterial standard of 14 fecal coliforms/100 ml in the Bay would require each river to meet an instream limit of 28 fecal coliforms/100ml at the mouth.

Allocations are determined separately for each river, and are based on subbasin specific percent reductions in runoff concentrations from all land uses as a function of flow. Each river will be required to meet the instream limit at the mouth. The allowable runoff concentrations range from fairly high in cleaner rivers to very low depending on land use and flow rate in the rivers. Runoff concentrations refer to incipient runoff prior to flowing into creeks, streams, or rivers. This assumes that bacteria will decay and be diluted sufficiently to meet the instream targets. Overall, allocated instream concentrations reflect reductions ranging from 90% to 99% relative to current conditions.

Margin of Safety (MOS)

The Margin of Safety provides assurance that water quality standards will be met if the allocations are higher than the loading capacity of the water body. The MOS for both of these TMDLs are implicit; they derive from using conservative assumptions in modeling so that the allocations will also be conservative relative to the loading capacity

Water Quality Management Plan

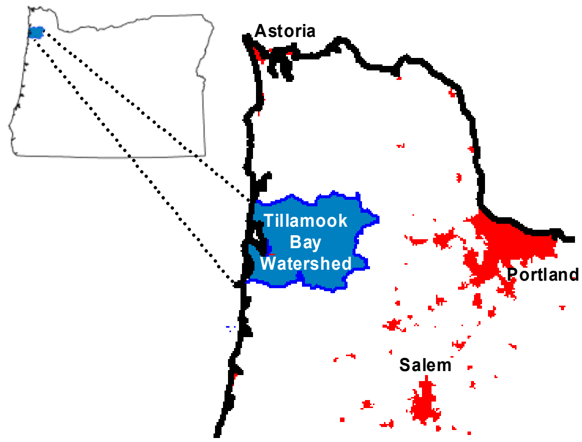
A Water Quality Management Plan (WQMP) is included as a companion document to the TMDLs. This document explains the roles of various land management agencies, federal, state, and local governments, as well as private landowners in implementing the actions necessary to meet the allocations in the TMDLs. It also includes directly or by reference the statutes, rules, ordinances, local plans, and all other known mechanisms for implementation. The WQMP is based largely on the Comprehensive Conservation and Management Plan developed for the Tillamook Bay National Estuary Program through a public process that included a range of interests. The WQMP for the Tillamook Bay Watershed focuses specifically on:

- State Forest Lands (Forest Practices Act);
- Federal Forest Lands (Northwest Forest Plan);
- Private Agricultural Lands (North Coast Basin Agricultural Water Quality Management Area Plan – SB1010);
- County Ordinances;
- Tillamook Bay National Estuary Program – Coordinated Conservation and Management Plan
- Regional stormwater controls, including the option of a storm water permit for Small Cities.

CHAPTER I – OVERVIEW AND BACKGROUND

1.1 Introduction

The Tillamook Bay Watershed lies near the northwest corner of Oregon on the western side of the Coast Range Mountains. Aside from some small creeks and sloughs that drain directly to the Bay, the majority of water entering the Tillamook Bay is carried by 5 large rivers – the Miami, Kilchis, Wilson, Trask, and Tillamook. These Rivers have their headwaters at varying elevations up to nearly 3700ft (~1100 m) in the Coast Range. The majority of the watershed is contained within Tillamook County, though there are small portions in Washington and Yamhill Counties.



The watershed includes vast forests, rich agricultural lands, several small communities, a large bay supporting commercial shellfish, and abundant habitat for salmon and trout. The forests are included mostly within the Tillamook State Forest, though there are significant private holdings of forestland. Agricultural lands are all privately owned and predominantly support a thriving dairy and cheese-making industry. The towns of Tillamook, Bay City, and Garibaldi are located near or on the shore of the Bay. Commercial shellfish harvesting has been continuous since the 1930's. The Tillamook Bay Watershed has historically supported some of the largest human populations along the coast and has sustained a popular sport fishing industry and the breeding grounds and nursery for offshore fisheries.

The Tillamook Bay Watershed supports populations of Spring Chinook, Fall Chinook, Summer Steelhead, Winter Steelhead, Coho Salmon, Chum Salmon, Sea-Run Cutthroat, and Resident Cutthroat Trout. Coho are currently listed as threatened, and Winter Steelhead are a candidate for listing by the National Marine Fisheries Service under the Federal Endangered Species Act. Habitat for these species has been in decline in the watershed for many years resulting from a variety of problems including large, intense forest fires, removal of riparian vegetation communities, flow modification, and direct habitat modification. These events have resulted in rivers that are wider and shallower, and which receive more direct sunlight than what would be expected under natural conditions. Excessive summertime temperatures, diminished availability of appropriate spawning gravels, and reduced cover all make the habitat of poorer quality than historical conditions.

Tillamook Bay also supports commercial shellfish harvesting, and the rivers are used for recreational swimming and wading. Concentrations of bacteria in the waters of the rivers and the Bay are commonly too high to allow safe use for either of these activities. Sources of bacteria in the watershed include rural and urban residential development (many homes have failing septic systems), urban stormwater runoff, livestock management and other agricultural activities, and several wastewater treatment plants that discharge either to the rivers or the Bay.

As a result of these problems, parts of the rivers and Bay have been listed under section 303(d) of the Clean Water Act as impaired water bodies. This listing requires development of a Total Maximum Daily Load (TMDL) for temperature and bacteria.

1.2 Total Maximum Daily Loads

1.2.1 What is a Total Maximum Daily Load

The quality of Oregon's streams, lakes, estuaries and groundwater is monitored by the Oregon Department of Environmental Quality (DEQ). This information is used to determine whether water quality standards are being violated and, consequently, whether the *beneficial uses* of the waters are *impaired*. *Beneficial uses* include fisheries, aquatic life, drinking water, recreation and irrigation. Section 303(d) of the Federal Clean Water Act requires the EPA or delegated states such as Oregon to set water quality standards and to prepare a list of water bodies whose water quality does not meet these approved water quality standards. The resulting list (the "303(d) list") is a comprehensive catalog of all waterbodies in the state that fail to meet one or more water quality criteria based on available data.

The term *water quality limited* is applied to streams, lakes and estuaries where required treatment processes are being used, but violations of State water quality standards occur. With a few exceptions, such as in cases where violations are due to natural causes, the State must establish *a Total Maximum Daily Load* or *TMDL* for any waterbody designated as *water quality limited*. A *TMDL* is the total amount of a pollutant (from all sources) that can enter a specific waterbody without violating the water quality standards.

The total permissible pollutant load is allocated to point, non-point, background, and future sources of pollution. *Wasteload Allocations* are portions of the total load that are allotted to point sources of pollution, such as sewage treatment plants or industries. The *Wasteload Allocations* are used to establish effluent limits in discharge permits. *Load Allocations* are portions of the *Total Maximum Daily Load* that are attributed to either natural background sources, such as soils, or from non-point sources, such as urban, agriculture or forestry activities. *Allocations* can also be set aside in reserve for future uses. Simply stated, *allocations* are quantified measures that assure water quality standard compliance. The *TMDL* is the integration of all these developed *Wasteload* and *Load Allocations.*

1.2.1.1 Elements of a TMDL

The U. S. Environmental Protection Agency (EPA) has the responsibility under the Clean Water Act to approve or disapprove TMDLs that states submit. When a TMDL is officially submitted by a state to EPA, EPA has 30 days to take action on the TMDL. In the case where EPA disapproves a TMDL, EPA must establish the TMDL.

The required elements of a TMDL that must be submitted to EPA include:

1. A description of the geographic area to which the TMDL applies;
2. Specification of the applicable water quality standards;
3. An assessment of the problem, including the extent of deviation of ambient conditions from water quality standards;
4. Evaluation of seasonal variations
5. Identification of point sources and non-point sources;
6. Development of a loading capacity including those based on surrogate measures and including flow assumptions used in developing the TMDL;
7. Development of Waste Load Allocations for point sources and Load Allocations for non-point sources;
8. Development of a margin of safety.

TMDLs addressed in this report

This report contains TMDLs for the following parameters :

- **Temperature** – based on the 303(d) listing of approximately 101 miles of rivers and streams in the Tillamook Bay Watershed;

- **Bacteria** – based on the 303(d) listing of approximately 64 miles of rivers and of Tillamook Bay due to elevated concentrations of fecal coliform bacteria that exceed the criteria for recreational use (rivers) and commercial shellfish harvest (Bay), respectively.

1.3 TMDL Implementation

1.3.1 Water Quality Management Plans (WQMPs)

Implementation of TMDLs is critical to the attainment of water quality standards. The support of Designated Management Agencies (DMAs) in implementing TMDLs is essential. In instances where DEQ has no direct authority for implementation, DEQ works with DMAs on implementation to ensure attainment of water quality standards.

DEQ intends to submit a WQMP to EPA concurrently with submission of TMDLs. This WQMP is appended to the TMDL document as Appendix D.

The following are elements of the WQMPs that will be submitted to EPA:

1. *Condition assessment and problem description*
2. *Goals and objectives*
3. *Identification of responsible participants*
4. *Proposed management measures*
5. *Timeline for implementation*
6. *Reasonable assurance*
7. *Monitoring and evaluation*
8. *Public involvement*
9. *Costs and funding*
10. *Citation to legal authorities*

A Total Maximum Daily Load (TMDL) has been developed to address fisheries and human health concerns for all streams in the Tillamook Bay Watershed that builds upon the current land management programs:

- ***Tillamook National Estuary Program (NEP - all lands)***
- ***Northwest Forest Plan and Forest Ecosystem Management Assessment Team (FEMAT) protection/restoration measures (federal forest lands),***
- ***Oregon's Forest Practices Act (state and private forest lands),***
- ***Senate Bill 1010 (agricultural lands), and***
- ***Oregon Plan (all lands).***

1.3.2 Existing Water Quality Programs

Tillamook National Estuary Program

The Comprehensive Conservation and Management Plan (CCMP) of the Tillamook Bay National Estuary Program (NEP) was completed in 1999 with broad community, state and federal participation. EPA provides funding for the NEP. Water quality is one of the four major sections of the CCMP, and stream temperature and bacteria are addressed directly. The CCMP is to be implemented by the Tillamook County Performance Partnership, an organization specially created to implement or track actions related to the CCMP. The basic premise of the CCMP is that it incorporates the recommendations of all these plans and local ordinances

(Oregon Forest Practices, SB1010, Tillamook County, local governments and the Oregon Plan) into one overall plan for Tillamook County.

Following development of the CCMP, the Natural Resource Conservation Service has recently published a Watershed Plan/Environmental Assessment for the Lower Tillamook Bay Watershed (NRCS 2001) with sponsorship from the Tillamook Soil and Water Conservation District. The Plan is designed as an implementation measure for the Comprehensive Conservation and Management Plan developed by the TBNEP. This document describes the development of agricultural facilities, practices and restoration activities that will address TMDL-related water quality issues in the Tillamook Bay Watershed. In addition to description of these activities, the Plan identifies large-scale matching funding available through NRCS for its implementation. Modeling performed as part of the Environmental Assessment indicates significant improvements are possible through implementation of the Plan.

Northwest Forest Plan

In response to environmental concerns and litigation related to timber harvest and other operations on Federal Lands, the United States Forest Service (USFS) and the Bureau of Land Management (BLM) commissioned the Forest Ecosystem Management Assessment Team (FEMAT) to formulate and assess the consequences of management options. The assessment emphasizes management alternatives that comply with existing laws while maintaining the highest contribution of economic and social well being. The "backbone" of ecosystem management is construction of a network of late-successional forests and an interim and long-term scheme that protects aquatic and associated riparian habitats adequate to provide for *threatened species*. Biological objectives of the Northwest Forest Plan include assuring adequate habitat on Federal lands to aid the "recovery" of late-successional forest habitat-associated species listed as threatened under the Endangered Species Act and preventing species from being listed under the Endangered Species Act.

Oregon Forest Practices Act

The Oregon Forest Practices Act (FPA) contains regulatory provisions intended to: classify and protect water resources; reduce the impacts of clearcut harvesting; maintain soil and site productivity; ensure successful reforestation; reduce forest management impacts to anadromous fish; conserve and protect water quality and maintain fish and wildlife habitat; develop cooperative monitoring agreements; foster public participation; identify stream restoration projects; recognize the value of biodiversity; and monitor/regulate the application of chemicals. Oregon's Department of Forestry (ODF) has adopted Forest Practice Administrative Rules (1997) that define allowable actions on State, County and private forestlands. Forest Practice Administrative Rules allow revisions and adjustments to the regulatory parameters it contains. Several revisions have been made in previous years and it is expected that the ODF, in conjunction with DEQ, will continue to monitor the success of the Forest Practice Administrative Rules and make appropriate revisions when necessary to address water quality concerns.

Senate Bill 1010

Senate Bill 1010 requires the Oregon Department of Agriculture (ODA) to develop Water Quality Management Plans for agricultural lands where such actions are required by State or Federal Law, such as TMDL requirements. ODA is developing these plans for Basins throughout the state, and the North Coast Basin Agricultural Water Quality Management Area Plan was approved by the Board of Agriculture in June 2000. The Water Quality Management Plan was crafted so that landowners in the local area can determine the best means of preventing and controlling water pollution resulting from agricultural activities. Local stakeholders will be asked to take corrective action against identified problems such as soil erosion, nutrient transport to waterways and degraded riparian areas. It is the ODA's intent to establish individual farm plans on a voluntary basis. However, Senate Bill 1010 allows the ODA to use civil penalties when necessary to enforce against agricultural activity that is found to transgress parameters of administrative rules ODA has adopted in association with an approved basin Water Quality Management Plan. ODA has expressed its intention to work with the local stakeholders and other state and federal agencies to implement the North Coast Basin Water Quality Management Plan and to enforce the associated Oregon Administrative Rules where necessary.

National Pollutant Discharge Elimination System (NPDES)

The Oregon Department of Environmental Quality (DEQ), under delegation from the EPA, requires permits for any point-source discharges of wastewater to waters of the state. These discharges include those from sewage treatment plants, industries, food processors, and a variety of other activities that require discharge through a defined conveyance. Permits establish the amount of a given pollutant that may be discharged to waters of the state, and are designed to ensure that the load of that pollutant will not result in impairment of the waterbody. There are also permits required for certain types of non-point source discharges from municipalities, industries, and construction activities that result in runoff directly or as a result of stormwater management.

Oregon Plan

The State of Oregon has formed a partnership between Federal and State agencies, local groups and grassroots organizations that recognizes the attributes of aquatic health and their connection to the health of salmon populations. The Oregon Plan considers the condition of salmon as a critical indicator of ecosystems (CSRI, 1997). The decline of salmon populations has been linked to impoverished ecosystem form and function. In response, the Oregon Plan has committed the State of Oregon to the following obligations: an ecosystem approach that requires consideration of the full range of attributes of aquatic health, focuses on reversing factors for decline by meeting objectives that address these factors, develops adaptive management and a comprehensive monitoring strategy, and relies on citizens and constituent groups in all parts of the restoration process. The intent of the Oregon Plan is to conserve and restore functional elements of the ecosystem that supports fish, wildlife and people. The Oregon Plan is designed to build on existing State and Federal water quality programs, namely: the Federal Clean Water Act, Coastal Zone Non-point Pollution Control Programs, the Northwest Forest Plan, Oregon's Forest Practices Act, Oregon's Senate Bill 1010 and Oregon's TMDL Program.

1.3.3 Implementation and Adaptive Management Issues

1.3.3.1 Implementation Measures

The goal of the Clean Water Act and associated Oregon Administrative Rules is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where non-point sources are the main concern. To achieve this goal, implementation must commence as soon as possible.

TMDLs are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met. DEQ recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and techniques are simplifications of these complex processes and, as such, are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is for this reason that the TMDLs have been established with a margin of safety.

WQMPs are plans designed to reduce pollutant loads to meet TMDLs. DEQ recognizes that it may take some period of time—from several years to several decades after full implementation before management practices identified in a WQMP become fully effective in reducing and controlling non-point source pollution. In addition, DEQ recognizes that technology for controlling non-point source pollution is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated surrogates cannot be achieved as originally established.

DEQ also recognizes that, despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated surrogates. Such events could be, but are not limited to, floods, fire, insect infestations, and drought.

In this TMDL, pollutant surrogates have been defined as alternative targets for meeting the TMDL for temperature. The purpose of the surrogates is not to bar or eliminate human access or activity in the subbasin or its riparian areas. It is the expectation, however, that WQMPs will address how human activities will be managed to achieve the surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, WQMPs should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

If a non-point source that is covered by this TMDL complies with its WQMP or applicable forest practice rules, it will be considered in compliance with the TMDL.

DEQ intends to regularly review progress of WQMPs to achieve TMDLs. If and when DEQ determines that WQMPs have been fully implemented, that all feasible management practices have reached maximum expected effectiveness and a TMDL or its interim targets have not been achieved, DEQ shall reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary.

The implementation of TMDLs and the associated management plans is generally enforceable by DEQ, other state agencies and local government. However, it is envisioned that sufficient initiative exists to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the responsible agency will work with land managers to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. This could occur first through direct intervention from land management agencies (e.g. ODF, ODA, counties and cities), and secondarily through DEQ. The latter may be based in departmental orders to implement management goals leading to water quality standard attainment.

An unlisted source may be issued a permit for discharge of the pollutant causing impairment, without modification of the TMDL, if it is demonstrated that the discharge will not cause or contribute to a violation of the water quality standard (See 40 CFR 122.44(d) in the NPDES permitting regulations). New discharges that achieve water quality standards at end-of-pipe would be candidates for permitting without a TMDL modification. For instance, it may be allowable for a new facility to discharge at a concentration lower than the water quality criterion (where accumulation of the pollutant is not a concern). Similarly, in temperature impaired waters, it may be allowable for a new facility to discharge wastewater that is cooler than the temperature standard without modification of the TMDL. The demonstration that the new discharge will not cause or contribute to a violation of the water quality standard would be included in the Fact Sheet for the permit in question.

1.3.3.2 Adaptive Management

In employing an adaptive management approach to this TMDL and WQMP, DEQ has the following expectations and intentions:

- On a five-year periodic basis, DEQ will review the progress of the TMDL and the WQMP.
- In conducting this review, DEQ will evaluate the progress towards achieving the TMDL (and water quality standards) and the success of implementing the WQMP.
- DEQ expects that each management agency will also monitor and document its progress in implementing the provisions of its component of the WQMP. This information will be provided to DEQ for its use in reviewing the TMDL.
- As implementation of the WQMP proceeds, DEQ expects that management agencies will develop benchmarks for attainment of TMDL surrogates, which can then be used to measure progress.
- Where implementation of the WQMP or effectiveness of management techniques are found to be inadequate, DEQ expects management agencies to revise the components of the WQMP to address these deficiencies.
- When DEQ, in consultation with the management agencies, concludes that all feasible steps have been taken to meet the TMDL and its associated surrogates and attainment of water quality standards, the TMDL, or the associated surrogates is not practicable, it will reopen the TMDL and revise it as appropriate. DEQ would also consider reopening the TMDL should new information become available indicating that the TMDL or its associated surrogates should be modified.

CHAPTER 2 – DESCRIPTION OF THE TILLAMOOK BAY WATERSHED

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 3,700 feet. These upland areas consist mostly of volcanic basalt base material overlying soils formed from basalt, shale, and sandstone material. Primarily an Astoria-Hembre Association, moderately deep upland soils cover the gently sloping to very steep terrain of the forested uplands.

-Tillamook Bay National Estuary Project, 1997

2.1 Geographic Description

The Tillamook Bay Watershed is located in northwest Oregon occupying approximately 572 square miles. This sub-basin is contained within the "4th-field watershed designated by the USGS as Hydrologic Unit Code (HUC) 17100203 (USGS, 1989). The watershed includes the land areas that drain to Tillamook Bay and Netarts Bay. There are five major rivers in the watershed: the Miami, Kilchis, Trask, Wilson and Tillamook Rivers. All originate in the forested Coast Range Mountains and flow westward to estuary/tidal areas. Two major estuary/bay areas occur: Tillamook Bay and Netarts Bay. The Tillamook Bay is the northernmost and receives the Miami River, Kilchis River, Wilson River, Trask River and Tillamook River.

Headwater streams generally originate in the conifer forests of the Coastal Mountains at elevations over 2,000 feet (the highest point in the watershed is 3,691 feet in elevation). All of the river systems flow for a short length through low gradient and tidally influenced areas as is easily seen in the shaded relief developed for topography.

Five rivers enter Tillamook Bay from the south, east, and north. Salmon fishermen still recognize the Bay and its five rivers – the Tillamook, Trask, Wilson, Kilchis, and Miami – as some of the most productive fishing spots on the West Coast. Yet their bounty of chinook, chum, coho, and steelhead pales compared with earlier harvests. Today coho salmon is listed as a threatened species and chum and steelhead fish populations have been declining. Scientists point to the dramatic loss of spawning and rearing habitat as one of the principal reasons for the decline of Tillamook Bay salmonids. Today's salmon rivers drain 550 mi^2 (1,424 km^2) watershed that includes some of North America's richest timber and dairy lands. Although essential to the economy and character of Tillamook County, forestry, agriculture, and fishing activities have taken a high toll on salmon and other living resources dependent on the aquatic environment.

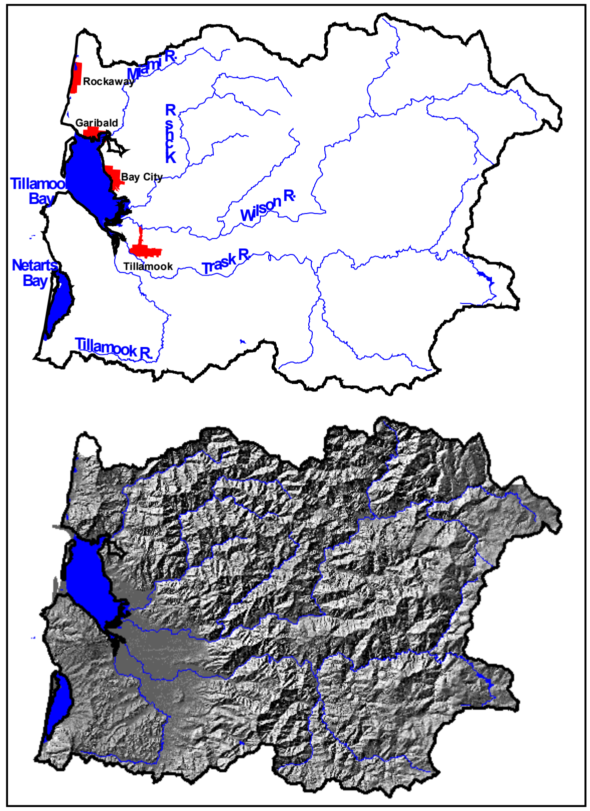
Like most Pacific Northwest estuaries, Tillamook Bay is part of a coastal, temperate rainforest ecosystem. The Bay is surrounded by rich forests that blanket the rainy Coast Range. With mean annual precipitation around 100 inches per year in the lower basin and close to 140 inches per year in the uplands, 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, especially as second growth riparian areas. 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 a highly productive ecosystem – from both biological and commodity perspectives.

In the lower Watershed, the forest gives way to rich alluvial plains used primarily for dairy agriculture. Early settlers recognized the rich agricultural potential of the lowlands and drained the area with numerous dikes, levees, and ditches. Once characterized by meandering rivers and networks of small channels that provided fish habitat, woody debris, and organic matter; today's 40 mi^2 (104 km^2) lowland supports about 30,000 dairy cattle and produces half of Oregon's cheese. It is also the source of hundreds of thousands of tons of manure annually and much of the bacteria that washes into the estuary.

-Tillamook Bay National Estuary Project, 1997

2.2 Land Ownership and Land Uses

The largest landholder in the Tillamook Bay Watershed is the State of Oregon (59% of the surface area) with 338 square miles that is predominately forested lands. Private lands account for 206 square miles (36% of the surface area) distributed throughout the watershed. The Bureau of Land Management manages 15 square miles of the Tillamook Bay Watershed (3% of the surface area). Other smaller land ownership designations include Oregon lands (2% of the surface area), County lands (0.4% of the surface area), **Figure 1** displays land ownership within the Tillamook Bay Watershed.



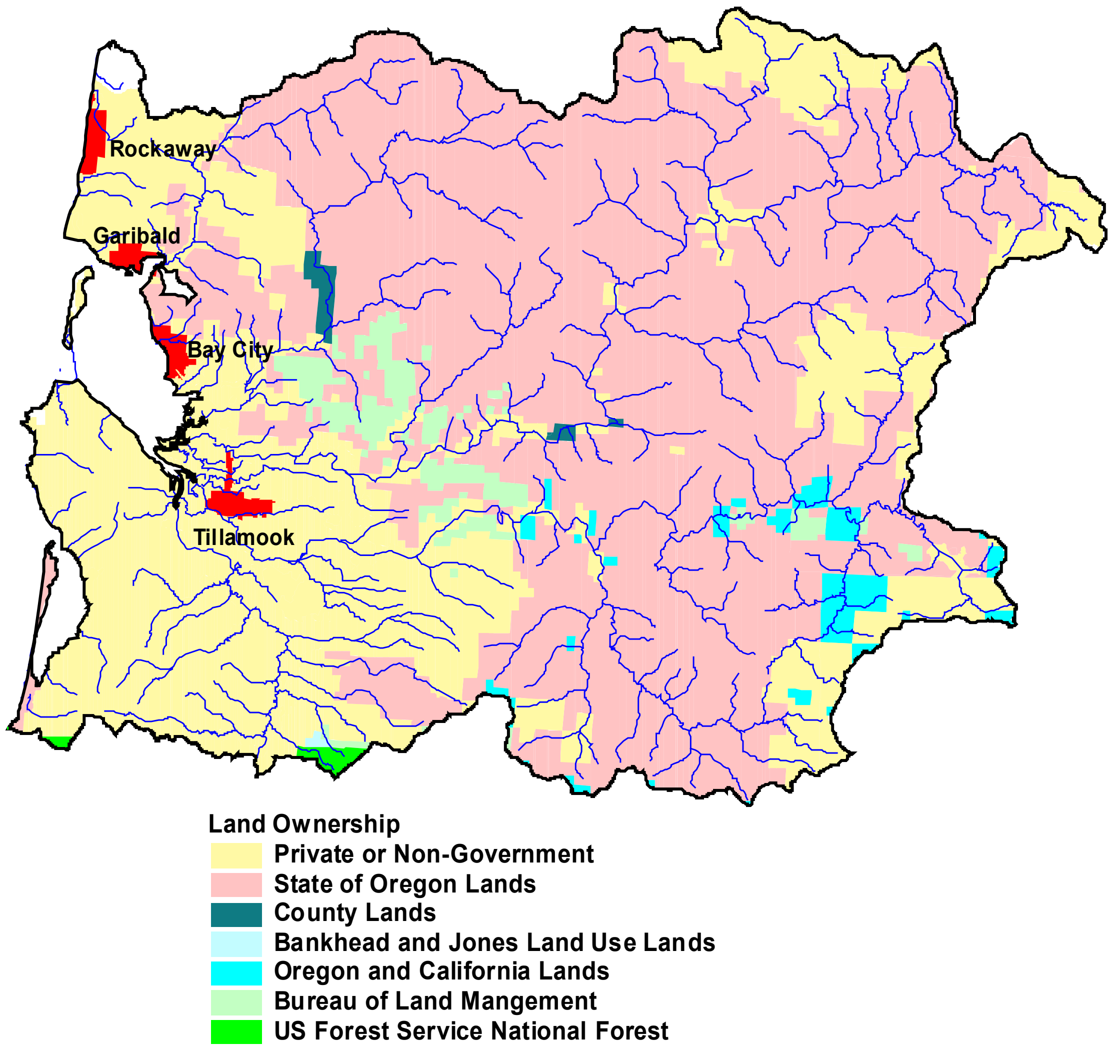
Tillamook Bay is a shallow estuary about 6.2 miles long (10 km) and 2.1 miles (3.4 km) wide with strong tidal influence. Depth of the Bay averages only 6.6 feet (2 m) over a total area of 13 square miles (34 km^2) with mixed semi-diurnal tides that can reach over 13 feet (TBNEP, September 1998). Oysters have been grown commercially in Tillamook Bay since the 1930's (TBNEP, July 1998).

Tillamook Bay has a long history of bacterial pollution problems (Jackson and Glendening, 1982*)*. Bacterial concentrations in the Bay have historically been high during the wet seasons of the year: fall, winter and early spring (TBNEP, July 1998). Because of the varying water quality in the Bay and the proximity of five wastewater treatment plants, oyster harvesting is allowed in specified areas of the Bay and only under certain conditions. Conditionally approved areas are closed when the Wilson River rises to 7 feet (TBNEP, July 1998).

The five rivers that enter Tillamook Bay cut through the steep uplands and drain to the alluvial plain and estuary below. The 40 square miles of lowland supports rural residential, rural industrial, and urban land uses as well as 28,600 dairy cattle (TBNEP, July 1998), all of which are important sources of bacterial contamination

Figure 2 shows the land uses within the Tillamook Bay Watershed as identified by USGS (1979). Forest land uses predominate in the Tillamook Bay Watershed, with 93.8% if the watershed area mapped as conifer and mixed forests. Crop and pasture land uses are confined to low gradient areas near tidally influenced areas and comprise 5.0% of the watershed area.

Figure 1. Land Ownership within the Tillamook Bay Watershed



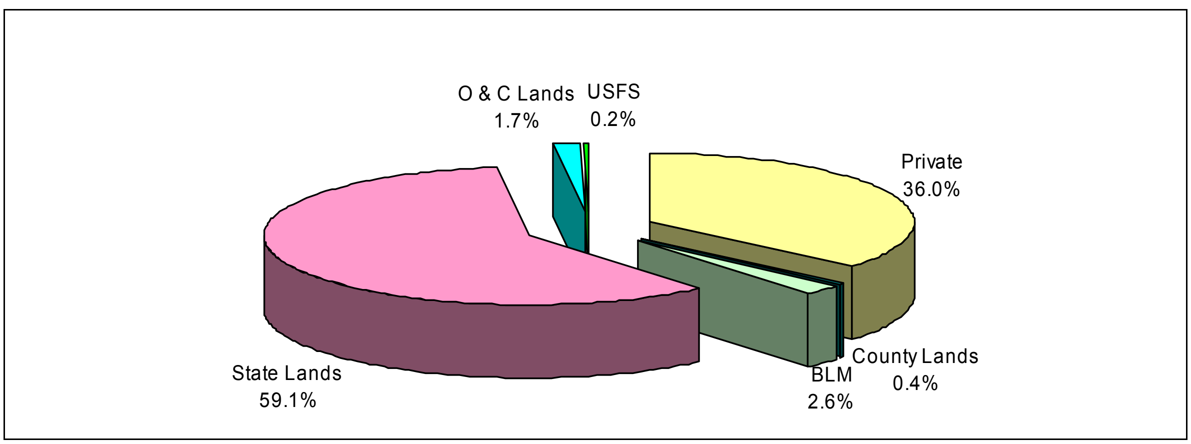
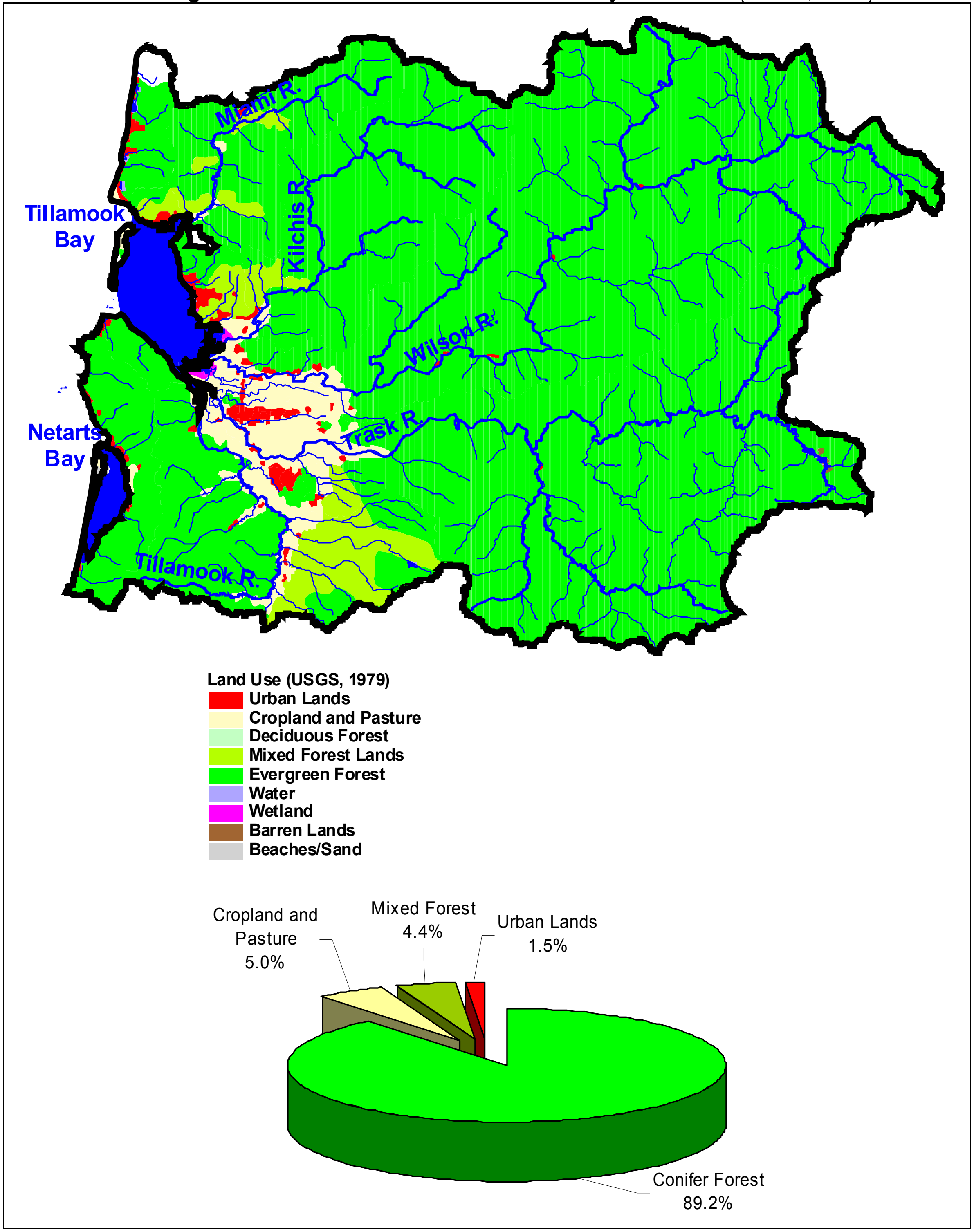


Figure 2. Land Use within the Tillamook Bay Watershed (USGS, 1979)



The seasonal, episodic nature of precipitation defines the natural system. Fall chinook migrate upstream with the first heavy rains in late autumn. Big storms 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 (Coultan, 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 south and southwest during the summer.

Temperatures in Tillamook County are moderate. The mean annual temperature is 10.2°C (50.4°F), with yearly mean and maximum temperatures documented at 15.1°C (59.3°F) and 5.4°C (41.6°F), respectively. Those 30 years [1961-1990] *averaged less than one day per year with a temperature over 32°C (90°F). September had the greatest number of extreme temperatures while July and August recorded the highest temperature of 38.89°C (102°F).*

-Tillamook National Estuary Project, 1997

2.3 Climate

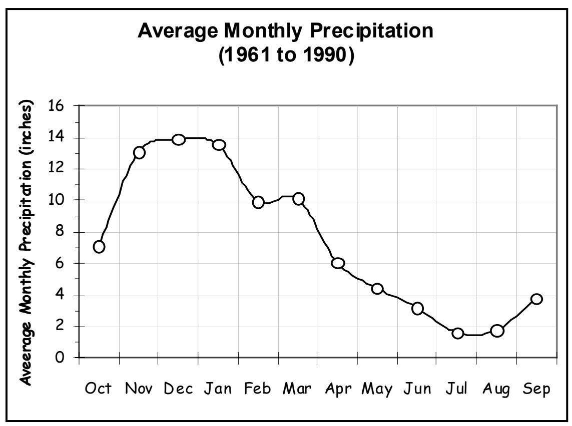
The Tillamook Bay Watershed receives an average of 125 to 200 inches of precipitation annually, comprised largely as rainfall. Fall, winter and spring are usually wet seasons, while summertime is often drier. However, rainfall patterns vary considerably throughout the watershed and from year to year.

2.3.1 Annual Patterns

Tillamook Bay Watershed climate is influenced by proximity to the Pacific Ocean and elevation. Climatic conditions can vary considerably, and are a function of *orographic*[1] influence and ocean effects. The Coastal Mountains that surround the city of Tillamook to the east often receive between 125 and 200 inches of annual precipitation, most as rainfall. Lower portions of the watershed, closer to the City of Tillamook, receive average annual precipitation totals between 80 and 125 inches. **Figure 3** displays the average annual precipitation (rainfall equivalent).

2.3.2 Seasonal Variation

Precipitation totals are greatest in winter and spring months (November through April), while less precipitation is received in summer and early fall months (May through October). Air temperatures in the Tillamook Bay Watershed are mild throughout the year (Table 1). The Pacific Ocean has a moderating effect on air temperature, much more so at close proximity to the ocean. Summertime air temperatures may be much greater in areas only a few miles inland, relative to areas near the ocean.



[1] Orographic Precipitation is caused by surface winds that are forced to rise against mountains. The winds cool as they rise against the mountain slopes the moisture in the air condenses and changes into rain. Precipitation formed by winds rising against mountains is orographic (from the Greek word oros, "mountain").

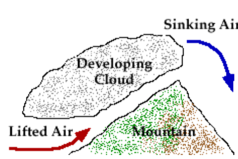


Figure 3. Average Annual Precipitation in the Tillamook Bay Watershed

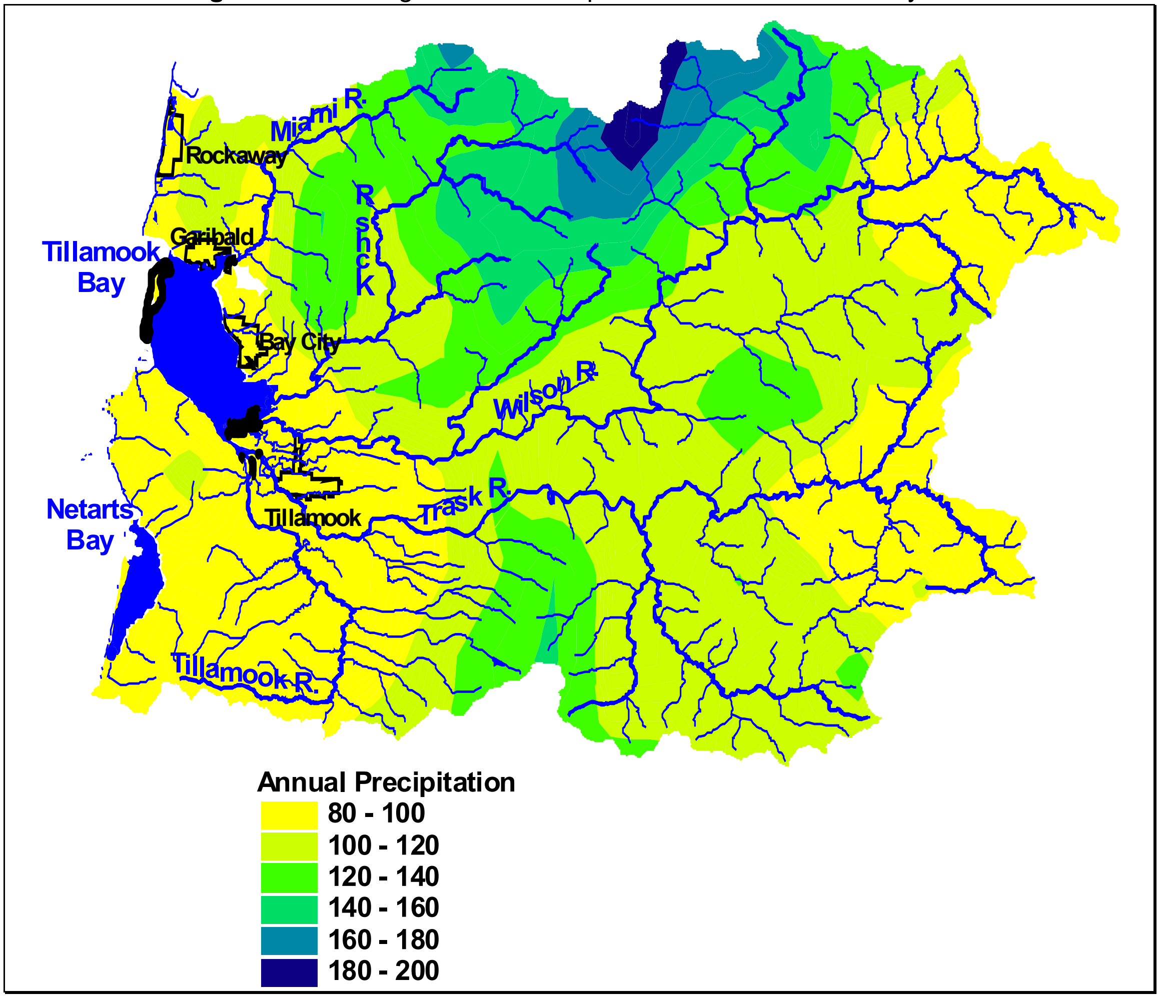


Table 1. Average Monthly Climate Data for Tillamook, Oregon (1961 to 1990)

Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
Air Temperature (°F)													
Mean	53	47	43	43	45	46	48	52	56	58	59	58	50
Maximum	92	80	66	69	73	73	84	86	92	102	102	97	102
Minimum	22	14	4	11	8	21	23	27	31	35	34	27	4
Precipitation (inches)													
Mean	7	13	14	14	10	10	6	4	3	2	2	4	89
Extreme 24 hour	4	4	5	5	3	4	3	2	3	2	2	3	5
Precipitation (days)													
.01 inches or more	15	21	23	21	19	21	18	15	10	7	7	11	187
.10 inches or more	11	18	19	18	16	17	13	10	7	4	4	7	143
.50 inches or more	6	10	10	10	8	9	4	3	2	1	1	3	65
1.00 inches or more	2	4	4	4	3	3	1	1	1	0	0	1	24

2.4 Flow

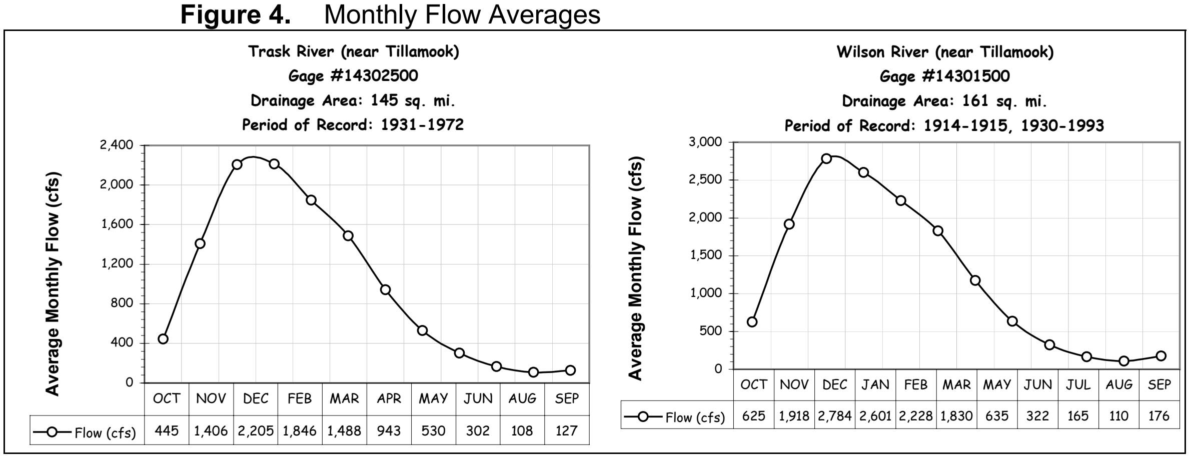
Flow data has been collected in the Tillamook Bay Watershed by 4 U.S. Geological Survey (USGS) gages. Two of these gages have been collecting daily stream flow measurements since 1930 (USGS #14301500 and USGS #14302500). Flow data files were processed by DEQ staff to quantify *return periods*[2] for both high and low flow conditions. Long-term flow data collection has not been high priority in the Tillamook Bay watershed. Statistical descriptions of temporal and spatial flow regimes/patterns require many years of daily collected flow data. This level of data duration does not exist in the Miami River, Kilchis River and Tillamook River.

Using historical gage data for the Trask River and Wilson River:

- ***10 year low flows are roughly 50 cfs.***
- ***Yearly average low flows are approximately 110 cfs.***
- ***Wintertime high flows are generally greater than 2,000 cfs.***
- ***Ten year high flows are 10,000 cfs for the Wilson River and 8,000 cfs for the Trask River.***

Long-term average monthly flow values for the lower Trask and Wilson Rivers reflect the seasonal precipitation patterns (**Figure 4**). Flow in these systems is associated with rain events, and as a result, both rivers exhibit flashy flow regimes during periods of intense rainfall. *Perennial* streams are those with flow throughout the year. *Intermittent* streams experience a period of time during the year without flow, becoming completely de-watered. This intermittance produces harsh conditions for aquatic life and water quality. Intermittent streams are determined as such when the 7Q10 values were *zero*. The Wilson River has a 7Q10 low flow of 48 cfs and the Trask River has a 7Q10 low flow of 54 cfs.

Figure 4. Monthly Flow Averages



[2] Duration periods for which flows were averaged were 1 day, 7 days and 14 days. Return period estimations were performed using the Log Pearson Type III distribution for the following *return periods*: 1 year, 2 years, 5 years, 10 years, 25 years, 50 years and 100 years. Average monthly flows were also calculated for many of the gages, depending on the length of the period of recorded flow values. Return flows are presented as *XQY*, where "*X"* represents the flow duration (days) and "*Y*" represents the return period (years). For example, a *7Q10* would represent the 7-day average flow that occurs on average once every 10 years. Therefore, the probability that seven-day duration 10-year *return period* flow (7Q10) conditions will occur during any year is 10%.

CHAPTER 3 – TOTAL MAXIMUM DAILY LOADS

Summary of Temperature TMDL Development and Approach

Why Is Temperature Important?

Excessive summer water temperatures in several tributaries and mainstem reaches throughout the Tillamook Bay Watershed are reducing the quality of rearing habitat for chinook, coho and chum salmon, as well as steelhead trout and cutthroat trout. Primary watershed disturbance activities that contribute to surface water temperature increase include past forest and fishery management within riparian areas, current timber harvest in near stream areas and outside the riparian zone, agricultural land use within the riparian area, road construction and maintenance, and rural residential development near streams and rivers. Point source discharges of warm water also contribute to stream heating in the lower watershed. As a result of water quality standards (WQS) exceedances for temperature, waters in the Tillamook Bay Watershed are on Oregon's 1998 303(d) list.

Scope

All lands (572 square miles) with intermittent or perennial streams that drain to the Tillamook Bay within HUC 17100203 are included in the temperature TMDL. All land uses and both point-sources and nonpoint sources of heat are included: lands managed by the State of Oregon, the U.S. Forest Service (USFS) and Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, military lands and urban areas.

Applying Oregon's Temperature Standard

The reduction in thermal loading needed to meet the water quality standard is evaluated using a variety of data (ground level, GIS and remote sensing) and analytical modeling. Attainment of the temperature standard relies on simulating the thermal effects of "system potential" riparian vegetation and channel morphology that reduce thermal patterns to those that minimize human caused increases in stream temperatures. In areas where the numeric criteria are being exceeded, DEQ considers attainment of system potential conditions as measured by % effective shade to demonstrate compliance with the temperature standard. This is obtained through restoration/protection of riparian vegetation, channel morphology, and hydrologic processes.

Development of System Potential Conditions

System potential conditions are determined by riparian and channel morphology parameters. DEQ assessed potential vegetation with field measurements and literature regarding vegetation distributions. Channel morphology was assessed via the application of hydrologic principles and distributions of current channel geometry. Flows were evaluated with instream measurements and gage data. A current condition flow profile was derived. DEQ calculated the thermal effects associated with achieving both riparian and channel morphology system potential conditions. Other factors, such as groundwater/stream interactions and floodplain/stream connection, are more difficult to quantitatively assess and are indirectly addressed through the riparian and channel morphology TMDL targets.

Temperature TMDL Overview

Stream temperature pollutants are identified as human-caused increases in solar radiation that reaches the stream surface and warm water discharges. The resultant TMDL loading capacities are expressed as pollutant loading limits for both non-point and point sources of pollution. Allocations of the pollutant load are provided to all sources of pollution in the Tillamook Bay Watershed. Surrogate measures are also provided to non-point sources of pollution to help translate the loading capacity and to provide a clear list of site-specific targets for management and implementation considerations.

3.1 Stream Temperature TMDL

3.1.1 Temperature Pollutant Identification

The pollutants identified for stream temperature pollution are human caused increases solar radiation loading at the stream surface and warm water discharge to surface waters.

With a few exceptions, such as in cases where violations are due to natural causes, the State must establish *a Total Maximum Daily Load* or *TMDL* for any waterbody designated on the 303 (d) list as violating water quality standards. A *TMDL* is the total amount of a pollutant (from all sources) that can enter a specific waterbody without causing violation of the water quality standards.

Water temperature change is an expression of heat energy exchange per unit volume:

$$\Delta Temperature \propto \frac{\Delta Heat \quad Energy}{Volume}.$$

Anthropogenic increase in heat energy is derived from solar radiation as increased levels of sunlight reach the stream surface and raise water temperature. The pollutants targeted in this TMDL are (1) human caused increases in solar radiation loading to the stream network and (2) warm water discharges of human origin.

3.1.2 Temperature Target Identification – CWA §303(d)(1)

The stream temperature TMDL targets protection of the most sensitive beneficial use: salmonids. Oregon's stream temperature standard, which is based on the temperature requirements of salmonids, is designed for protection during all salmonid life stages. Several numeric criteria and other triggers for the temperature standard establish factors for designating surface waters as water quality limited. The temperature standard specifies that anthropogenic (i.e. human caused) impacts that cause stream heating should be removed. The TMDL targets this no anthropogenic warming condition. A stream condition that has no anthropogenic induced warming is considered to be at the system potential.

3.1.2.1 Salmonid Stream Temperature Requirements

Stream temperatures above 64°F (17.8°C) are considered sub-lethal and can be stressful for cold water fish species, such as salmon and trout.

Salmonids, often referred to as cold water fish, and some amphibians are highly sensitive to temperature. In particular, Chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*) are among the most temperature sensitive of the cold water fish species. Oregon's water temperature standard employs logic that relies on using these *indicator species,* which are the most sensitive. If temperatures are protective of *these indicator species*, other species will share in this level of protection.

If stream temperatures become too hot, fish die almost instantaneously due to denaturing of critical enzyme systems in their bodies (Hogan, 1970). The ultimate *instantaneous lethal limit* occurs in high temperature ranges (upper-90°F). Such warm temperature extremes may never occur in the Tillamook Bay Watershed.

More common and widespread within the Tillamook Bay Watershed, however, is the occurrence of temperatures in the mid-70°F range (mid- to high-20°C range). These temperatures cause death of cold-water fish species during exposure times lasting a few hours to one day. The exact temperature at which a cold water fish succumbs to such a thermal stress depends on the temperature that the fish is acclimated to, and on life-stage of development. This cause of mortality termed the *incipient lethal limit*, results from breakdown of physiological regulation of vital processes such as respiration and circulation (Heath and Hughes, 1973).

The most common and widespread cause of thermally induced fish mortality is attributed to interactive effects of decreased or lack of metabolic energy for feeding, growth or reproductive behavior, increased exposure to pathogens (viruses, bacteria and fungus), decreased food supply (impaired macroinvertebrate populations) and increased competition from warm water tolerant species. This mode of thermally induced mortality, termed indirect or *sub-lethal*, is more delayed, and occurs weeks to months after the onset of elevated temperatures (mid-60°F to low-70°F). **Table 2** summarizes the modes of cold water fish mortality.

Table 2. Modes of Thermally Induced Cold Water Fish Mortality

(Brett, 1952; Bell, 1986, Hokanson et al., 1977)

Modes of Thermally Induced Fish Mortality	Temperature Range	Time to Death
Instantaneous Lethal Limit – Denaturing of bodily enzyme systems	> 90°F > 32°C	Instantaneous
Incipient Lethal Limit – Breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation	70°F - 77°F 21°C - 25°C	Hours to Days
Sub-Lethal Limit – Conditions that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supply and increased competition from warm water tolerant species	64°F - 74°F 20°C - 23°C	Weeks to Months

3.1.3 Sensitive Beneficial Use Identification

Beneficial uses and the associated water quality standards are generally applicable throughout the Tillamook Bay Watershed (Table 3). Some uses require further delineation. At a minimum, uses are considered attainable wherever feasible or wherever attained historically. In applying standards and restoration, it is important to know where existing salmonid spawning locations are and where they are potentially attainable. Salmonid spawning and the quality of the spawning grounds are particularly sensitive to water quality and streambed conditions. **Figure 5** identifies occurrence of anadromous salmonids (*Oncorhynchus*) in the Tillamook subbasin and the various habitat uses (migration, spawning and rearing) for four important anadromous salmonids present in the Tillamook Bay Watershed (ODFW data):

Salmonid fish spawning, incubation, fry emergence, and rearing are deemed the most temperature-sensitive beneficial uses within the Tillamook Bay Watershed.

- Chinook Salmon (Spring and Fall) – *Oncorhynchus tshawytscha*
- Chum Salmon (Dog Salmon) - *Oncorhynchus keta*
- Coho Salmon (Silver Salmon) - *Oncorhynchus kisutch*
- Steelhead (Winter and Summer) - *Oncorhynchus mykiss*

Other sensitive uses (such as drinking water and water contact recreation) are applicable throughout the subbasin. Oregon Administrative Rules (OAR Chapter 340, Division 41, Section 202, Table 1) lists the "Beneficial Uses" occurring within the Tillamook Bay watershed (Table 3). Numeric and narrative water quality standards are designed to protect the most temperature sensitive *beneficial uses*. In the Tillamook Bay Watershed, resident fish and aquatic life and salmonid spawning, rearing and migration are designated the most sensitive *beneficial uses*. Use for various life history stages or events are presented in Table 4. The distribution of fish in the watershed varies through the year and temperature impairment is in part a function of fish habitat requirements.

Table 3. Beneficial uses occurring in the Tillamook Bay Watershed

(OAR 340 – 41 – 202)
Temperature-Sensitive Beneficial uses are marked in gray

Beneficial Use	***Occurring***	***Beneficial Use***	***Occurring***
Public Domestic Water Supply	✓	Anadromous Fish Passage	✓
Private Domestic Water Supply	✓	Salmonid Fish Spawning	✓
Industrial Water Supply	✓	Salmonid Fish Rearing	✓
Irrigation	✓	Resident Fish and Aquatic Life	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Commercial Navigation & Trans.		Hydro Power	

Figure 5. Chinook Salmon, Coho Salmon, Chum Salmon and Steelhead Trout Distributions (ODFW). Range of dates indicate spawning and incubation periods for each species.

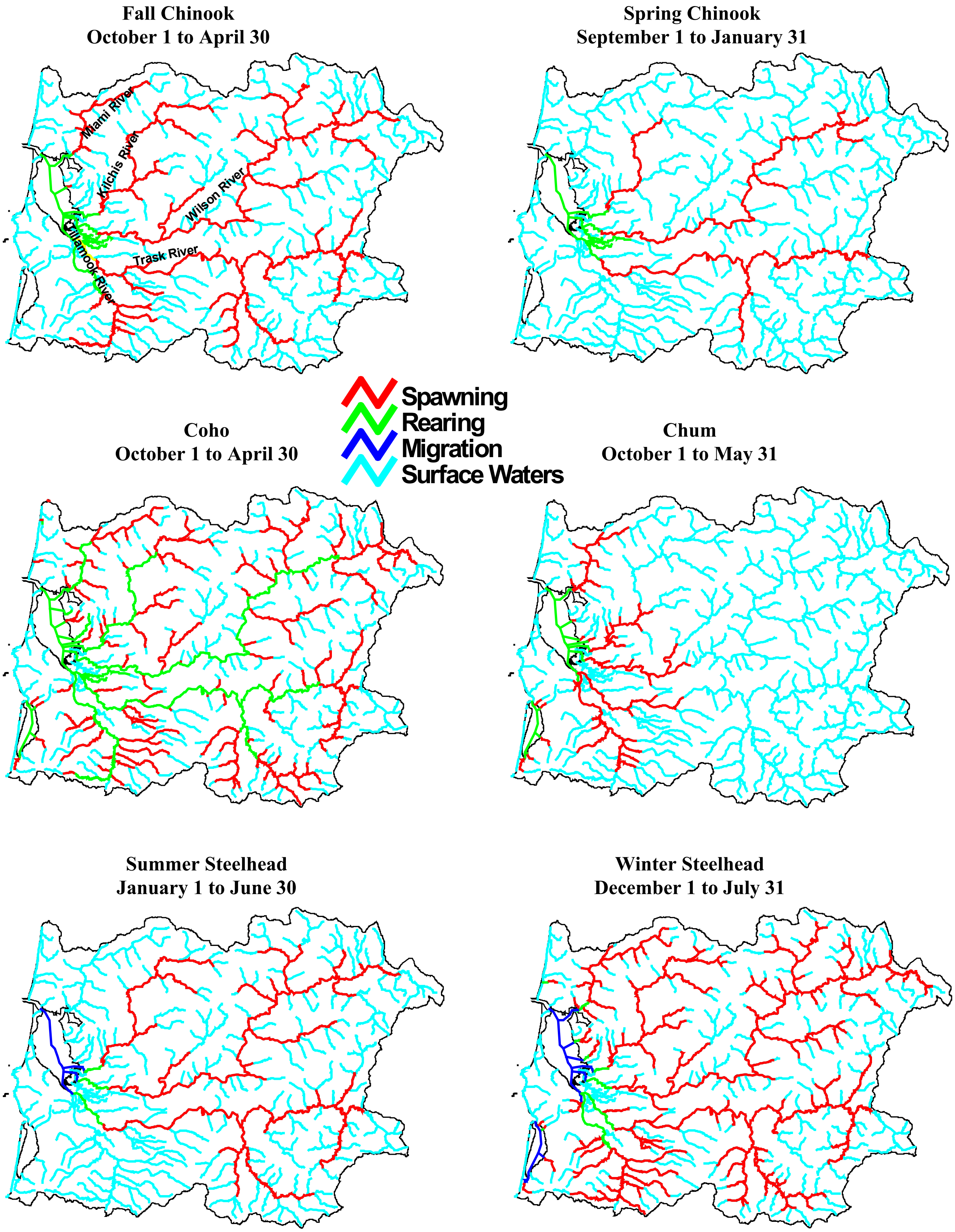


Table 4. Tillamook Bay Watershed Spawning Periods of Use by Species

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration/Holding												
Spring Chinook					Range	Peak	Range	Range	Range			
Summer Steelhead	Range	Range			Range	Peak	Peak		Range	Range	Range	Range
Sea-Run Cutthroat	Range	Range	Range	Range	Range	Peak	Peak	Peak	Peak	Peak	Peak	Range
Coho	Range	Range							Range	Range	Peak	Peak
Chum										Range	Peak	Peak
Fall Chinook								Range	Range	Range	Peak	Range
Winter Steelhead	Range	Peak	Peak	Peak							Range	Range
Resident Cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Spawning												
Spring Chinook									Peak	Peak		
Summer Steelhead	Range	Peak	Range	Range								
Sea-Run Cutthroat	Range	Peak	Peak									Range
Coho	Range	Range								Range	Peak	Peak
Chum	Range									Range	Peak	Peak
Fall Chinook	Peak	Range	Range							Range	Range	Peak
Winter Steelhead	Range	Range	Range	Peak	Peak							
Resident Cutthroat	Range	Peak	Peak									Range
Incubation												
Spring Chinook	Range								Range	Range	Peak	Peak
Summer Steelhead	Range	Peak	Peak	Range	Range	Range						
Sea-Run Cutthroat	Range	Range	Peak									Range
Coho	Range	Range	Range	Range	Range					Range	Range	Peak
Chum	Peak	Range	Range	Range	Range					Range	Peak	Peak
Fall Chinook	Range	Peak	Peak	Range						Range	Range	Range
Winter Steelhead	Range	Range	Range	Range	Peak	Peak	Peak					Range
Resident Cutthroat	Range	Range	Peak	Peak	Peak							Range
Rearing												
Spring Chinook	Range	Range	Range	Range	Range	Range	Range	Range				Range
Summer Steelhead	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Sea-Run Cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Coho	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Chum	No Freshwater Rearing Period											
Fall Chinook	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range		
Winter Steelhead	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Resident Cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Peak Smolt Outmigration												
Spring Chinook					Peak	Peak						
Summer Steelhead					Peak							
Sea-Run Cutthroat					Peak	Peak						
Coho				Peak	Peak							
Chum				Peak								
Fall Chinook					Peak	Peak						
Winter Steelhead					Peak							
Resident Cutthroat	Grow to Adulthood and Remain in River											

Peak Use Period
Range of Use

3.1.4 Water Quality Standard Identification

The temperature standard applicable in the Tillamook Bay Watershed specifies that "no measurable surface water temperature increase resulting from anthropogenic (human induced) activities is allowed" unless specifically allowed under a DEQ-approved management plan, when trigger temperatures are exceeded (see temperature standard below - i through viii).

A seven-day moving average of daily maximums (7-day statistic) was adopted as the statistical measure of the stream temperature standard. Absolute numeric criteria are deemed action levels and indicators of water quality standard compliance. Unless specifically allowed under a DEQ-approved surface water temperature management plan (as required under (OAR 340-041-0026(3)(a)(D)), no measurable surface water temperature increase resulting from anthropogenic activities is allowed in State of Oregon Waters determined out of compliance with the temperature standard. A much more extensive analysis of water temperature related to aquatic life and supporting documentation for the temperature standard can be found in the *1992-1994 Water Quality Standards Review Final Issue Papers (ODEQ, 1995)*.

It is important to understand the State of Oregon's temperature standard and that there is more to it than just a 64^{o}F criterion. Specifics for the Tillamook Bay Watershed temperature standard can be found in OAR 340-041-202(2)(b)(A) and in **Appendix C**.

Tillamook Bay Watershed Temperature Standard - OAR 340-041-202(2)(b)(A)(i-viii)

To accomplish the goals identified in OAR 340-041-120(11), unless specifically allowed under a DEQ-approved surface water temperature management plan as required under OAR 340-041-026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:

(i) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64.0°F (17.8°C);

(ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface waters exceed 68.0°F (20.0°C);

(iii) In waters and periods of the year determined by DEQ to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C);

(iv) In waters determined by DEQ to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);

(v) In waters determined by DEQ to be ecologically significant cold-water refugia;

(vi) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;

(vii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or Basin; and

(viii) In natural lakes.

3.1.4.1 Deviation from Water Quality Standard (Temperature Impairments)

Many reaches of the Tillamook Bay Watershed are designated as temperature limited on Oregon's 1998 303(d) list. In total, 101 stream miles are temperature limited (triggers for the standard are exceeded and/or occur).

Monitoring has shown that water temperatures in the Tillamook Bay Watershed often exceed numeric criteria of the State water quality standard. There are approximately 100 miles of stream segments within the Tillamook Bay Watershed on the 1998 §303(d) list for exceeding numeric temperature criteria (Table 5). Generally, stream temperatures follow a longitudinal (downstream) heating pattern, where smaller tributaries are cooler than the mainstem reaches. **Figure 6** displays stream heating as a function of measured perennial stream distance from headwaters. Headwater temperatures are in the mid-50^{o}F to upper-50^{o}F range, and warm roughly 15^{o}F to 20^{o}F to tidewater influences. **Figure 7** displays the locations and corresponding 7-day temperature statistic ranges (based on temperature data collected in the Tillamook

Bay Watershed during the 1997 and 1998 summertime seasons using temperature monitoring instruments that recorded hourly stream temperatures).

Table 5. Tillamook Bay Watershed Temperature Limited Waterbodies and miles of listed stream. (Oregon 303(d) List, 1998)

Location:	• Kilchis River (Mouth to headwaters)	7.0
	• Miami River (Mouth to Moss Creek)	1.5
	• Tillamook River (Mouth to Yellow Fir)	13.6
	• Trask River (Mouth to S.F. Trask River)	19.2
	• Wilson River (Mouth to headwaters)	32.8
	• Coal Creek (Mouth to headwaters)	2.3
	• Fawcett Creek (Mouth to headwaters)	6.75
	• Mill Creek (Mouth to headwaters)	2.6
	• Murphy Creek (Mouth to headwaters)	2.5
	• Myrtle Creek (Mouth to headwaters)	1.3
	• Trask River, North Fork (Mouth to Bark Shanty Creek)	4.4
	Trask River, North Fork of North Fork (Mouth to headwaters)	7.1
Supporting Data:	• ODEQ (1997 – 2000) • NRCS (1992 – 1994)	Total = **101**

Figure 6. Maximum Daily Temperature Values Related to Distance from Headwaters
(ODEQ, August 12, 1998)

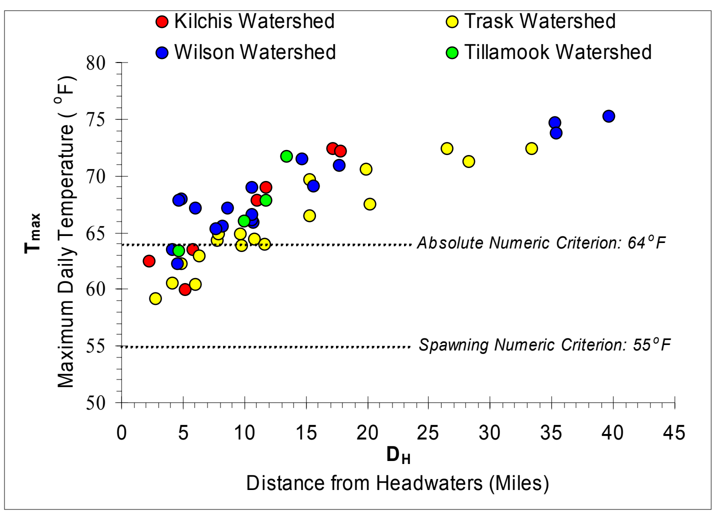
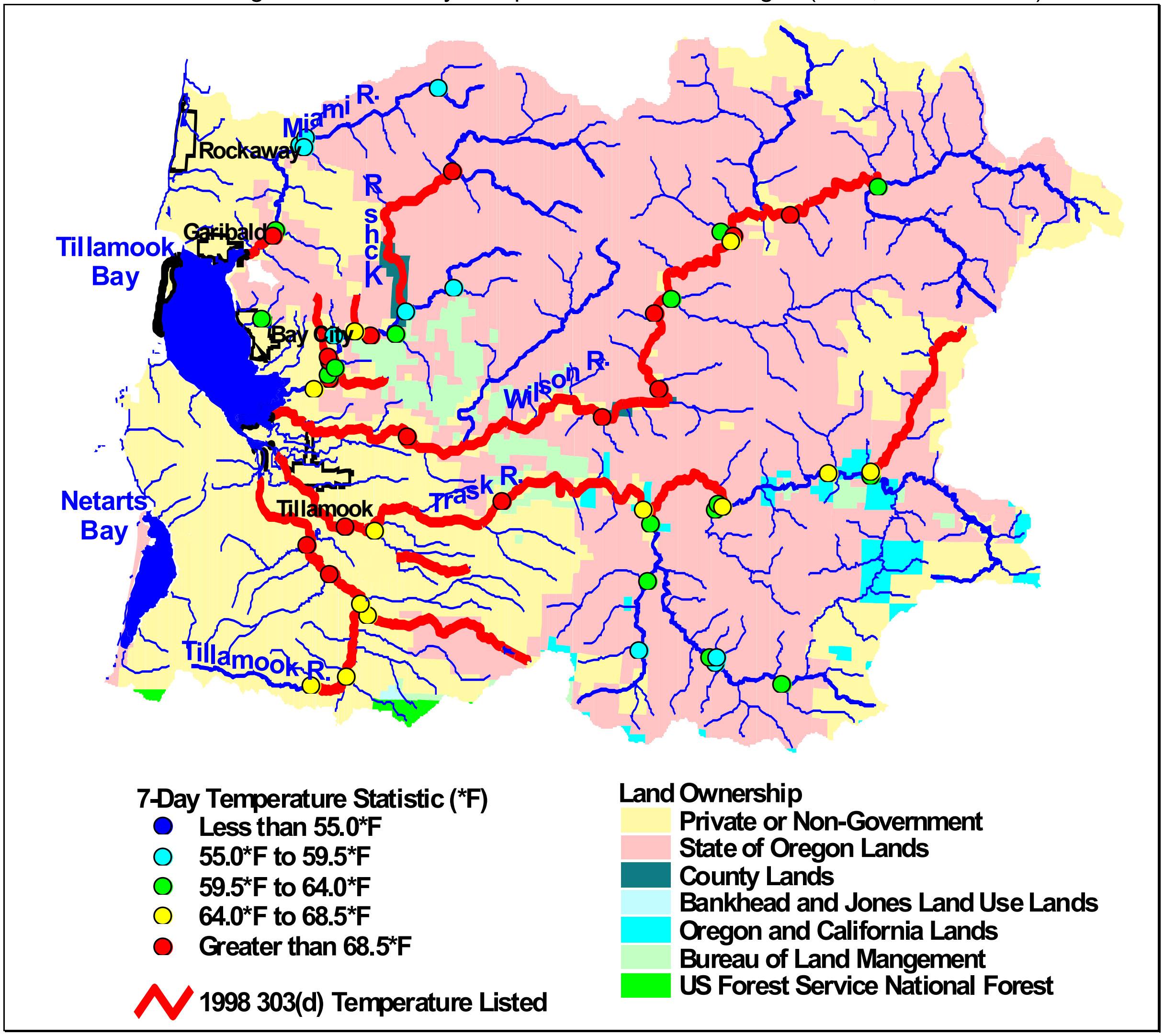


Figure 7. Segments on the 1998 §303(d) List for Temperature and Continuous Temperature Monitoring Sites with 7-Day Temperature Statistic Ranges (DEQ, 1997 to 1998)



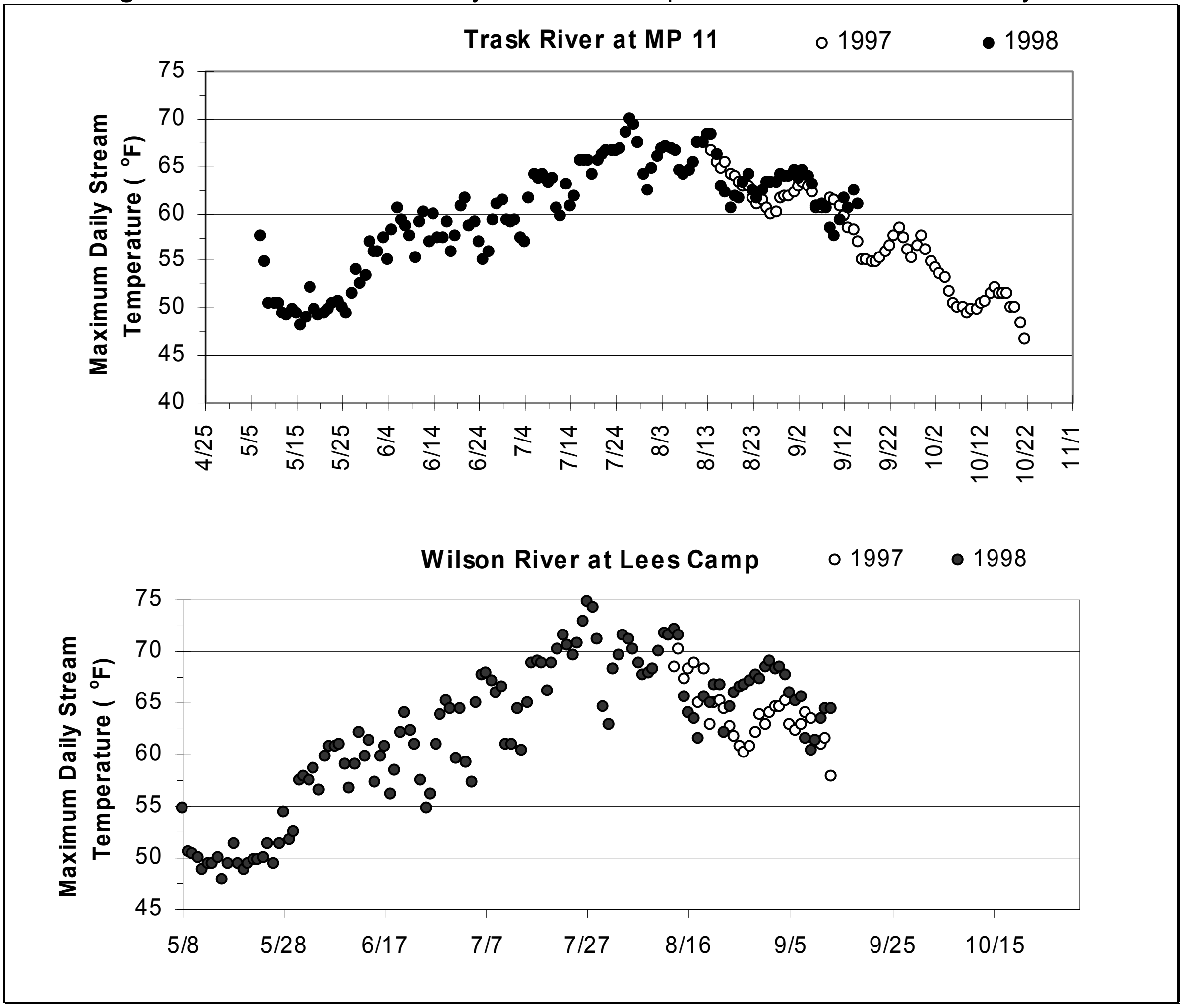
3.1.5 Seasonal Variation – CWA §303(d)(1)

The Tillamook Bay Watershed mainstem and tributaries stream reaches experience prolonged warming starting in late spring and extending into the fall. Maximum temperatures typically occur in July and August (**Figure 8).** The TMDL focuses the analysis during the late July and early August period as a critical condition as identified by 1998 temperature data. It should also be noted that the Tillamook Bay watershed streams are commonly above the 55°F numeric criterion during the period that spans June through October. The 64°F numeric criterion is exceeded in the period between mid-June through mid-September.

The critical temperature period occurs when stream temperatures are above the numeric criterion.

The critical temperature period occurs from May through October

Figure 8. 1998 Observed Daily Maximum Temperatures for the Tillamook Bay Watershed



3.1.6 Existing Sources – CWA §303(d)(1)

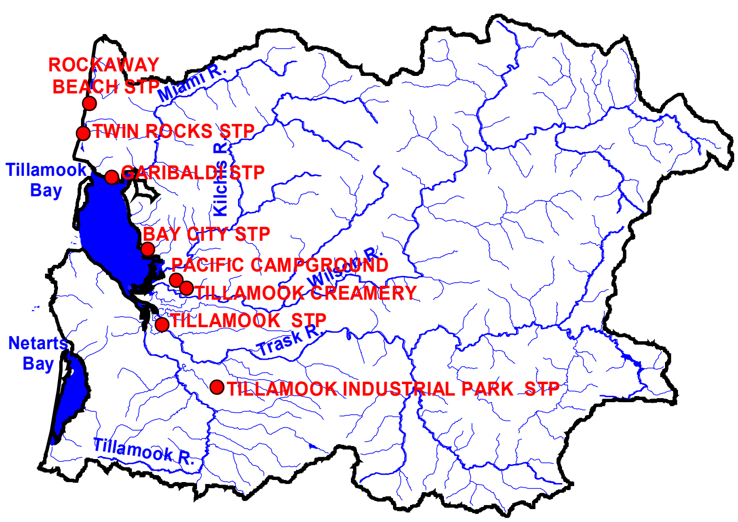
3.1.6.1 Point Sources

Warm point source discharges in the Tillamook Bay Watershed are sources of stream heating. Eight NPDES permitted discharges are mapped and presented below. Discharge temperature data is limited for many of the facilities, and discharge flow rates are generally very low. Discharge temperatures are typical of small wastewater treatment facilities (≈70°F), however the Tillamook Creamery has a warm effluent temperature ranging as high as 92°F. The STPs for Rockaway Beach and Twin Rocks discharge to the Pacific Ocean, and Garibaldi and Bay City facilities discharge to Tillamook Bay. Receiving waters for these discharges are not water quality limited for temperature, and will not receive temperature allocations.

Table 6. NPDES Permitted Facilities

Facility Name	City	Receiving Water	River Mile	Permit Type	Flow Rate (cfs)	Critical Temp.
Rockaway Beach STP	Rockaway	Clear Lake		NPDES	NA	NA
Twin Rocks STP[3]	Twin Rocks	Watseco Cr.	0.2	NPDES	NA	NA
Garibaldi STP	Garibaldi	Tillamook Bay		NPDES	0.77	NA
Bay City STP	Bay City	Tillamook Bay		NPDES	0.33	NA
Pacific Campground	Tillamook	Wilson R.	0.9	NPDES	0.08[4]	70 °F
Tillamook Creamery	Tillamook	Wilson R.	1.7	NPDES	0.75[5]	92 °F
Tillamook STP	Tillamook	Trask R.	1.9	NPDES	1.64	71 °F
Tillamook Industrial Park STP[6]	Tillamook	Trask R.	5.2	NPDES	No Data	No Data

NPDES Permitted Facilities



There are eight point sources that discharge into surface waters in the Tillamook Bay Watershed.

Effluent temperature range from 68°F to 92°F.

[3] Rockaway Beach STP, Twin Rocks STP, do not discharge to tributaries of Tillamook Bay.

[4] Pacific Campground has no reported dry weather design flow. Reported value is maximum value recorded during May to October for 1998.

[5] Tillamook Creamery has no reported dry weather design flow. Reported value is maximum value recorded during May to October for 1998.

[6] Tillamook Industrial Park STP does not discharge from June 1 to October 31.

3.1.6.2 Non-point Sources

Riparian vegetation, stream morphology, hydrology, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology and hydrology are affected by land use activities. Human activities that contribute to degraded thermal water quality conditions in the Tillamook Bay Watershed are associated with agriculture, forestry, roads, urban development and rural residential related riparian disturbance.

Elevated summertime stream temperatures attributed to nonpoint sources in the Tillamook Bay Watershed result from riparian vegetation disturbance (reduced stream-surface shade) and channel widening (increased stream surface area exposed to solar radiation).

Specifically, the elevated summertime stream temperatures attributed to anthropogenic non-point sources result from:

1. ***Near stream vegetation disturbance/removal*** *reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is commonly measured as percent effective shade or open sky percentage). Riparian vegetation also plays an important role in shaping channel morphology, resisting erosive high flows and maintaining floodplain roughness.*
2. ***Channel modifications and widening*** *(increased width to depth ratios) increases the stream surface area exposed to energy processes, namely solar radiation. Near-Stream Disturbance Zone (NSDZ) widening decreases potential shading effectiveness of shade-producing near-stream vegetation.*

Both shade and channel morphology are affected by riparian vegetation. Trees and shrubs along streambanks control erosion and maintain the width of the stream. Sediment loads entering the streams cause the depths to decrease and the channels to widen. By controlling erosion, streams maintain narrower and deeper channels that allow trees to more effectively shade the surface of the water. There is a strong inverse relationship between effective shade and temperature evident in data collected in the Tillamook Bay Watershed (Figure 9). These data suggest that an effective shade of 80% averaged over all reaches would result in instream temperatures below the water quality standard of 64°F (17.8°C) throughout the basin.

Riparian vegetation and channel widths were characterized in all of the river basins through analysis of a combination of satellite data, digital orthophoto quadrats, and direct measures in the field. Current conditions were measured directly from one or more of these sources and system potential shade conditions were estimated/modeled by altering vegetational characteristics and modifying Near-Stream Disturbance Zone widths (See Appendix A for details). The resulting curves can be compared to assess the current quality of riparian areas relative to potential throughout each of the basins (Figures 10 and 11).

Figure 9. Reach Length Averaged Effective Shade and Maximum Daily Stream Temperature (DEQ, August 12, 1998

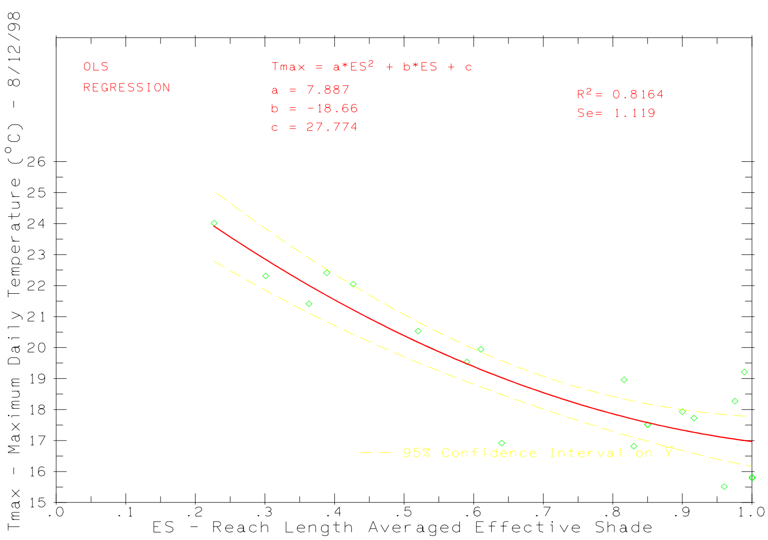


Figure 10. Effective Shade Profile – Current Condition and System Potential

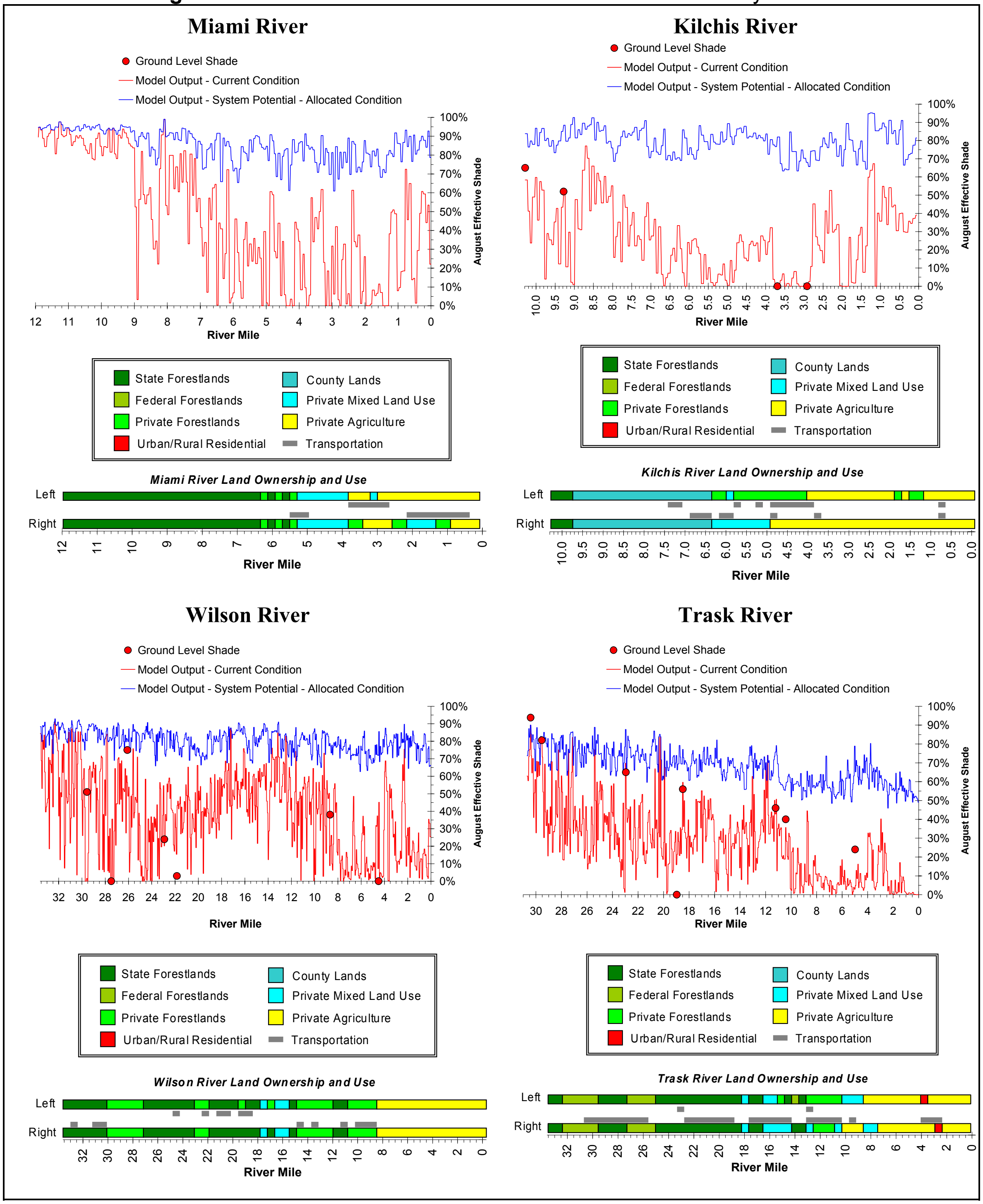
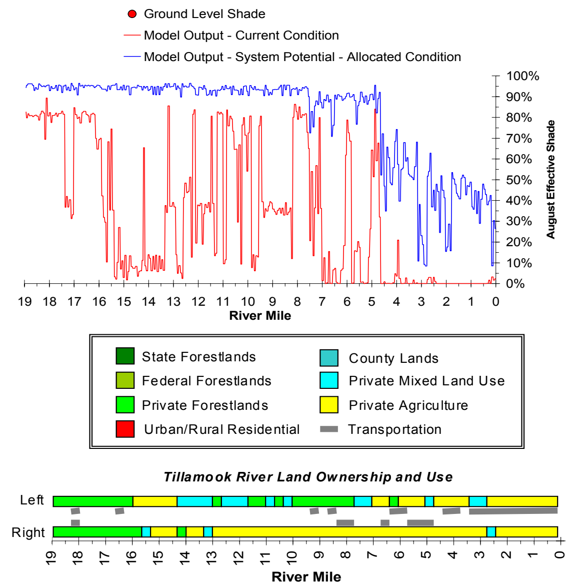


Figure 10 (continued). Effective Shade Profile – Current Condition and System Potential

Tillamook River



Comparison of these curves demonstrates a significant difference between the current condition and the potential in all of the sub-watersheds. The lack of effective shading has resulted from removal of trees throughout the watershed, and a subsequent widening of stream and river channels.

Natural Sources and Stream Temperature

Natural conditions that may impact riparian vegetation and result in elevated stream temperature include drought, fires, insect damage to riparian vegetation, diseased riparian vegetation and windthrow and blowdown in riparian areas. The processes in which natural conditions affect stream temperatures include increased stream surface exposure to solar radiation and decreased summertime flows. Legacy conditions (increased width to depth ratios and decreased levels of stream surface shading) that currently exist are, in part, a result of the extensive Tillamook burn, and fires that occurred prior to the burn.

3.1.7 Loading Capacity – 40 CFR 130.2(f)

*The Water Quality Standard mandates a **Loading Capacity** based on the condition that meets the **no measurable surface water temperature increase resulting from anthropogenic activities when the temperature standard is exceeded.** This condition is termed **System Potential** and is achieved when (1) non-point source solar radiation loading is representative of a near stream vegetation and channel morphology conditions without human disturbance and (2) point source discharges cause no measurable temperature increases in surface waters.*

The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. EPA's current regulation defines loading capacity as "*the greatest amount of loading that a water can receive without violating water quality standards*." (40 CFR § 130.2(f)).

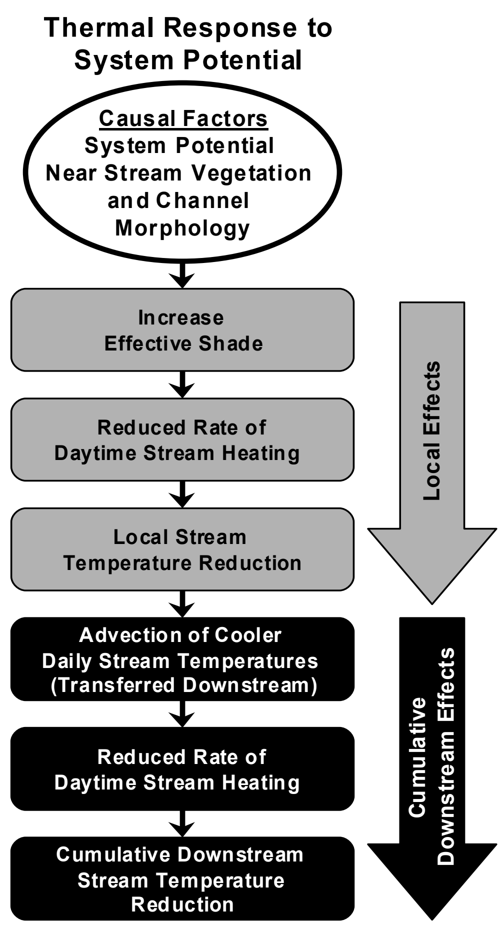
The water quality standard states that ***no measurable surface water temperature increase resulting from anthropogenic activities*** is allowed in the Tillamook Bay Watershed when the appropriate criteria are exceeded. The pollutants are human-caused increases in solar radiation loading (non-point sources) and warm water discharge (point sources).

Loading capacities in the Tillamook Bay Watershed consist of (1) NPDES permitted point source effluent discharge temperature limits, and (2) solar radiation loading profiles for the Miami, Kilchis, Wilson, Trask and Tillamook Rivers (expressed as Langleys per day) based on potential near stream vegetation characteristics and channel morphology conditions without anthropogenic disturbance

3.1.7.1 System Potential Simulation

Loading capacity in the Tillamook Bay Watershed is largely controlled by non-point source influences of heat to the system. Heat accumulates through much of the watershed by direct solar radiation loading. System potential was estimated as August solar radiation levels that would reach the stream surface under conditions where anthropogenic activities would not measurably increase temperature. **The system potential radiation load is the loading capacity (Figure 11).**

Current conditions were modeled and calibrated using recently collected data. These data included continuous temperature, flow, near-stream vegetation, channel width and depth. System potential conditions were derived from existing conditions and characteristics of each of the sub-watersheds. Effective shade, tree height and density, channel width and depth were all measured in the field. These features were measured on a very fine scale using existing GIS databases and by digitizing Digital Orthophoto Quadrats (See Appendix A). Simulations were performed by increasing near stream vegetation to potential height, width and density and adjusting channel morphology as described in **Appendix A**. Simulations were performed only for the Wilson, Trask, and Kilchis Rivers, although all of the rivers were characterized with respect to the data described. Significant reductions in daily maximum stream temperature resulted from system potential conditions. Diurnal temperature fluctuations were also moderated. Daily minimum stream temperatures were reduced slightly.



System Potential shade was simulated in a mathematical model (Heatsource 6.5) by increasing tree heights and densities to those expected in mature riparian communities. These tree heights were obtained from foresters with the Oregon Department of Forestry, Tillamook State Forest (Wayne Auble, personal communication) and the US Forest Service (Hebo Ranger District, Siuslaw National Forest, John Johanssen, personal communication). Tree heights for all species that this information was available for averaged 175 feet in upland areas and 125 feet in lowland areas. The lesser averages in the lowlands were due to greater proportions of deciduous trees in these areas.

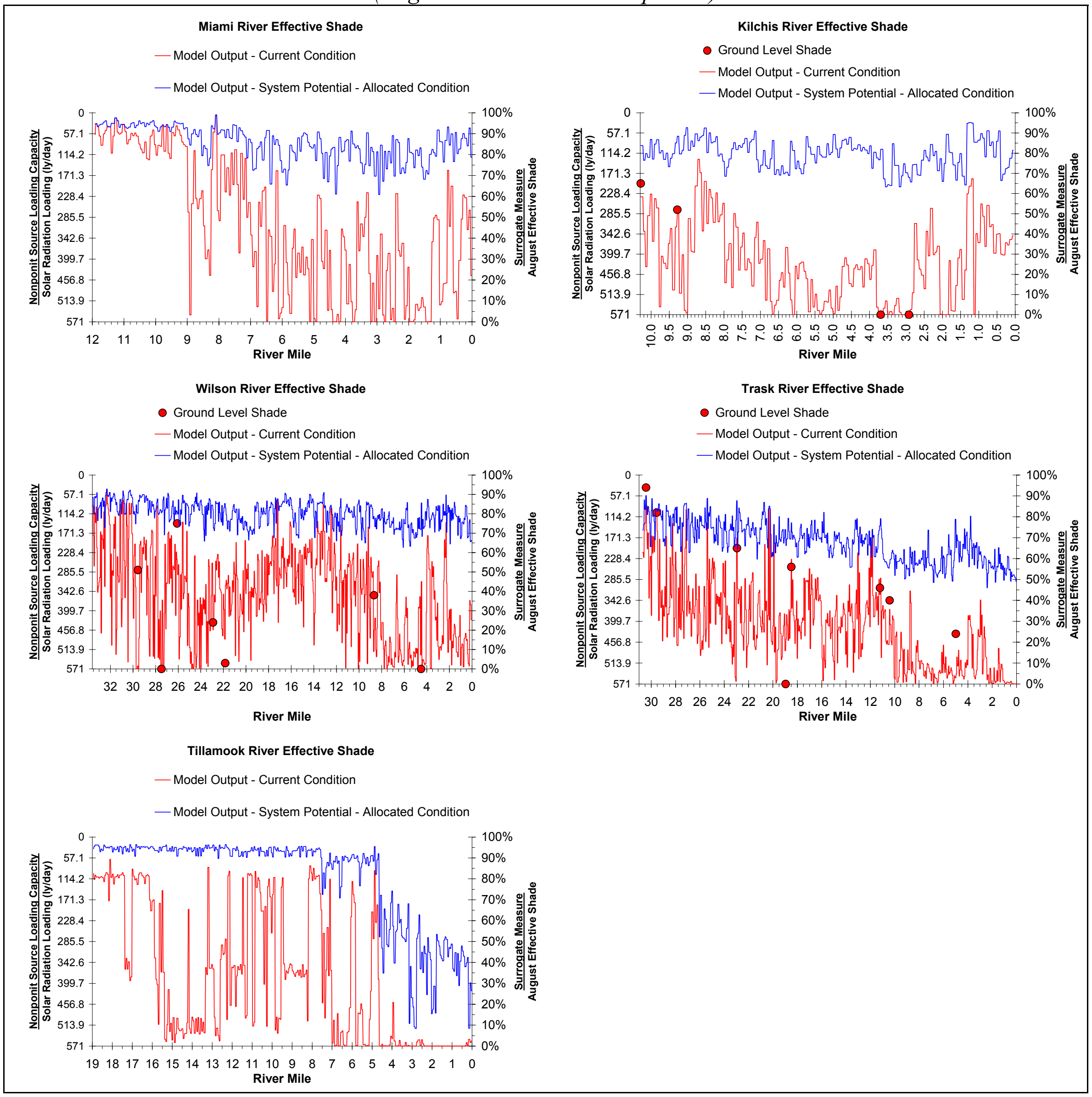
System potential channel widths were based on existing channel widths as measured through analysis of aerial photos. System potential widths are reduced to an estimate of the current median channel width (Figure 12), which steadily increases with distance from headwaters to mouth. This resulted in a reduced overall channel width, but simulated channels below headwaters were never narrower than a significant portion of the river upstream, thus would provide adequate capacity for normal flow in the river.

Individual near stream vegetation and channel morphology simulations were performed for each mainstem stream segment. Results from these single parameter simulations confirm the importance of both riparian vegetation and channel morphology as stream parameters that influence stream heating processes (Figures 13 and 14).

When both system potential riparian vegetation and channel morphology were simulated together, the stream heating rate was affected to a greater extent than for either factor singly. Increasing height and width of near stream vegetation increased the effective shade throughout each stream system. In effect, the shadows created by the vegetation are longer. Decreased near-stream disturbance zone widths and wetted widths decrease the stream surface area and allow vegetation to more effectively shade this surface area (Figure 12). Healthy near-stream vegetation and channel morphology are physically related. Channel morphology is often affected by riparian vegetation condition. Improvements in riparian condition would likely lead to improvements in channel morphology. In the case of stream thermodynamics, the riparian vegetation and channel morphology combine to increase the effect of casting shadows across the stream surface.

Figure 11. Site Specific Solar Radiation Loading and Effective Shade under Current and System Potential Conditions.

(August Solar Radiation Exposure)



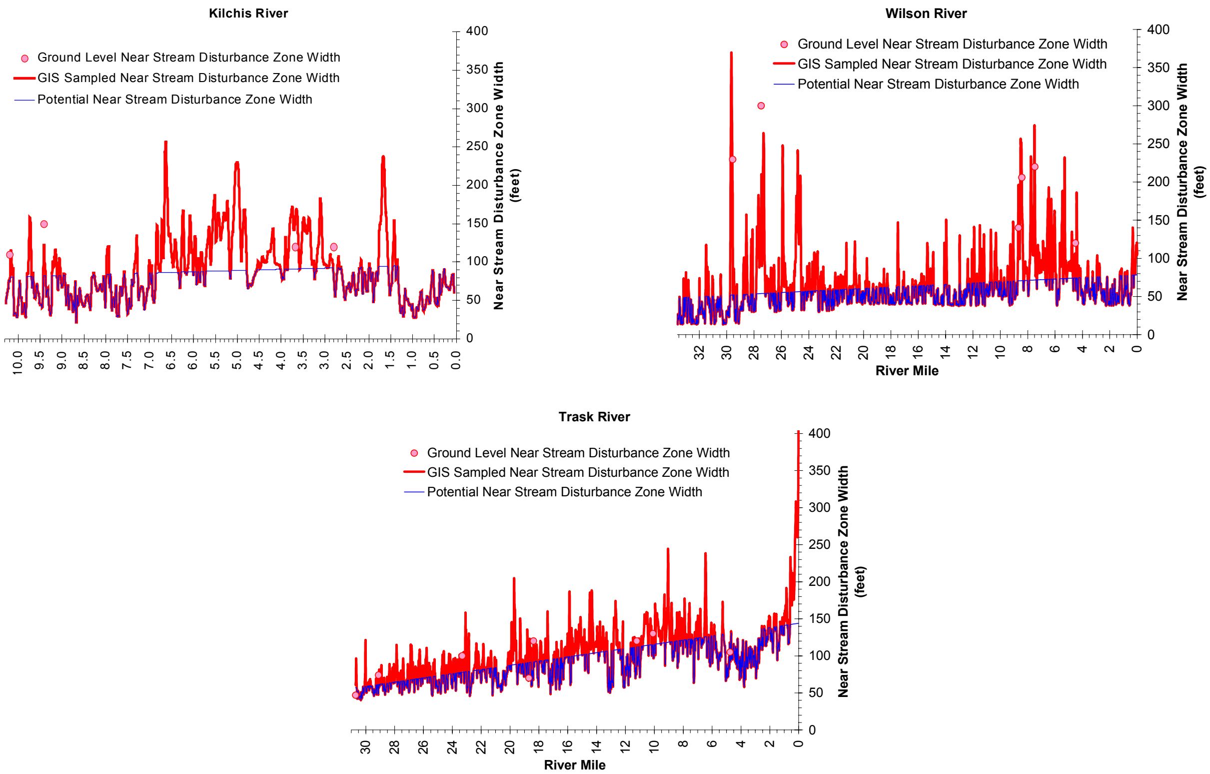
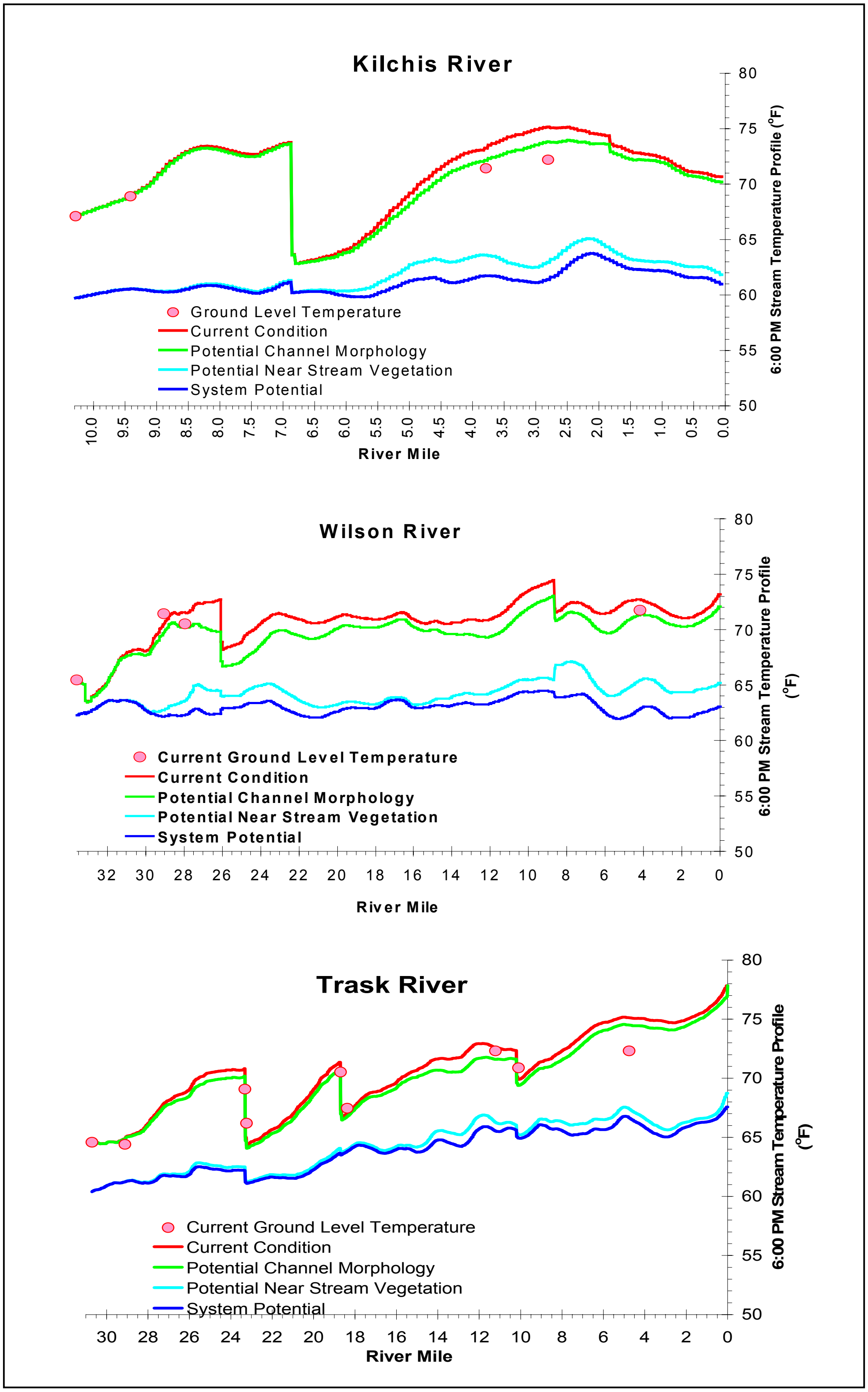


Figure 12. Current and Potential Channel Widths. Blue Areas are Existing Widths Less than the 1000-ft Median Value.

While the TMDL is primarily concerned with maximum daily stream temperature, it is important to consider the cumulative downstream effects that produce daily maximum stream temperatures. System potential conditions produce local effects that include site-specific increases in shade, reductions in daytime stream heating and stream temperature reductions. Cumulative downstream effects also impact stream temperatures. The transport of cooler water downstream coupled with the reduced rate of daytime heating produce the cumulative effect of stream

Figure 13. Stream Temperature Profiles (August12, 1998 - 6:00 PM) for current conditions, potential channel morphology and effective shade, and for the two combined (system potential) on the Kilchis, Wilson, and Trask Rivers.

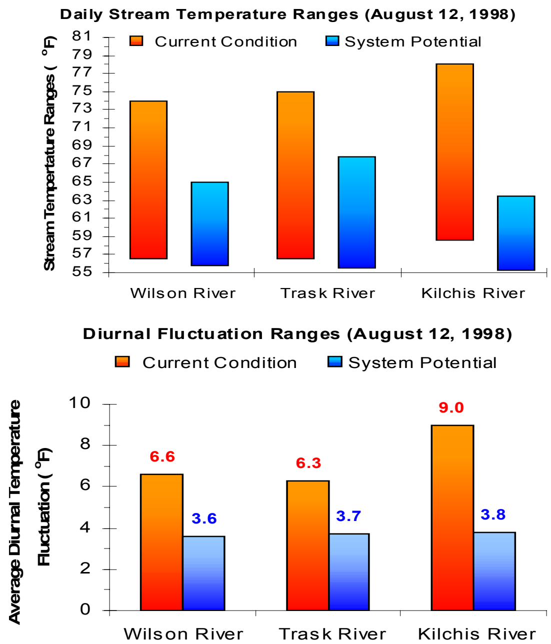


temperature reductions. Changes in upstream temperature often affect the temperatures of downstream areas.

The cumulative effect of the system potential conditions is demonstrated in the simulated cooler downstream steam temperatures and narrower range of daily temperatures (Figure 11). The daily minimum temperatures reflect less daytime heat absorption, less daytime heat retention, and less heat advection (downstream transfer). When upstream sources of heat energy are reduced, the cumulative effect is reduced nighttime and morning stream temperatures that allow for a cooler starting point for the daily heating. Since daily heating processes are reduced, the diurnal rate of stream warming is also lower.

Figure 14. System potential temperature ranges

- *Less diurnal fluctuation*
- *Lower daily maximum values*
- *Lower daily minimum values*



The observed system potential temperatures are caused by the following relationships:

- Reduced rates of daytime heating,
- Less diurnal temperatures fluctuation.
- Lower daily maximum temperatures, and
- Cumulative effect - advection of cooler downstream temperatures and reduced rates of daytime heating.

3.1.7.2 Loading Capacity (Point Sources)

The Loading Capacity is dependent on the available assimilative capacity of the receiving water (river). For rivers whose system potential temperatures are at or above the temperature standard for a given period, there is no assimilative capacity and the loading capacity is zero. This means that the discharge of pollutants would not be allowed to increase the concentration of that pollutant outside of an appropriate mixing zone. The loading capacities of the 5 rivers in the watershed were presented in **Figure 11**. These loading rates are in terms of solar radiation and % effective shade, and provide the amount the river will absorb with the system potential riparian conditions in place. Ultimate temperatures at system potential were presented in Figure 13 and indicate what the temperature will be relative to the numeric criteria of the water quality standard.

Point Source Discharges currently are permitted only for sources on the Trask and Wilson Rivers. Under system potential conditions, the Trask River will still not meet the numeric criteria of the water quality standard in many places, particularly in the lower reaches of the watershed, and there is no allocable assimilative capacity. Temperatures in the Wilson River are expected to decrease below the migration and rearing temperature criterion (64°F) in the area where the Tillamook County Creamery Association (TCCA) operates at wastewater discharge to approximately 62.5°F (Figure 13). This means there will be approximately 1.5°F of assimilative capacity for the TCCA discharge.

3.1.7.3 Loading Capacity (Non-Point Sources)

Results of the simulations demonstrate that even with system potential conditions, water temperatures in some reaches of each of the rivers will continue to be above the numeric criteria of the water quality standard during the critical period. Though temperatures may decrease below the criteria in upper parts of the watershed, loading in these areas will typically result in failure to meet the criteria in lower reaches. Since there is no additional decrease in loading that can be obtained by control or management measures, there is no available loading capacity for anthropogenic non-point sources of heat.

3.1.8 Allocations – 40 CFR 130.2(g) and 40 CFR 130.2(h)

Loading capacity will be available for allocation where surface water temperatures throughout a given river decrease below the standard by an amount sufficient to accommodate either point-source or non-point source influences. In general, modeling has indicated there will be no assimilative capacity for non-point sources of heat in the watershed.

3.1.8.1 Wasteload Allocations (Point Sources) - Temperature wasteload allocations are determined based on defined conditions, or may be calculated for a discharge given site-specific flow and temperature information. Surface water discharges into receiving waters must not exceed the temperatures listed in **Table 8** or those calculated for other river flows as specified in **Table 8**. The wasteload allocation is the maximum allowable effluent temperature that, in combination with all sources, will remain within the loading capacity (as calculated through Equations 1 or 2). Permitted pointsource discharges only occur on the Wilson and Trask Rivers. Allocations are not provided for Rockaway Beach STP or Twin Rocks STP, which discharge to the Pacific Ocean, or for the City of Garibaldi STP and Bay City STP, which discharge to Tillamook Bay. These waterbodies are not water quality limited due to temperature.

Point Source allocations (Table 8) are the allowable effluent temperatures derived by DEQ (**using Equations 1 or 2**) and apply during the appropriate critical period. The assumptions used in evaluating the “no measurable increase as measured by 0.25°F at the edge of the mixing zone relate to both the standard and mixing zone policy. Wasteload allocations generally are based on 0.25°F allowable increase above system potential at edge of mixing zone using 25% of the receiving water volume for mixing, or other appropriate proportion related to the mixing zone as provided by the responsible permit writer. In the case of discharges to reaches with available assimilative capacity when system potential conditions are achieved (e.g., Wilson River) and additional allowance is given while ensuring that the WQS is met (e.g., Tillamook Creamery discharge). This latter case is calculated through **Equation 2**.

Critical Period

Critical periods for wasteload allocations are determined by distribution and use of the rivers by salmonid fishes based on information from ODFW (refer to Table 4). Wasteload allocations are calculated for the period of June through September based on the salmonid migration and rearing criterion of 64°F for all salmonid species. Spawning of chum salmon occurs in the lower reaches of the rivers from October through May. River flows are typically higher during this period (i.e., fall-winter-spring) than in the lower flow periods of the year, but allocations must be based on the spawning criterion of 55°F. October flows may still be quite low, so the low flow condition (7Q10) is included in Table 8 for the spawning period. An option to calculate the allocation based on real-time flow rates in the river would generally allow a higher allocation than that of 7Q10 flow conditions, and this would be appropriate for much of the summer and as flows increase in October.

Long-term flow records demonstrate that average monthly flows were lowest in August overall. These flows averaged 108 cfs in the Trask River and 110 cfs in the Wilson River. The use of these values in allocating effluent temperatures is meant as an example of how the volume of river flow affects the allocation at a given discharge rate. Discharging lesser volumes of effluent, or effluent at different temperature would have allocations derived from the appropriate formula.

Equation 1. Wasteload Allocation Calculation when system potential temperature is greater than the appropriate numeric criterion.

$$WLA = \frac{\left[\left(Q_E + \frac{1}{4}Q_R\right)\cdot\left(T_P + \Delta T\right)\right] - \left(\frac{1}{4}Q_R \cdot T_P\right)}{Q_E}$$

where,
WLA = Load Allocation (Allowable Effluent Temperature)
T_P = System Potential Temperature
T_C = Numeric Criterion
ΔT = Allowable Temperature Increase at Edge of Mixing Zone (0.25°F)
Q_E = Facility Design Flow
Q_R = Receiving Water Flow

In rivers where system potential conditions will result in temperatures below the migration and rearing standard, there will be some degree of assimilative capacity for point sources. This capacity will be divided among sources according to the following proportions (Table 7). The bulk of this assimilative capacity is reserved for future uses, some of which may be available for pollution trading scenarios.

Table 7. Proportions of Assimilative Capacity Provided to Various Uses.

Source	Percentage
Future Growth and development	75
Agriculture	0
Forestry	0
Urban Development	0
Permitted Discharges	25

Only the Wilson River has both a point source discharge (Tillamook County Creamery Association -- TCCA) and expected assimilative capacity. TCCA will be given half of the capacity provided to dischargers, or 12.5% of the total assimilative capacity for the river. The remainder will be held as a reserve. The effluent temperature allocation for TCCA when there is some assimilative capacity will be based on Equation 2. This allocation will only be realized when temperatures have decreased sufficiently to provide the expected assimilative capacity. Results are in Table 9.

Equation 2. Wasteload Allocation Calculation with assimilative capacity available.

$$WLA = \left[\left(Q_E T_P\right) + \left(Q_R\left(T_c - T_P\right)\times P_{WLA}\right)\right]$$

where,
WLA = Wasteload Allocation (Allowable Effluent Temperature)
T_P = System Potential Temperature
T_C = Numeric Criterion
Q_E = Facility Design Flow
Q_R = Receiving Water Flow
P_{WLA}= Proportion of Assimilative capacity for source.

Table 8. Temperature Wasteload Allocations for Point Sources at System Potential (SP).

Facility Name/Flow Conditions	Q_R River Flow Rate	Q_E Facility Flow (cfs)	T_E Critical Condition Effluent Temp.	T_C Numeric Criterion	ΔT Allowable Temp. Increase	T_A Load Allocation Allowable Effluent Temp.
Pacific Campground	**Wilson River**					
June through September Low Flow -- **7Q10**	48 cfs	0.08 cfs	70 ºF	64 ºF	0.25ºF	77ºF[2]
June through September Average Flow [1]	110 cfs	0.08 cfs	70 ºF	64 ºF		77ºF[2]
October through May **7Q10**	48 cfs	0.08 cfs	70 ºF	55 ºF		77ºF[2]
Other River and Effluent Flow Rates	**See Equation 1**					
Tillamook Creamery	**Wilson River**					
June through September Low Flow - **7Q10**	48 cfs	0.75 cfs	92 ºF	64ºF	0.25ºF	68.25 ºF
June through September Average Flow [1]	110 cfs	0.75 cfs	92 ºF	64ºF		73.4 ºF
October through May **7Q10**	48 cfs	0.75 cfs	92 ºF	55 ºF		59.25ºF
June through September Low Flow at SP-**7Q10**	48 cfs	0.75 cfs	92 ºF	62.5ºF		74.5 ºF [3]
Other River and Effluent Flow Rates	**Equation 1 until System Potential achieved, then Equation 2**					
City of Tillamook STP	**Trask River**					
June through September Low Flow **7Q10**	54 cfs	1.64 cfs	71 ºF	64ºF	0.25ºF	66.3 ºF
June through September Average Flow [1]	108 cfs	1.64 cfs	71 ºF	64ºF		68.4 ºF
October through May **7Q10**	54 cfs	1.64 cfs	71 ºF	55ºF		57.3 ºF
Other River and Effluent Flow Rates	**See Equation 1**					
Tillamook Ind. Park STP **No Discharge June 1-October 31**	**Trask River**					
June through September Low Flow[4] **7Q10**	54 cfs	No Data	71 ºF **[4]**	64ºF	0.25ºF	64ºF
June through September Average Flow [1]	108 cfs	No Data	71 ºF **[4]**	64ºF		64ºF
October through May **7Q10**	54 cfs	No Data	71 ºF **[4]**	55ºF		55ºF
Other River and Effluent Flow Rates	**See Equation 1**					

1=Average Flows for August, which are typically lowest of the year.
2= Maximum allowable effluent temperature based on incipient lethality to salmonids (see Table 2).
3= Based on one-half of allocable assimilative capacity or one-eighth of total assimilative capacity.
4= Assumed temperature – no monitoring data available

3.1.8.2 Surrogate Measures and Load Allocations (Non-point Sources – *40 CFR 130.2(i)*

Load Allocations (Non-Point Sources) *- Since the* ***Loading Capacity*** *targets system potential (i.e. no measurable temperature increases from anthropogenic sources), 100% of the* ***Loading Capacity*** *is allocated to natural sources.*

Portions of the loading capacity are typically divided among natural, human and future non-point pollutant sources. **Table 9** lists load allocations (i.e. distributions of the loading capacity) according to land-use. In the Tillamook Bay Watershed, the loading capacity of the system is all allocated to natural sources since, even at system potential conditions, temperatures in the watershed will still exceed the standard in some reaches of some rivers. No assimilative capacity exists for the other sources. This requires that heat from non-point sources reduce temperature inputs to reach system potential conditions. The means of achieving these conditions is through restoration and protection of riparian vegetation and narrowing of stream channel widths. The remainder of this section describes how those conditions are assessed.

The Tillamook Bay Watershed Temperature TMDL incorporates measures other than "*daily loads*" to fulfill requirements of §303(d). Although a loading capacity for heat energy is derived [e.g. Langleys per day], it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat energy loads, this TMDL allocates "*other appropriate measures*" (or surrogates measures) as provided under EPA regulations [40 CFR 130.2(i)].
The *Report of Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program"* (FACA Report, July 1998) offers a discussion on the use of surrogate measures for TMDL development. The FACA Report indicates:

> *"When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional "pollutant," the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not. The criterion must be designed to meet water quality standards, including the waterbody's designated uses. The use of BPJ does not imply lack of rigor; it should make use of the "best" scientific information available, and should be conducted by "professionals." When BPJ is used, care should be taken to document all assumptions, and BPJ-based decisions should be clearly explained to the public at the earliest possible stage.*
>
> *If they are used, surrogate environmental indicators should be clearly related to the water quality standard that the TMDL is designed to achieve. Use of a surrogate environmental parameter should require additional post-implementation verification that attainment of the surrogate parameter results in elimination of the impairment. If not, a procedure should be in place to modify the surrogate parameter or to select a different or additional surrogate parameter and to impose additional remedial measures to eliminate the impairment."*

The non-point source assessment demonstrates that stream temperatures warm as a result of increased solar radiation loads, due to anthropogenic disturbance to near stream vegetation and channel morphology. A loading capacity for radiant heat energy (i.e., incoming solar radiation) can be used to define a reduction target that forms the basis for identifying a surrogate. The specific surrogate used is percent effective shade (expressed as the percent reduction in potential solar radiation load delivered to the water surface). The solar radiation loading capacity is translated directly (linearly) by effective solar loading. The definition of effective shade allows direct measurement of the solar radiation loading capacity.

Because factors that affect water temperature are interrelated, the surrogate measure (percent effective shade) relies on restoring/protecting riparian vegetation to increase stream surface shade levels, reducing stream bank erosion, stabilizing channels, reducing the near-stream disturbance zone width and reducing the surface area of the stream exposed to radiant processes. Effective shade screens the water's surface from direct rays of the sun. Highly shaded streams often experience cooler stream temperatures due to reduced input of solar energy (Brown 1969, Beschta et al. 1987, Holaday 1992, Li et al. 1994).

Over the years, the term shade has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, shade is defined as the percent reduction of potential direct beam solar radiation load delivered to the water surface. Thus, the role of effective shade in this TMDL is to prevent or reduce heating by solar radiation and serve as a linear translator to the solar loading capacities.

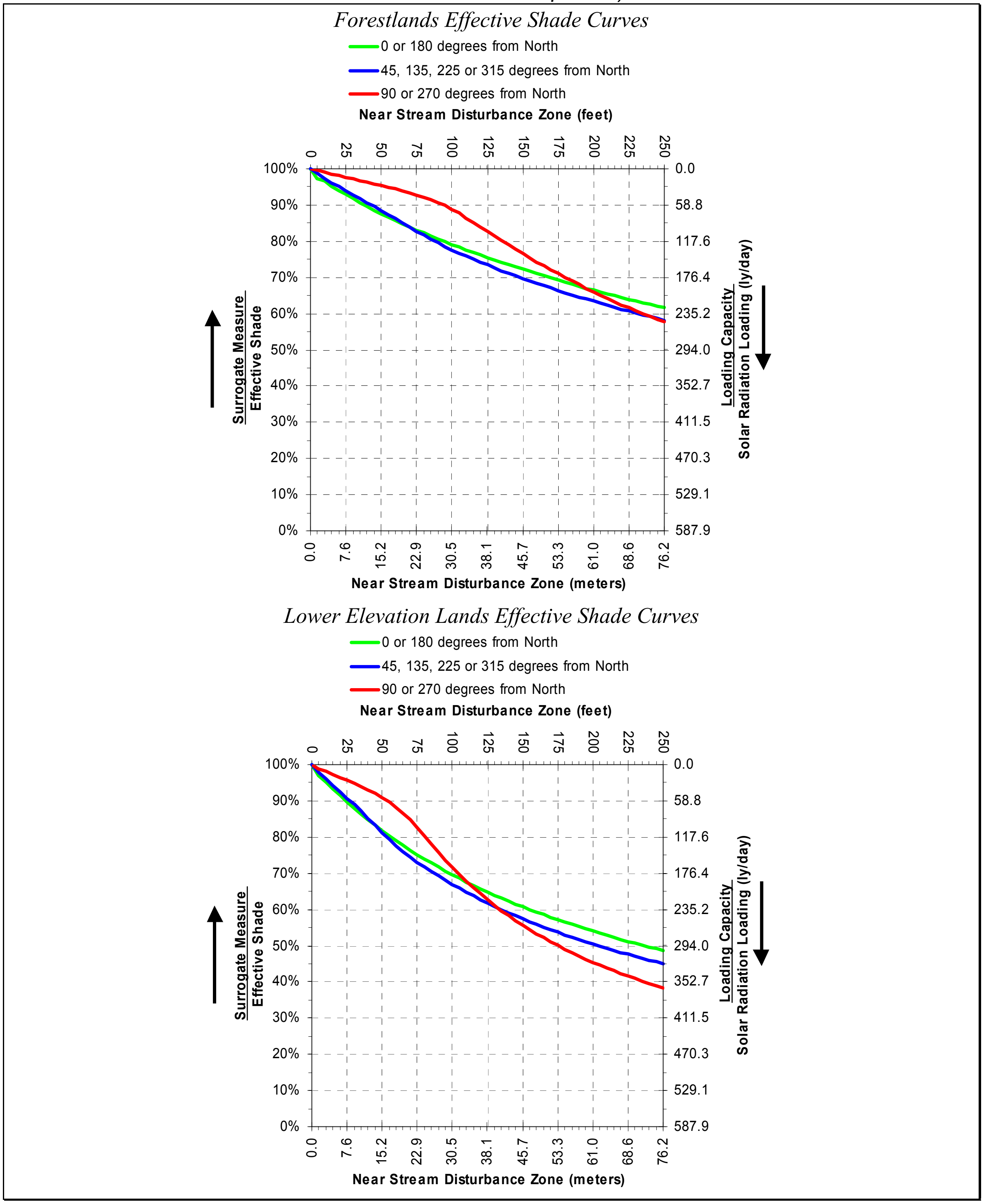
Table 9. Temperature Non-Point Source Allocation Summary

Non-Point Sources	
Source	*Loading Allocation* *Distribution of Solar Radiation Loading Capacity*
Natural	100%
Agriculture	0%
Forestry	0%
Urban	0%
Future Sources	0%

3.1.9 Site Specific Effective Shade Surrogate Measures

A load allocation in terms of Langleys per day is not very useful in guiding non-point source management practices. Percent effective shade is a surrogate measure that can be calculated directly from the loading capacity. Additionally, percent effective shade is simple to quantify in the field or through mathematical calculations. **Figure 15** displays effective shade curves that can be applied across areas where the site-specific surrogate measures are not developed.

Figure 15. Effective Shade Surrogate Measures as a Function of Channel Width *(August Solar Radiation Exposure)*



3.1.10 Water Quality Standard Attainment Analysis - – CWA §303(d)(1)

*Maximum daily temperatures (displayed in **Figure 46**) represent the system potential when **no measurable surface water temperature increase resulting from anthropogenic activities** is allowed.*

Simulations were performed to calculate the hourly temperatures that result with the allocated measures that form the basis for the factors that represent the system potential condition with ***no measurable surface water temperature increase resulting from anthropogenic activities***. The resulting simulated temperatures represent attainment of system potential, and therefore, attainment of the temperature standard.

A total of 74.6 river miles in the Kilchis, Wilson and Trask Rivers were analyzed and simulated during the critical period (August 12, 1998). **Figure 16** compares the current maximum daily temperatures with those that result with system potential conditions. Generally speaking, all of the analyzed rivers currently experience critical condition maximum daily temperatures in the upper-60°F to low 70°F range. Under the allocated system potential condition, maximum daily temperatures shifted to the lower-60°F range. In 1998, 98.4% of the analyzed mainstem reaches had critical condition maximum daily temperatures greater than 64°F, with approximately 85% exceeding 68°F. Under the system potential, 26% of the these reaches would experience maximum daily temperatures greater than 64°F and none would exceed 68°F. The distribution of temperatures throughout the analyzed reaches is detailed in Figure 17.

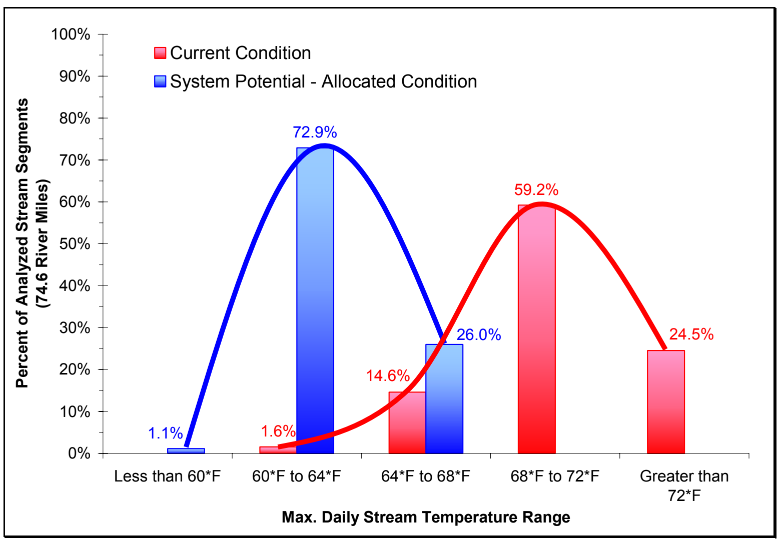


Figure 16. Distribution of Current Condition and System Potential Maximum Daily Stream Temperatures (August 12, 1998)

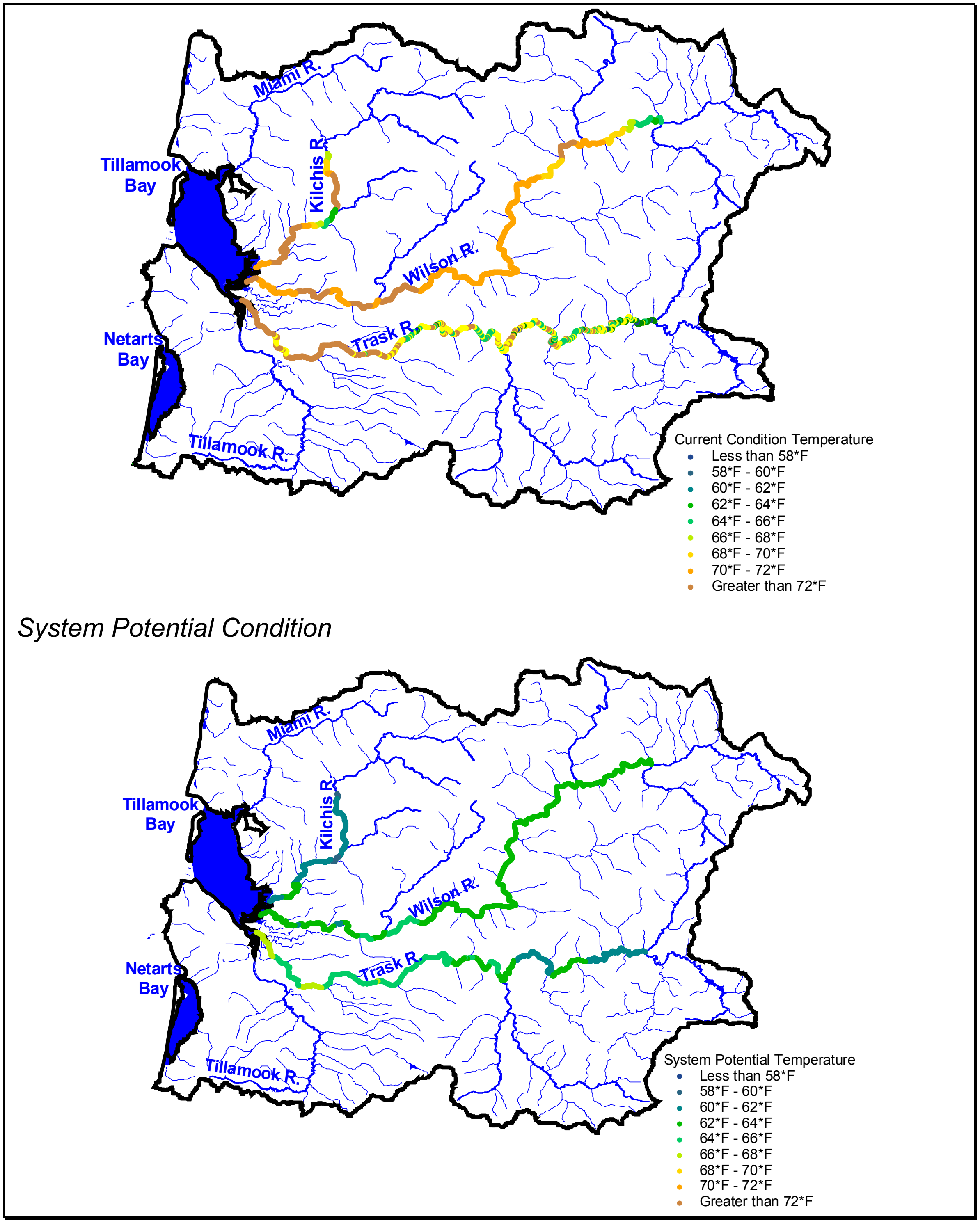


Figure 17. Current Condition and System Potential temperature distributions in the Tillamook Bay Watershed

3.2 Bacteria TMDL

Summary of Bacterial TMDL Development and Approach

Why Is Bacterial Contamination Important?

Bacterial contamination from a variety of sources accumulates in rivers, streams and Tillamook Bay throughout the year. This contamination is most severe during winter storms, but is sufficiently concentrated during dry weather to impair water quality relative to the beneficial uses described for the basin; particularly those of recreational use and commercial shellfish harvesting.

Scope

All lands (572 square miles) with streams that drain to Tillamook Bay within HUC 17100203 are included in the bacterial TMDL. All land uses are included: lands managed by the State of Oregon, the U.S. Forest Service (USFS) and Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, military lands and urban areas.

Assessing Bacterial Contamination Processes and Setting Loads

To evaluate bacteria loading in the Tillamook Bay Watershed, an event based, unit load model was used. The model uses estimated peak flow, Event Mean Concentrations (EMC) for various land uses, and bacteria die off rates to predict total bacteria concentration and loads in the streams. Five major geographic data bases were used in this project: soils, land use, precipitation pattern, watersheds, and distance from the stream. These five data bases were overlaid in ArcView to create a composite GIS database, with over 12000 entries, which was used for estimating peak flow, travel time of overland flow in the watershed, the bacteria die-off rate as function of the travel time, and bacteria load. These parameters were modeled for all locations in the watershed. To calculate loading to the Bay, a bacteria die-off rate was incorporated for travel time instream to the Bay. Each of these parameters is discussed below.

Bacterial TMDL Overview

The bacteria TMDL provides an analysis of the sources and concentrations of fecal bacteria throughout the year in the Tillamook Bay Watershed. Loading capacity of the Bay is determined as a function of concentrations at the mouths of rivers that drain to the Bay. Allocations are expressed in terms of percent reductions for each land use in each of five major river subbasins.

3.2.1 Pollutant Identification

The pollutants identified for stream and bay bacterial pollution are human caused point and non-point source discharges of fecal bacteria loading to surface waters.

The pollutant causing impairment of 303(d) listed waters is fecal coliform bacteria. These bacteria are produced in the guts of warm-blooded vertebrate animals, and indicate the presence of pathogens that cause illness in humans. Although non-domestic animals are sources of the bacteria, human controlled sources demonstrably account for the greatest proportion in rivers and Tillamook Bay.

The method of fecal coliform bacteria analysis has also changed over time, with some DEQ samples analyzed using the Most Probable Number (MPN) technique and some analyzed using the membrane filtration technique. According to *Bacterial Indicators of Pollution* (Pipes, 1982) "the differences between MPN estimates and MF counts were not of any practical significance mainly because of the inherently low degree of reproducibility of the MPN estimates." Fecal coliform data have been combined for this report regardless of the analytical technique.

3.2.2 Target Identification – CWA §303(d)(1)

The bacterial TMDL is designed to protect two sensitive beneficial uses in two different landscape situations. Bacteria impair the recreational use of rivers if concentrations exceed those determined through epidemiological studies to cause illness through body contact at a rate of 8 or more cases per 1000 swimmers. Bacterial levels in estuarine shellfish harvesting waters must be lower than those used for body contact, as shellfish filter large volumes of water and accumulate bacteria and the pathogens they are associated with at concentrations higher than found in ambient water. Although recreational uses in rivers are considered safe if bacterial concentrations are higher than those allocated in this TMDL, protection of shellfish harvesting is a more sensitive beneficial use, and requires lower concentrations in the rivers to ensure low concentrations in the Bay. The TMDL targets river concentrations that will limit the loading to the Bay and result in low concentrations in shellfish harvesting beds.

The indicator bacterium used by DEQ for assessing bacterial contamination for recreational waters changed in 1996 from fecal coliform bacteria to *E. coli*, the species associated with gut flora of warm-blooded vertebrates. In general, *E. coli* are a subset of Fecal Coliform bacteria. This change was made in part because *E. coli* is a more direct reflection of contamination from sources that also carry pathogens harmful to humans and is correlated more closely with human disease. Fecal coliform bacteria are still used in the standard as the indicator for protection of human health in assessing water quality in commercial shellfish harvesting areas. These areas and monitoring of water quality associated with them are under the jurisdiction of the Oregon Department of Agriculture (ODA). Since there are two standards that use two different indicators, DEQ still samples and analyzes water for both. This has resulted in a large data set of paired samples that allow statistical analysis and development of a mathematical relationship. Although the relationship is significant, bacterial concentration estimates in environmental samples are not very precise, as indicated by substantial variability among paired and duplicate samples. This results in relatively large errors in estimates of fecal coliform from *E. coli* concentrations or vice-versa.

3.2.3 Sensitive Beneficial Use Identification

Beneficial uses in the Tillamook Bay Watershed are defined in the Oregon Administrative Rules (Table 10). The key beneficial uses affected by elevated concentrations of fecal bacteria are body contact recreation in rivers, and fishing (commercial shellfish harvesting) in the Bay. The Bay is divided by the ODA into areas with specific use designations for shellfish harvesting. Some areas do not support harvesting, while harvesting is allowed in others depending on flow rates in the Wilson River. There is potential for harvesting in areas that are currently categorized as restricted or prohibited for use.

Table 10. Beneficial uses occurring in the Tillamook Bay Watershed

(OAR 340 – 41 – 202)
Bacteria -Sensitive Beneficial uses are marked in gray

Beneficial Use	*Occurring*	*Beneficial Use*	*Occurring*
Public Domestic Water Supply	✓	Anadromous Fish Passage	✓
Private Domestic Water Supply	✓	Salmonid Fish Spawning	✓
Industrial Water Supply	✓	Salmonid Fish Rearing	✓
Irrigation	✓	Resident Fish and Aquatic Life	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Commercial Navigation & Trans.		Hydro Power	

3.2.4 Water Quality Standard Identification

Bacterial criteria for the waters of the North Coast-Lower Columbia Basin are contained in the Oregon Administrative Rules (Table 11 and Appendix C of this document). The criteria for "bacteria in shellfish waters" apply to Tillamook Bay and the criteria for "recreational contact in water" applies to all other waters in the watershed. The beneficial uses affected by elevated bacteria levels are primary contact recreation (swimming) and shellfish harvesting (fishing).

Table 11. Water quality standards for the North Coast Basin of Oregon.

Parameter	Description
Bacteria in Shellfish Waters Marine Waters and Estuarine Shellfish Growing Waters: OAR 340-41-205 (2)(e)(A)(ii) and OAR 603-100-0010:	A fecal coliform median concentration of 14 organisms per 100 ml, with not more than ten percent of the samples exceeding 43 organisms per 100 ml. Fecal coliform median or geometric mean MPN of the water sample results shall not exceed 14 per 100 ml, and not more than 10% of the samples shall exceed 43 colonies per 100 ml for a 5 tube decimal dilution test. A minimum of the most recent 15 samples collected under adverse pollution conditions from each sample station shall be used to calculate the median or geometric mean and percentage to determine compliance with this standard.
Recreational Contact in Water OAR 340-41-205 (2)(e)(A)(i):	Prior to March 1996: a geometric mean of five fecal coliform samples should not exceed 200 colonies per 100 ml, and no more than 10% should exceed 400 colonies per 100 ml. Effective March 1996 through present: a 30-day log mean of 126 *E. Coli* organisms per 100 ml, based on a minimum of five samples; and no single sample shall exceed 406 *E. Coli* organisms per 100 ml.

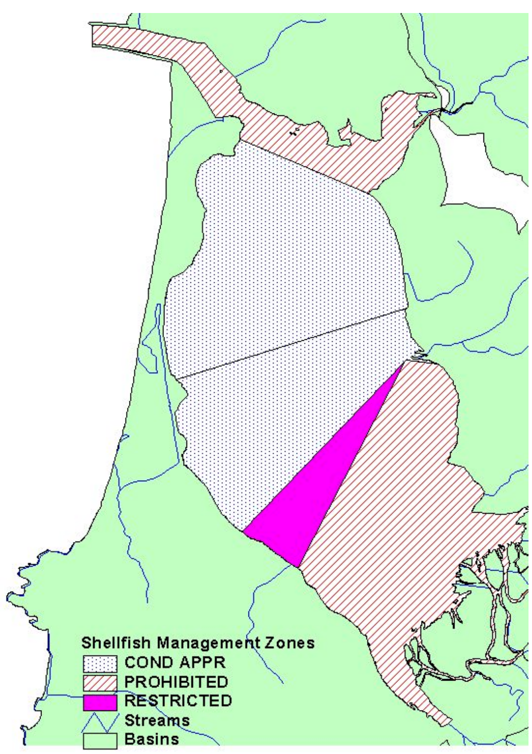
As stated earlier, the shellfish harvesting standard is still based on fecal coliform bacteria indicator, because the national standard has not changed. The appropriate WQS for comparison of data in this document are those in effect prior to March 1996, which specify a geometric mean of five fecal coliform samples must not exceed 200 colonies/100 ml, and no more than 10% may exceed 400 colonies per/100 ml.

Much of the data available for this watershed were fecal coliform concentrations as these were collected for years before the standard changed, and ambient monitoring has included both fecal coliform and *E. coli*. Since the shellfish harvesting standard is still based on fecal coliform, all analyses and descriptive statistics are based on this indicator. This necessitates observance of the recreational contact standard in effect prior to 1996 in describing concentrations in rivers.

3.2.5 Deviation from Water Quality Standard (Bacterial Impairments)

3.2.5.1. Tillamook Bay

Tillamook Bay is categorized among three conditional use states for shellfish harvesting based on likelihood

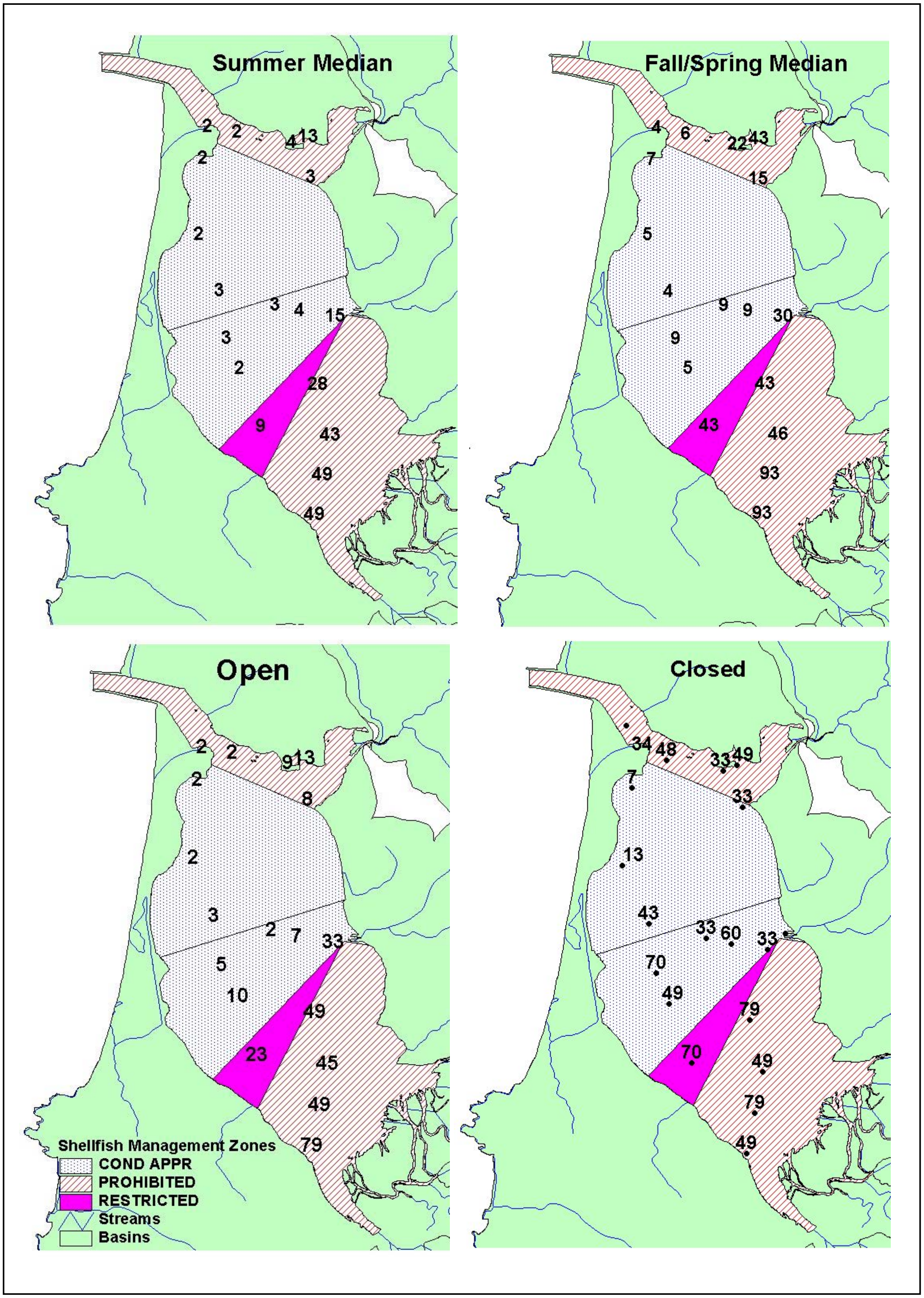


of contamination by fecal coliform bacteria (example at right). These are conditionally approved, restricted and prohibited areas. Shellfish harvesting is allowed in the conditionally approved areas unless river flow or rainfall increase beyond limits specified in the Tillamook Management Plan for Commercial Shellfish Harvesting (Appendix E). When these conditional limits are exceeded, harvesting is prohibited, and cannot resume during a period specified for a given conditionally approved area. Restricted use has a limited degree of pollution to the extent that shellfish may be made safe for human consumption by *relaying or depuration*[7] Prohibited areas are principally designated around the mouths of the Rivers that enter the bay, and where sewage treatment plants discharge to the Bay. Shellfish harvesting is not allowed in any prohibited area. Although the commercial harvest of shellfish is regulated under a management plan, ODA must react to changes into an area's compliance with the fecal coliform standard for shellfish growing waters. Reactions may include temporary closures or bay management plan changes requiring closures for predictable increases in fecal coliform levels.

Fecal coliform concentrations in the Bay are routinely monitored by ODA when the bay is open to commercial shellfish harvesting as part of the shellfish program. Median concentrations in both summer and winter generally meet the standard for shellfish harvesting when the conditionally approved areas are open for harvesting (Figure 18). Concentrations in the Prohibited sections of the Bay exceed the standard for protection of shellfish harvesting more often than not regardless of flow conditions in the rivers. Concentrations in the Restricted area typically meet the standard when flows are low in the summer period and exceed the standard throughout the fall-winter-spring period and when flows are above the 7-foot stage.

[7] Relaying or Depuration of shellfish requires moving the live animals to purified, controlled conditions for sufficient time to become safe for consumption.

Figure 18. Median Concentrations of fecal coliform bacteria in Tillamook Bay during (l-r;t-b): summer, Fall through spring, Open to harvesting, closed to harvesting.



3.2.5.2 Rivers of the Tillamook Bay Watershed – Long-Term Data

Concentrations of fecal coliform bacteria in rivers throughout the basin often exceed one or more water quality standards (WQS). Routine and synoptic water quality data show violations of the bacteria criteria occur in the 5 major rivers and in several creeks in the basin. Violations were more common in the lower elevations of the watersheds associated with agriculture, rural and urban development.

To determine if there are spatial or temporal distributions of the bacteria apparent in the historical data, seasonal box plots were created for each of the five rivers in the Tillamook Bay Watershed. An explanation and description of box plots is provided in the Glossary. The summer season is defined as the period from June through September (Figure 19), when primary contact recreation is most likely. The remaining months of the year are designated as fall through spring (Figure 20). Water quality data for each river basin are discussed separately below. The data was retrieved from STORET for the dates and locations listed on the plots. Because the data was collected intermittently, sampling may not have occurred during rain events.

The Kilchis River basin covers an area of about 65 mi^2, with forest as the predominant land use (63 mi^2). Agriculture covers a relatively small area of the Kilchis basin (1.3 mi^2). The observed data indicate common violations of the bacteria criterion in the summer months near the mouth of the river. More than 10% of the samples exceed 400 fecal coliform/100 ml. During the fall-spring period, the fecal coliform criterion was not violated on the river

The Miami River basin covers an area of about 36 mi^2. The predominant land use is forest (34 mi^2), followed by agriculture (1.4 mi^2). The observed data exceed the bacteria criterion near the mouth throughout the year.

The Trask River basin includes approximately 169.5 mi^2. Forested areas cover 156 mi^2 and agriculture covers about 11 mi^2 in the basin. Urban and rural residential development covers 1.2 mi^2 and 1.4 mi^2, respectively. Two wastewater treatment plants discharge to the Trask River; the Port of Tillamook Bay wastewater treatment plant discharges to the river during the fall-spring period at river mile 5.2 and the City of Tillamook discharges year around at river mile 1.9. The Trask River is not on the 303(d) list for bacteria, however examination of the historical data reveals violations of the criterion. At the lower river miles, the criterion (no more than 10% of the samples can be greater than 400 counts/100 ml) is exceeded throughout the year.

The Tillamook River Basin extends over approximately 62 mi^2, with forests covering 45 mi^2. Of the five river basins, agriculture covers the largest percentage in the Tillamook Bay Watershed; about 20% or 13 mi^2. Rural residential and rural industrial land uses each cover about 1.6 mi^2. Many of the samples in this data set were not diluted adequately, resulting in underestimates of concentration. This makes the comparison of stations along the river ill-advised. However, the data clearly indicate the WQS are exceeded throughout the year over much of the river.

The Wilson River basin covers about 192 mi^2, with 184 mi^2 covered with forests. Agriculture accounts for about 5 mi^2 and rural residential development covers about 3 mi^2. The Tillamook County Creamery Association (TCCA) discharges a mix of treated domestic and industrial waste to the Wilson River at river mile 1.6 throughout the year. Dilution of TCCA effluent varies with tidal cycles, as velocity of the receiving water varies. The Wilson River data set (DEQ data) also contains many estimated values in samples collected from river miles 1.4 to 1.8. Despite this, these data indicate that fecal coliform concentrations exceed the WQS near the mouth throughout the year below river mile 4. Concentrations were relatively low in the upper, forested part of the watershed.

Based on review of these data, two segments of the Bay and 13 reaches of streams or rivers were included on the 1998 303(d) list submitted by DEQ (Tables 12 and 13). These listed reaches account for nearly 65 miles of waterway within the watershed.

Table 12. Segments listed for Bacteria (Marine and shellfish growing area – fecal coliform) in Tillamook Bay on the 1998 303(d) List:

Waterbody Name	Location	Year-around
Tillamook Bay - Main	Marker No. 19 to South Bay	X
Tillamook Bay - Upper	Southeast Bay to Dick Point	X

Table 13. Segments listed for Bacteria [Water Contact Recreation (fecal coliform-96 Std)] in the Tillamook Bay Watershed on the 1998 303(d) List:

Waterbody Name	Miles	Fall-Winter-Spring	Summer
Bewley Creek (mouth to river mile 2)	2.0	X	X
Doherty Slough (mouth to headwaters)	4.9	X	X
Holden Creek (mouth to headwaters)	3.6	X	X
Hoquarton Slough (mouth to headwaters)	3.1	X	X
Kilchis River (mouth to Little So. Fork Kilchis River)	6.3	X	X
Killam Creek (mouth to headwaters)	5.8	X	X
Miami River (mouth to Stuart Creek)	5.6	X	X
Mill Creek (mouth to headwaters)	1.4	X	X
Mills Creek (mouth to USFS boundary)	1.2	X	X
Murphy Creek (mouth to headwaters)	2.5	X	X
Simmons Creek (mouth to 0.5 mi. upstream Hwy 101)	1.0	X	X
Tillamook River (mouth to headwaters)	18.5	X	X
Wilson River (mouth to Little North Fork Wilson River)	8.5	X	X
Total Miles	**64.4**		

Figure 19. Concentrations of fecal coliform bacteria in each river during the low-flow period of the year; June through September. Duration of data record and number of samples varies for each river. River Mile 0 represents the mouth of each river.

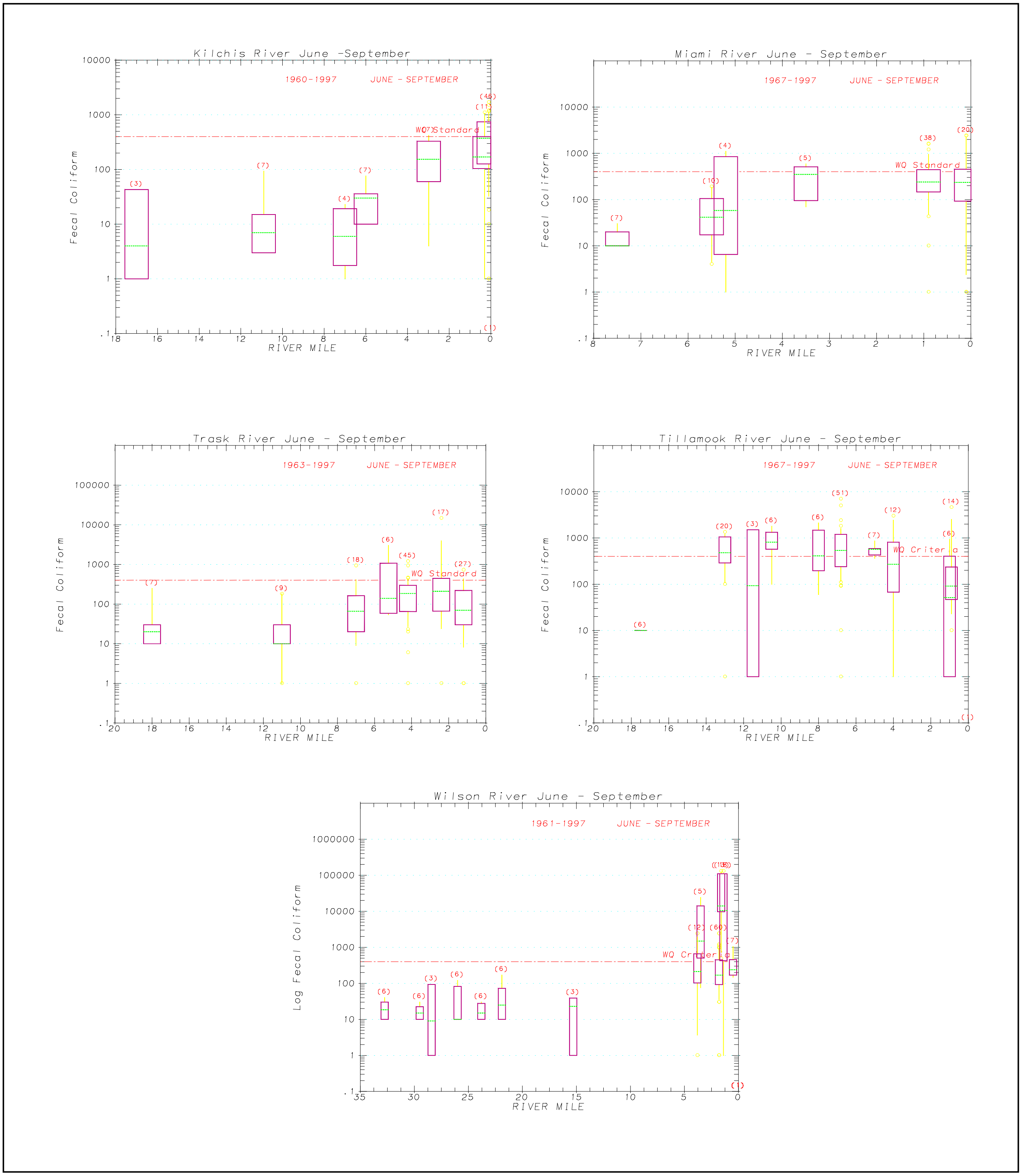
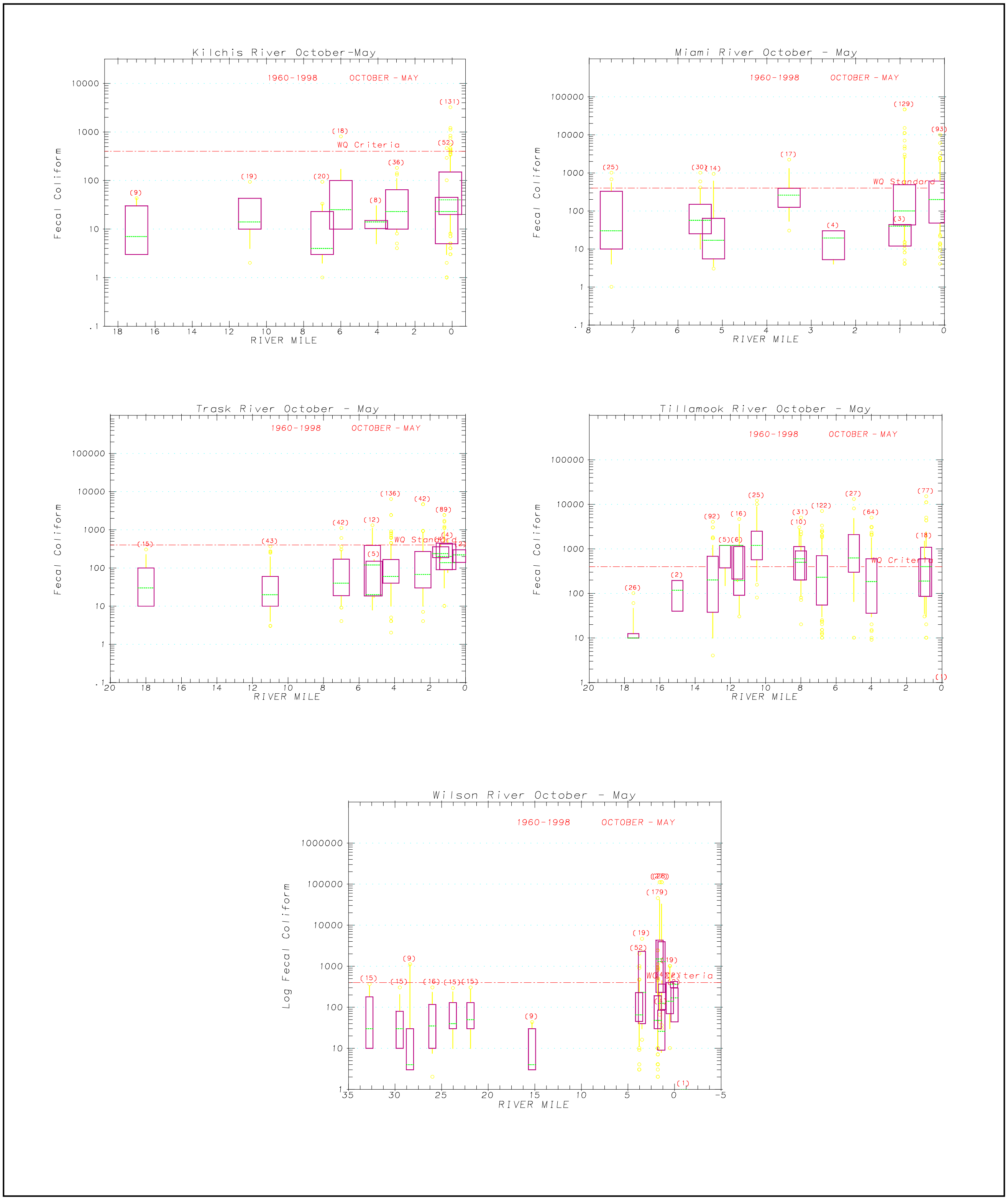


Figure 20. Concentrations of fecal coliform bacteria in each river during the wet period of the year; October through May. Duration of data record and number of samples varies for each river. River Mile 0 represents the mouth of each river.



3.2.5.3 Tillamook Bay Watershed – Stormwater Sampling

Intensive storm sampling has been conducted on all 5 rivers at various times over the years. The most recent data was collected in October 1997 and March 1998 (Figure 21). The Tillamook Bay National Estuary Program, DEQ and Tillamook County Creamery Association (TCCA) shared sampling responsibility in the March 1998 event. In general, concentrations were higher in the October 1997 event than in the March event. The observed differences in concentration may be explained by rainfall intensity or by prior rainfall patterns. Though somewhat different, both storms were relatively large, with peak rainfall rates of 0.48 and 0.30 inches per hour (measured at the Oregon Department of Forestry gage in Tillamook), in October and March, respectively. Early rainy-season storm events typically show higher concentrations of pollutants in runoff due to accumulation on land over the dry period. Additionally, review of historical data suggests that instream concentrations in later storms would be lower.

Concentrations in the Kilchis and Miami Rivers were comparatively low during storms, and did not exceed the standard for contact recreation. These two rivers were only sampled in the late winter storm, when concentrations were lower among the other rivers.

The Trask River exceeded the recreational standard (200 COUNTS/100ml geometric mean) at all sites during the October 1997 storm. During the March 1998 storm, however, geometric mean concentrations were generally below the standard. This pattern was also observed in the Tillamook River data for the two storm events. All sites violated the criteria in the October storm, while only the sites near the mouth violated the fecal criteria in March.

During the October 1997 storm, all concentrations exceeded the criteria in all samples collected below river mile 7.4 on the Wilson River. In March 1998 the criteria were exceeded only at river mile 1.3. These data cannot be directly compared to DEQ historical ambient monitoring data since DEQ did not sample the same sites as TCCA. In particular, DEQ has limited data from river mile 3.8 to river mile 15.3. However, increases in bacteria concentrations generally occur as the land use changes from predominantly forest to include agriculture, residential and the TCCA wastewater discharge.

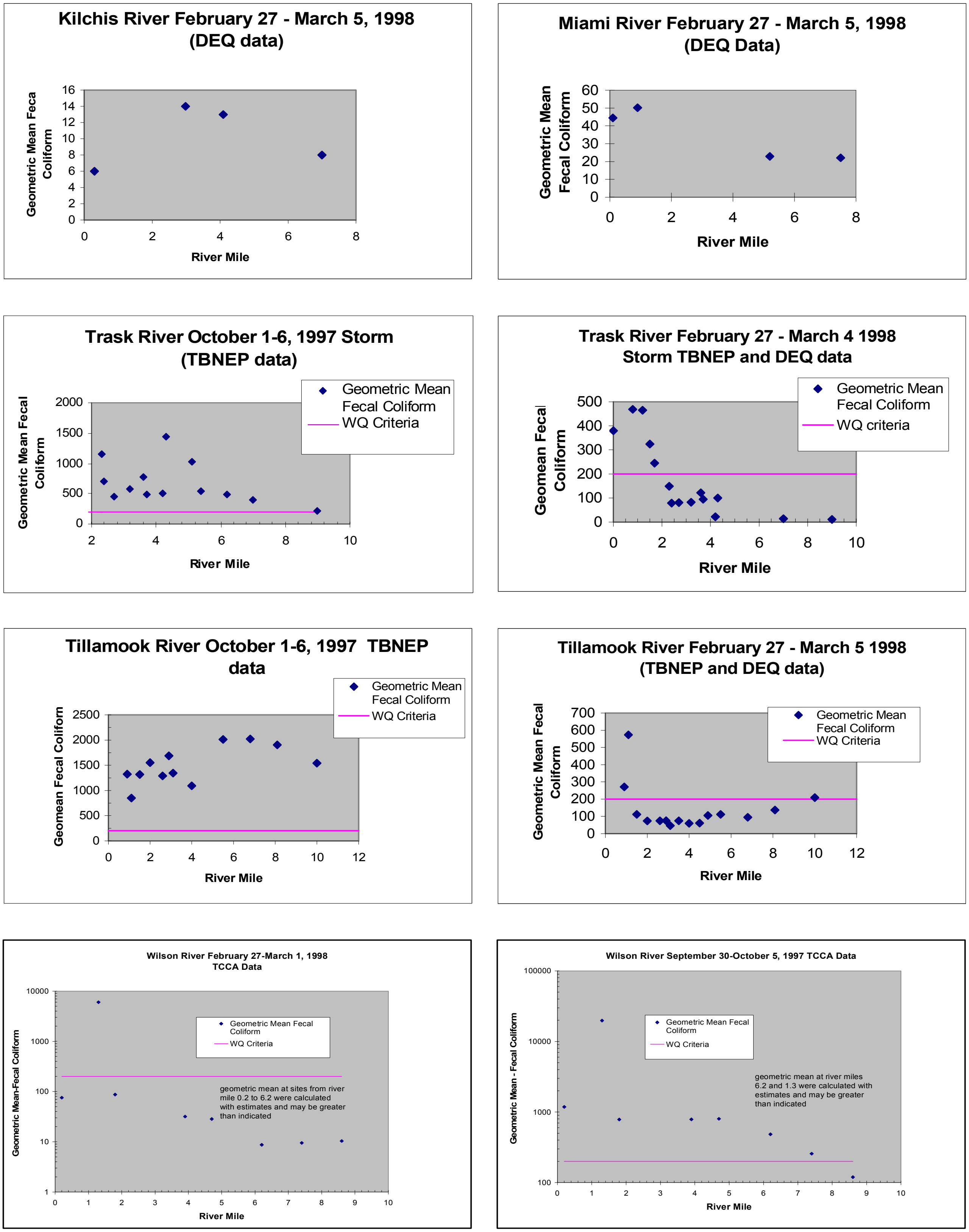
3.2.5.4 Summary of Bacterial Contamination Data

River bacterial concentrations were generally slightly higher during the summer (June-September) than in fall-spring (October-May). This is likely due to dilution by rainfall during the high runoff period, despite this runoff also carrying accumulated bacteria to the rivers.

Bacterial concentrations were lowest in the Kilchis and Miami Rivers throughout the year, followed by the Trask, Wilson and Tillamook. Concentrations were low through most of the Trask and Wilson watersheds, where higher elevation forests are the primary landuse, while they were relatively high through most of the Tillamook except the uppermost reaches.

Stormwater runoff resulted in some of the highest concentrations observed in the watershed. However, concentrations were much higher in the fall storm than in a late-spring storm. This is most likely a result of cleansing of the land by early season storms and comparatively less accumulation during the winter months than over the summer.

Figure 21. Geometric Means of bacterial concentration during storms in each of the major rivers.



3.2.6 Source Identification

3.2.6.1 Point Sources:

The Tillamook Bay drainage basin has four domestic wastewater treatment plants that discharge to the Bay or rivers. The Tillamook County Creamery Association (TCCA) operates a combined domestic and industrial treatment plant that discharges to the Wilson River. The locations and permit limits are summarized below in Table 13. Table 14 lists the remaining facilities covered by NPDES permits in Tillamook Bay Watershed (except for construction permits).

Table 14. Individual NPDES Permits

Facility Name	Discharge Point	Permit Limits
Port of Tillamook Bay	Trask River at RM 5.2	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
City of Tillamook	Trask River at RM 1.9	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
City of Bay City	Tillamook Bay	Monthly geometric mean of 80 /100 ml Weekly geometric mean of 160 /100 ml
City of Garibaldi	Tillamook Bay	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
Pacific Campground[8]	Smith Creek →Boquist Slough→Wilson River	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
TCCA	Wilson River RM 1.3	Monthly geometric mean of 200 /100 ml No more than 10% of monthly samples > 400 /100 ml

3.2.6.2 Non-point Sources

There are several types of land use in the Tillamook Bay Watershed (Table 15), each of which is a potential source of bacterial runoff. Land uses have been broken down into more discreet categories for bacteria than for temperature. These uses differentiate between agriculture, agriculture/forest margins, farm buildings, and rural residential uses for instance. Confined animal feeding operations (CAFOs) are included in the farm building and farm building/agriculture category. Runoff from each of the land use types contributes to instream fecal coliform concentration and each category was included in the modeling of bacterial accumulation. Failing septic systems, which may be associated with either urban or rural residential development, may also contribute bacterial loads to the rivers. Concentrations typically associated with each land use are described in Appendix B.

Although land uses were divided into many categories, the majority of the area was accounted for by just a few of these land uses (Figures 22 and 23). Concentrations of bacteria in runoff from these land use types were derived from literature and from analysis of samples from the basin (Table 15). Proportions of a given land use were relatively similar among the Miami, Kilchis, Wilson, and Trask River watersheds, with more than 90% covered by forest lands and 7% or less in agriculture. The Tillamook River Watershed had significantly more land devoted to agricultural uses (approximately 21%) than the other basins. The Tillamook watershed also has the greatest proportion of land in the rural industrial and rural residential land use categories.

[8] Model resolution not detailed enough to identify sources to mainstem.

Table 15. General NPDES Permits

Facility Name	Receiving Water	Permit Type		Status
Tillamook County Landfill	Tillamook	GEN17	Vehicle Wash Water	Wash water not expected to contain fecal coliform
Pacific Coast Timber Company	Kilchis	GEN12A	Quarries	Discharge not expected to contain fecal coliform
Smith's Pacific Shrimp Company[9]	Tillamook Bay	GEN09	Seafood Processing	Permit limits based on effluent guidelines, fecal coliform not expected in effluent
East Fork Trask Pond	East Fork of Trask River	GEN03	Fish Hatcheries	No reasonable potential for fish hatcheries to be a significant source of fecal coliform (cold blooded animals)
Trask River Hatchery	Trask	GEN03	Fish Hatcheries	No reasonable potential for fish hatcheries to be a significant source of fecal coliform (cold blooded animals)
S-C Paving Company	Trask	GEN12A	Quarries	Discharge not expected to contain fecal coliform
Tillamook Lumber Company[10]	Holden Creek →Trask River	12Z Industrial Storm Water	Pulp, Paper or Hardwood	Sampled, average runoff concentration of 1900 FC/100 ml, modeled as point source
Tillamook County Landfill	Tillamook River	12Z Industrial Storm water	Inactive Landfill	Sampled, median of values from 1985-1997 is 43 FC/100 ml, modeled as point source
Northwest Hardwoods[11]	Tillamook Bay	12Z Industrial Storm water	Wood Products	April 99: 500 FC/100 ml, May 99: < 10 FC/100 ml, impact on Bay not modeled
Merrill Auto wrecking	Tillamook Bay	12Z Industrial Storm water	Auto wrecking	Discharge not expected to contain fecal coliform
Tillamook Creamery	Wilson River	12Z Industrial Storm water	Milk Products Processing	Sampled, results used in model
Port of Tillamook Bay	Anderson Crk. →Trask River	12Z Industrial Storm water	Domestic wastewater treatment facility	Sampled, results used in model, modeled under industrial land use category

[9] Contribution not included in model, discharges to Bay not river mainstems.

[10] Modeled as a source to the mainstem, model resolution not detailed enough to include tributary sources

[11] Contribution not included in model, discharges to Bay, not river mainstems.

Figure 22. Percentage of area in various land uses for each of the major river watersheds. Land uses with less than 1% area are not included in chart.

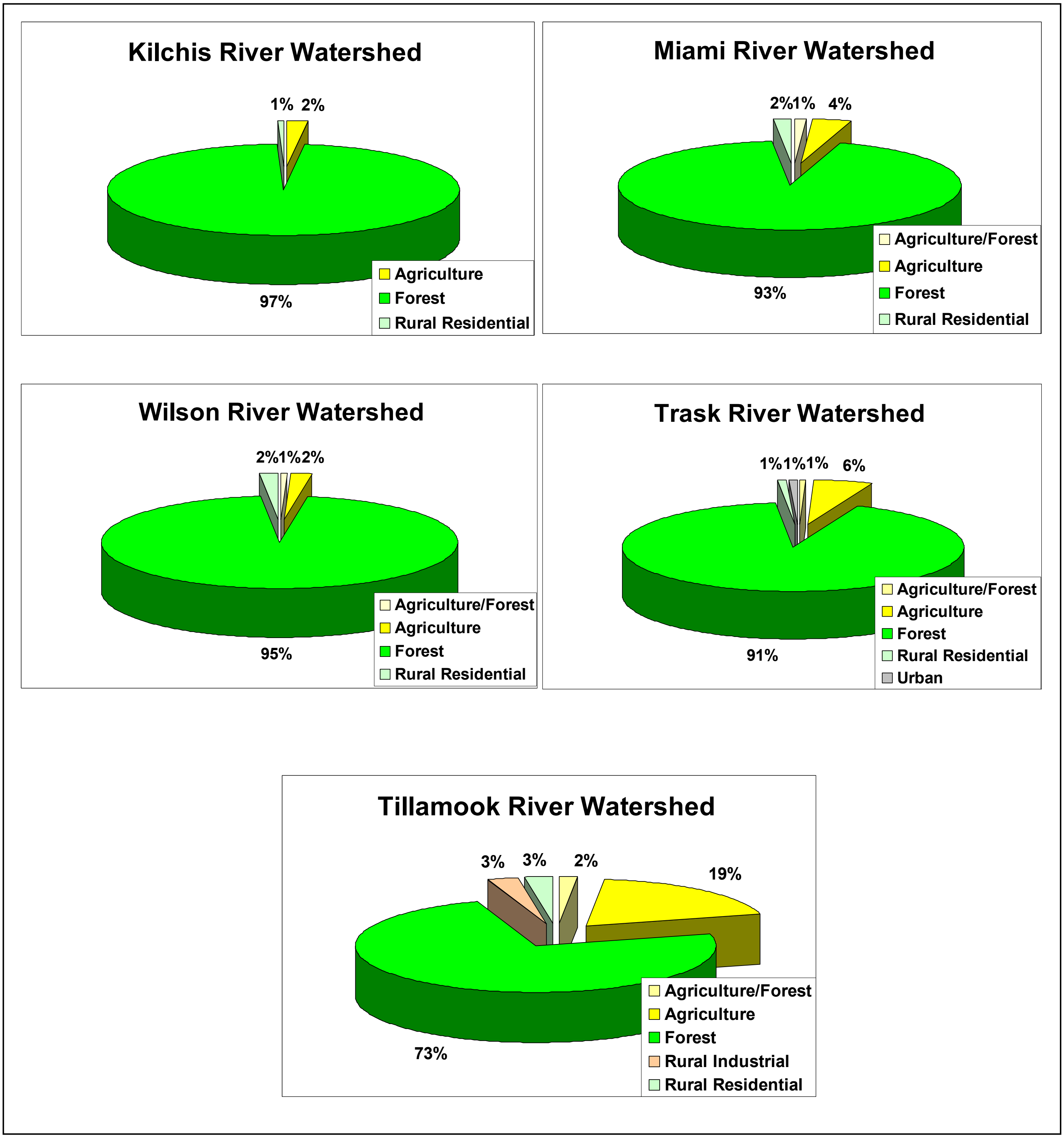


Figure 23. Landuse distributions and watershed boundaries in the Tillamook Bay Watershed.

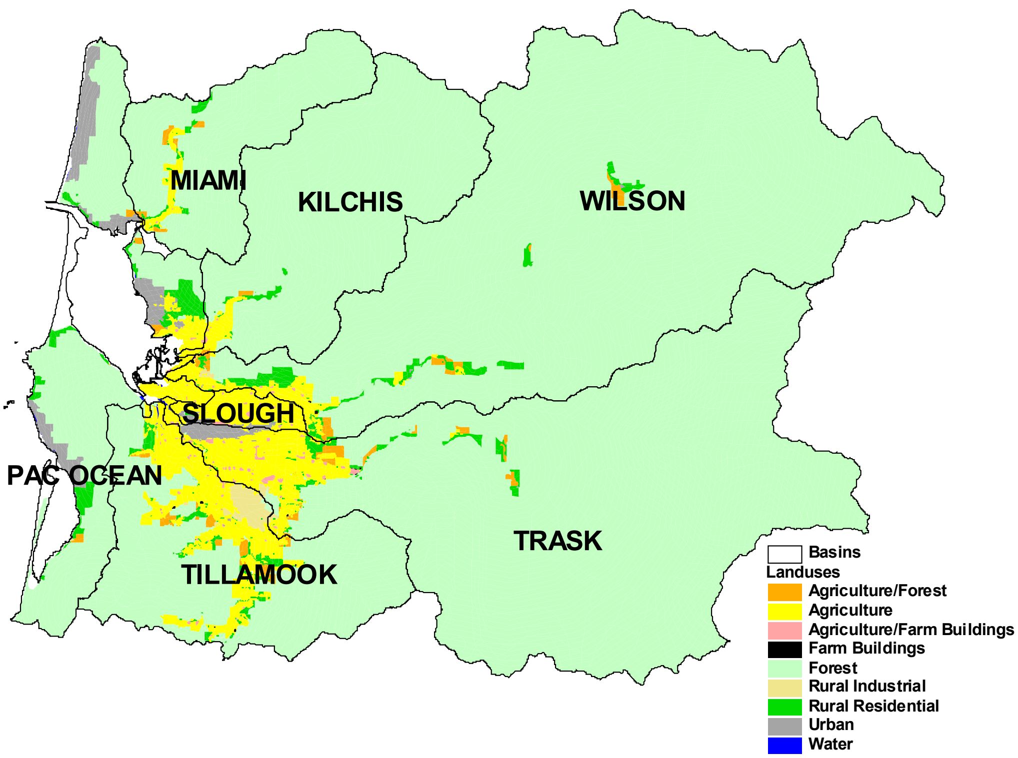


Table 16. Bacterial Concentrations associated with various Land Uses.

Land Use	Concentrations used in calibration to October 1997 storm data (counts/100ml)	Concentrations after 95% reductions (counts/100ml)	Concentrations after 99 % reduction (counts/100ml)
Agriculture/Forest[1]	25	1	0
Agriculture[2]	20000	500	100
Agriculture/Farm Bldg.[2]	100000	0	0
Farm Buildings[2]	100000	0	0
Forest[1]	25	1	0
Rural Industrial	1500	75	15
Rural Residential	9000	450	90
Urban	7000	350	70
Failing Septic[3] Systems	20000	0	0

1 = Considered natural minimum; will not be assigned an allocation.
2 = Assigned a discharge limit of zero based on terms of CAFO permits.
3 = Assigned a discharge limit of zero based on state requirement.

3.2.7 Loading Capacity:

The loading capacity is set to meet the shellfish criterion requiring that the median of fecal coliform concentration be no greater than 14 COUNTS/100mL in the Bay. This loading capacity relies on achieving low concentrations of bacteria in the rivers and dilution with bacteria free water in the Bay. River water is diluted by saline Bay water and conductivity increases with distance into the Bay from the river mouths. A dilution ratio of approximately 3:1 was determined based on examination of the conductivity data from shellfish monitoring stations throughout the Bay. Details of this dilution calculation are in Appendix B. There was no seasonal variation in the dilution at sites in the conditionally approved zones in the Bay. Therefore, given a concentration of 42 COUNTS/100 ml at the River mouths and the 3:1 dilution ratio, the fecal coliform standard would be met at the conditionally approved shellfish harvesting areas. The load capacity of 42 COUNTS/100 ml at the river mouths is in effect throughout the year to attain the shellfish criterion in the Bay. This load will also result in attainment of the recreational criterion in the Rivers and Bay.

3.2.7.1 Current loads

To evaluate bacteria loading in the Tillamook Bay Watershed, an event-based, unit-load model was used. The model uses estimated peak flow, Event Mean Concentrations (EMC) for various land uses, and bacteria die off rates to predict total bacteria concentration and loads in the streams. Details of this model are discussed in Appendix B. Concentrations were estimated based on data or literature values (see Appendix B for details of landuse runoff concentrations) and then adjusted to provide the best fit to measured concentrations of bacteria.

3.2.7.2 Background:

Background is defined as the concentration of bacteria in water where there are very limited human sources. Sites in forest lands that had historical data available were selected for data review. The median concentration of all the instream fecal coliform samples collected at the sites was 10 COUNTS/100 ml in all seasons. The value was chosen as the background instream concentration.

3.2.7.3 Seasonal Variation:

Seasonal differences were addressed in the allocations in two ways. First, winter (October through May) and summer (June – September) flows were simulated as described in Table 14, using daily mean flow. The Wilson River was chosen for simulation because the period of record (1932 through 1998) was the longest of the five rivers and could be used for frequency analysis, and closure of shellfish harvesting is based on Wilson River flow. Once the flow distribution was calculated for the river (Table 16), storms with rainfall intensities that resulted in these flows were modeled to determine loading rates. Secondly, the instream decay coefficient was increased for the summer allocation simulation to reflect higher decay during summer.

Table 17. Seasonal Wilson River Flows. Values are 90th percentile of flow distribution from 1932-1998.

Season	Flow at gage (CFS)
Summer (June-September)	356
Winter (October-May)	3700
Closure Periods	6515
Minimum Flow for Bay closure	2500

3.2.8 Allocations:

Allocations are the amounts of bacteria that various sources are allowed to discharge. In the case of point sources, these allocations will guide the development of NPDES permit limits. In the case of nonpoint sources, they will be targets that management practices will be designed to meet.

3.2.8.1 Point Source Allocations

The shellfish standard has two components. Meeting either of these components defines compliance with the standard. The limits in the standard are based on two points in the distribution of sample values; the

50th percentile (or "median" can also be met with a geometiric mean) may not exceed 14 MPN/100 ml, and the 90th percentile ("no more than 10% of samples may exceed") value of 43 MPN/100 ml.

The basic allocation allows a dilution ratio of 3:1, but does not give any allowance for decay. This basic allocation was given to the discharges to the Bay resulting in a concentration of 42 MPN/100 ml prior to dilution, with no more than 10% of samples to exceeding a limit of 129 MPN/100 ml prior to dilution. Discharges to the Bay are not given an allowance for decay, since the time of travel to the shellfish beds is variable and generally short throughout the year.

Discharges to the river were given the basic allocation described above, but are also given an allowance for decay based on temperature and velocity in the rivers. These factors result in the allocations presented in Table 18. Calculations resulted in concentrations that exceeded the criteria set for recreational contact (based on the fecal coliform standard used by DEQ prior to 1996) in some cases. These concentrations (City of Tillamook and Port of Tillamook Bay in summer only) were reduced to those criteria for allocations.

Table 18. Allocations of bacterial concentrations for individual NPDES permitted facilities.

Facility Name	Discharge Point	FWS Geometric Mean	Summer Geometric Mean	FWS 90th percentile	Summer 90th percentile
City of Bay City	Tillamook Bay	42	42	129	129
City of Garibaldi	Tillamook Bay	42	42	129	129
Port of Tillamook Bay	Trask River at RM 5.2	65	200[a]	200	400[a]
City of Tillamook	Trask River at RM 1.9	49	200[a]	151	400[a]
Pacific Campground[12]	Smith Creek - Boquist Slough→Wilson River	46	74	140	226
TCCA	Wilson River RM 1.7	48	109	149	336

a = Calculated concentrations were higher than recreational contact standard criteria and were set at those criteria.
FWS = Fall-Winter-Spring

As indicated in Table 15, general permits for most other operations and facilities in the basin were not expected to produce or discharge bacteria, so are not allocated. Those that were expected to discharge bacteria were included in the model.

3.2.8.2 Non-point Source Allocations

As discussed previously, the allocations are set to meet a concentration of 28 counts/100mL at the mouth of each river. The allocation method allows for attainment of the criteria to be determined for each river separately through different runoff concentrations (Table 18). Runoff concentrations also vary by flow rate (a seasonal consideration). Allocation concentrations presented below are those associated with each land use prior to mixing with a waterbody. These concentrations in runoff would be diluted locally by the indicated volume of river water without causing the concentration to exceed the instream recreational standard or the river mouth allocation. The categories Farm buildings and Agriculture Farm Buildings (refer to Table 15) receive a zero allocation as they are allowed zero discharge under the terms of their CAFO permits. Failing septic systems also receive a zero allocation since the failure is a result of maintenance and is not permitted under state law.

Each run of the model produced target runoff concentrations for each land use and an instream concentration at the mouth of a given river. Initial runoff concentrations for each land use were calibrated for the October 1997 storm. Simulations for each river were run at a range of flows that corresponded to the Wilson River flow at various sized flow events. The cumulative loads for each river were reduced with

12 Model resolution not detailed enough to identify sources to mainstem.

subsequent model runs until the instream concentration at the mouth approximated the allocation target of 28 COUNTS/100 ml. Reductions of 90% or greater relative to the October 1997 storm were required to meet the instream allocation. Where a
reduction of 99% did not meet the targeted instream concentration, the runoff targets resulting from this degree of reduction is the allocation. Allocations were reduced by the same proportion across all land uses except forestry, which was considered at a natural minimum.

The Tillamook River will require the greatest percent reduction of the rivers under all flow conditions. This is due to the density of agricultural land in the basin and the small size of the basin (62 mi^2), which results in less flow available to dilute runoff concentrations. Some apparent land uses are included in the overall allocation. Farm buildings and pastures that have had manure applied to them are set at zero allocation because of the effluent guideline requiring CAFOs to have a zero discharge to surface waters.

Table 19. Allocations for bacteria in runoff from various land uses[1] in rivers of the Tillamook Bay Watershed. All flow scenarios are based on events that caused the indicated flow in the Wilson River[2].

Miami River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Miami River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
1042	38	800	280	360	60	96
623	40	1000	350	450	75	95
93	42	15400	5390	6930	1155	23

Kilchis River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Kilchis River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
2826	41	3000	1050	1350	225	85
1678	42	3600	1260	1680	270	82
224	21.7	20000	7000	9000	1500	0

Wilson River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Wilson River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
6548	40	1200	420	540	90	94
3820	42	1400	490	630	105	93
366	42	5600	1960	2520	420	72

Trask River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Trask River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
5389	39	600	210	270	45	97
3187	40	800	280	360	60	96
398	41	4600	1610	2070	345	77

Tillamook River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Tillamook River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
1061	36	200	70	90	15	99
623	34	200	70	90	15	99
68	37	1200	420	540	90	94

1 = Forest bacterial concentrations were considered at a natural minimum, so were not given allocations. Farm Buildings, and Ag/Farm Buildings are not allowed to discharge under conditions of CAFO permits, and failing septic systems are not allowed under state law, so were not given allocations.

2 = Flows in the Wilson River were used to model flows in the other rivers, and all modeling was based on these relationships.

3.3 Margins of Safety – CWA §303(d)(1)

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

3.3.1 Two Types of Margin of Safety

The MOS may be implicit, as in conservative assumptions used in calculating the loading capacity, Waste Load Allocation, and Load Allocations. The MOS may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the MOS documented. The MOS is not meant to compensate for a failure to consider known sources. **Table 21** presents six approaches for incorporating a MOS into TMDLs.

Table 20. Approaches for Incorporating a Margin of Safety into a TMDL

Type of Margin of Safety	*Available Approaches*
Explicit	1. Set numeric targets at more conservative levels than analytical results indicate. 2. Add a safety factor to pollutant loading estimates. 3. Do not allocate a portion of available loading capacity; reserve for MOS.
Implicit	1. Conservative assumptions in derivation of numeric targets. 2. Conservative assumptions when developing numeric model applications. 3. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

The following factors may be considered in evaluating and deriving an appropriate MOS:

- ✓ *The analysis and techniques used in evaluating the components of the TMDL process and deriving an allocation scheme.*
- ✓ *Characterization and estimates of source loading (e.g., confidence regarding data limitation, analysis limitation or assumptions).*
- ✓ *Analysis of relationships between the source loading and instream impact.*
- ✓ *Prediction of response of receiving waters under various allocation scenarios (e.g., the predictive capability of the analysis, simplifications in the selected techniques).*
- ✓ *The implications of the MOS on the overall load reductions identified in terms of reduction feasibility and implementation time frames.*

A TMDL and associated MOS, which results in an overall allocation, represents the best estimate of how standards can be achieved. The selection of the MOS should clarify the implications for monitoring and implementation planning in refining the estimate if necessary (adaptive management). The TMDL process accommodates the ability to track and ultimately refine assumptions within the TMDL implementation-planning component.

3.3.2 Implicit Margins of Safety used in Tillamook Bay Watershed TMDLs

Description of the MOS begins with a statement of assumptions. A MOS has been incorporated into both the temperature and bacteria assessment methodology.

For temperature, conservative estimates for groundwater inflow and wind speed were used in the stream temperature simulations. Specifically, unless measured, groundwater inflow was assumed to be zero. In addition, wind speed was also assumed to be at the lower end of recorded levels for the day of sampling. Recall that groundwater directly cools stream temperatures via mass transfer/mixing. Wind speed is a controlling factor for evaporation, a cooling heat energy process. Further, cooler microclimates and channel morphology changes associated with late seral conifer riparian zones were not accounted for in the simulation methodology.

Calculating a numeric MOS is not easily performed with the methodology presented in this document. In fact, the basis for the loading capacities and allocations is the definition of system potential conditions. It is illogical to presume that anything more than system potential riparian conditions are possible, feasible or reasonable.

The margin of safety for the bacteria TMDL is also addressed through conservative modeling. First, no salinity or temperature effects on bacteria decay rate in the Bay were considered. Increased salinity in the Bay would be expected to decrease the bacteria concentrations through higher decay rates. Secondly, the model accounted for dilution by summer storm baseflow under all conditions; winter storm baseflow would be higher and lead to greater dilution instream for a given runoff load. By underestimating the dilution effects of baseflow in winter storms the modeled concentrations will appear higher than actual.

GLOSSARY OF TERMS

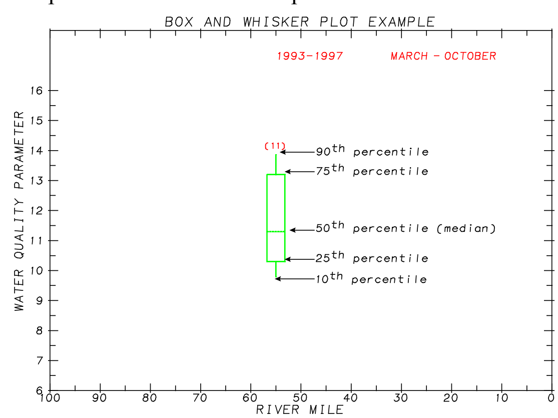
A

Abatement -- Reducing the degree or intensity of, or eliminating, pollution.
Acidic -- The condition of water or soil that contains a sufficient amount of acid substances to lower the pH below 7.0.
Acre -- A measure of area equal to 43,560 square feet (4,046.87 square meters). One square mile equals 640 acres.
Active Bank Erosion: Estimates from observation of the active stream bank erosion as a percentage (%) of the total reach length.
Adaptation -- Changes in an organism's structure or habits that allow it to adjust to its surroundings.
Adaptive management -- The process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans.
Alevin -- The developmental life stage of young salmonids and trout that are between the egg and fry stage. The alevin has not absorbed its yolk sac and has not emerged from the spawning gravels.
Allocation – Refers to the load allocation (nonpoint sources) and wasteload allocation (point sources). Specifically, an allocation is the division of the loading capacity between nonpoint and point sources of pollution.
Alluvial -- Deposited by running water.
Alluvium -- Sediment or loose material such as clay, silt, sand, gravel, and larger rocks deposited by moving water.
Anadromous -- Fish that hatch rear in fresh water, migrate to the ocean (salt water) to grow and mature, and migrate back to fresh water to spawn and reproduce.
Anthropogenic Sources of Pollution: Pollutant deliver to a water body that is directly related to humans or human activities.
Appropriate -- To authorize the use of a quantity of water to an individual requesting it.
Aquatic ecosystem -- Any body of water, such as a stream, lake or estuary, and all organisms and nonliving components within it, functioning as a natural system.
Aquatic habitat -- Habitat that occurs in free water.
At-risk fish stocks -- Stocks of anadromous salmon and trout that have been identified by professional societies, fish management agencies, and in the scientific literature as being in need of special management consideration because of low or declining populations.

Augmentation (of stream flow) -- Increasing steam flow under normal conditions, by releasing storage water from reservoirs.

B

Bank stability -- The properties of a stream bank that counteract erosion, for example, soil type, and vegetation cover.
Bank Building Event: A hydrologic event (usually high flow condition) that deposits sediments and organic debris in the flood plain and along stream banks.
Bankfull width -- The width of a river or stream channel between the highest banks on either side of a stream.
Bar (stream or river bar) -- An accumulation of alluvium(gravel or sand) caused by a decrease in water velocity.
Barrier -- A physical block or impediment to the movement or migration of fish, such as a waterfall (natural barrier) or a dam (man-made barrier).
Base flow -- The sustained portion of stream discharge that is drawn from natural storage sources, and not effected by human activity or regulation.
Bed load -- Sediment that moves near the streambed.
Bed Material -- The sediment mixture of which a streambed, lake, pond, reservoir, or estuary bottom is composed.
Beneficial Use: Legislatively approved use of water for the best interest of people, wildlife and aquatic species.
Blowdown -- Trees felled by high winds.
Boulder -- A large substrate particle that is larger that cobble, >256 mm in diameter.
Box and Whisker Plots: Water quality parameters and instream physical parameters are reviewed below using box and whisker plots for illustration. Below is an example of a box and whisker plot:



Example of box and whisker plot.

The box plots have river mile on the X-axis with the water quality parameter on the Y-axis. The box represents the data at the sampling sites, from upstream to downstream. Each box represents a summary of the data:

The upper corner of each box is the 75th percentile (75 percent of the data are below that concentration), and the lower corner is the 25th percentile (25 percent of the data are below that concentration). The upper and lower tails

are the 90th and 10th percentiles, respectively. Points above and below the tails represent data higher and lower than the 90th and 10th percentiles. The dashed line in the box is the median concentration for that site (half of the data fall above and below that concentration).
Brackish -- Having a somewhat salty taste, especially from containing a mixture of seawater and fresh water.
Braided stream -- A complex tangle of converging and diverging stream channels (Anabranches) separated by sand bars or islands. Characteristic of flood plains where the amount of debris is large in relation to the discharge.
Buffer strip -- A barrier of permanent vegetation, either forest or other vegetation, between waterways and land uses such as agriculture or urban development, designed to intercept and filter out pollution before it reaches the surface water resource.
Buoyancy -- The tendency of a body to float or rise when submerged in a fluid.

C

Canopy -- A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. Leavs, branches and vegetation that are above ground and/or water that provide shade and cover for fish and wildlife.
Canopy closure -- The degree to which the canopy (forest layers above one's head) blocks sunlight or obscures the sky.
Canopy density -- The degree to which the canopy (forest layers above one's head) covers a unit area. Commonly measured with a concave or convex densiometer or estimated from aerial photography.
Carrying capacity -- The maximum number of organisms that a certain habitat can sustain over the long term.
Catchment -- (1) The catching or collecting of water, especially rainfall. (2) A reservoir or other basin for catching water. (3) The water thus caught.
Channel -- An area that contains continuously or periodically flowing water that is confined by banks and a stream bed.
Channelization -- The process of changing and straightening the natural path of a waterway.
Channel Complexity: Implied high pool frequency of pools and large woody debris (instream roughness).
Channel Simplification: The loss (absence) of pools and large woody debris that is important for creating and maintaining channel features such as: substrate, stream banks and pool:riffle ratios.
Check dam -- A small dam constructed in a gully or other small water course to decrease the streamflow velocity, minimize channel erosion, promote deposition of sediment and to divert water from a channel.
Classic old growth -- Forest stands with unusually old and large trees that also meet criteria for old-growth forest.
Clay -- Substrate particles that are smaller than silt and generally less than 0.004 mm in diameter.
Clean Water Act: Established in 1977, is an amendment to the 1972 Federal Water Pollution Control Act which set the groundwork for regulating pollutant discharges into U.S. waters. The Clean Water Act makes discharging pollutants from a point source to navigable waters illegal without a permit. The Clean Water Act amendments of 1977 were aimed at toxic pollutants. In 1987, the Clean Water Act was reauthorized and focused on sewage treatment plants, toxic pollutants, and authorized citizen suit provisions. The Clean Water Act allows the EPA to delegate administrative and enforcement aspects of the law to the state agencies. In states with this EPA given authority of Clean Water Act implementation, the EPA still plays the role of supervisor.
Clear-cut harvest -- A timber harvest method in which all trees are removed in a single entry from a designated are, with the exception of wildlife trees or snags, to create an even-aged stand.
Climax -- The culminating stage in plant succession for a given site where the vegetation has reached a highly stable condition.
Coarse woody debris (CWD) -- Portion of a tree that has fallen or been cut and left in the woods. Usually refers to pieces at least 20 inches in diameter.
Cobble -- Substrate particles that are smaller than boulders and are generally 64-256 mm in diameter. Can be further classified as small and large cobble. Commonly used by salmon in the construction of a redd.
Coefficient of determination (r-squared) -- The percentage of variation of the independent variable (y) that is attributed to its linear regression in the dependent variable (x).
Confluence -- (1) The act of flowing together; the meeting or junction of two or more streams; also, the place where these streams meet. (2) The stream or body of water formed by the junction of two or more streams; a combined flood.
Conifer -- A tree belonging to the order Gymnospermae, comprising a wide range of trees that are mostly evergreens. Conifers bear cones (hence, coniferous) and needle-shaped or scalelike leaves.
Contaminate -- To make impure or unclean by contact or mixture.
Correlation Coefficient (R): Used to determine the relationship between two data sets. R-values vary between –1 and 1, where "–1" represents a perfectly inverse correlation relationship and "1" represents a perfect correlation relationship. A "0" R-value indicates that no correlation exists:

$$R = \frac{1}{n} \cdot \sum_{i=1}^{n} (x_i - \mu_x) \cdot (y_i - \mu_y)$$

Cover -- Vegetation used by wildlife for protection from predators, or to mitigate weather conditions, or to reproduce. May also refer to the protection of the soil and the shading provided to herbs and forbs by vegetation.
Crown -- The upper part of a tree or other woody plant that carries the main system of branches and the foliage.
Crown cover -- The degree to which the crowns of trees are nearing general contact with one another.
Cubic feet per second (cfs) -- A unit used to measure water flow. One cfs is equal to 449 gallons per minute.

Culvert -- A buried pipe that allows streams, rivers, or runoff to pass under a road.
Cumulative Effects -- The combined environmental impacts that accrue over time and space from a series of similar or related individual actions, contaminants, or projects.

D

Dam -- A concrete or earthen barrier constructed across a river and designed to control water flow or create a reservoir.
Debris flow -- A rapid moving mass of rock fragments, soil, and mud, with more that half of the particles being larger that sand size.
Debris torrent -- Rapid movement of a large quantity of materials (wood and sediment) down a stream channel during storms or floods. This generally occurs in smaller streams and results in scouring of streambed.
Deciduous -- Trees and plants that shed their leaves at the end of the growing season.
Decommission: The removal of a road to improve hillslope drainage and stabilize slope hazards.
Depressed stock -- A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.
Determinate Coefficient (R^2): The R^2 value represents "goodness of fit" for a linear regression. An R^2 value of "1" would indicate that all of the data variability is accounted for by the regression line. Natural systems exhibit a high degree of variability; R^2 values approaching "1" are uncommon. A value of "0" would indicate that none of the data variability is explained by the regression.
Dewatering -- Elimination of water from a lake, river, stream, reservoir, or containment.
Dike -- (1) (Engineering) An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee. (2) A low wall that can act as a barrier to prevent a spill from spreading. (3) (Geology) A tabular body of igneous (formed by volcanic action) rock that cuts across the structure of adjacent rocks or cuts massive rocks.
Discharge -- Volume of water released from a dam or powerhouse at a given time, usually expressed in cubic feet per second.
Distribution (of a species) -- The spatial arrangement of a species within its range.
Disturbance -- A force that causes significant change in structure and/or composition through natural events such as fire, flood, wind, or earthquake, mortality caused by insect or disease outbreaks, or by human-caused events, e.g., the harvest of forest products.
Ditch -- A long narrow trench or furrow dug in the ground, as for irrigation, drainage, or a boundary line.
Diversion -- The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system.
Draft -- Release of water from a storage reservoir.
Drainage -- An area (Basin) mostly bounded by ridges or other similar topographic features, encompassing part, most, or all of a watershed and enclosing some 5,000 acres.
Dredging -- Digging up and removing material from wetlands or waterways, usually to make them deeper or wider.
Drought -- Generally, the term is applied to periods of less than average or normal precipitation over a certain period of time sufficiently prolonged to cause a serious hydrological imbalance resulting in biological losses (impact flora and fauna ecosystems) and/or economic losses (affecting man). In a less precise sense, it can also signify nature's failure to fulfill the water wants and needs of man.
Duff layer -- The layer of loosely compacted debris underlying the litter layer on the forest floor.

E

Early seral stage forest -- Stage of forest development that includes seedling, sapling, and pole-sized trees.
Ecological Health -- The state of an ecosystem in which processes and functions are adequate to maintain diversity of biotic communities commensurate with those initially found there.
Ecological interaction -- The sum total of impacts of one species on another species, or on other members of the same species.
Ecologically significant -- Species, stands, and forests considered important to maintain the structure, function, and processes of particular ecosystems.
Ecosystem -- The biological community considered together with the land and water that make up its environment. Or a unit comprising interacting organisms considered together with their environment.
Ecosystem diversity -- The variety of species and ecological processes that occur in different physical settings.
Ecosystem management -- A strategy or plan to manage ecosystems to provide for all associated organisms, as opposed to a strategy or plan for managing individual species.
Eddy -- A circular current of water, usually resulting from an obstruction.
Edge -- Where plant communities meet or where successional stages or vegetative conditions with plant communities come together.
Edge effect -- "The drastically modified environmental conditions along the margins, or ""edges,"" of forest patches surrounded partially or entirely by harvested lands."
Effective old-growth forest -- Old-growth forest largely unmodified by external environmental influences from nearby, younger forest stands.
Effluent -- (1) Something that flows out or forth, especially a stream flowing out of a body of water. (2) (Water Quality) Discharged wastewater such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant.
Elevation -- Height in feet above sea level.
Embankment -- An artificial deposit of material that is raised above the natural surface of the land and used to

contain, divert, or store water, support roads or railways, or for other similar purposes.
Embeddedness -- The degree to which dirt is mixed in with spawning gravel.
Embryo -- The early stages of development before an organism becomes self supporting.
Emergence -- The process during which fry leave their gravel spawning nest and enter the water column.
Emigration -- Referring to the movement of organisms out of an area. See immigration and migrating.
Empirical -- (Statistics) Based on experience or observations, as opposed to theory or conjecture.
Endangered species -- Any species of plant of animal defined through the Endangered Species Act as being in danger of extinction throughout all or a significant portion or its range, and published in the Federal Register.
Endangered Species Act (ESA) -- A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.
Endemic -- Native to or limited to a specific region.
Energy -- The ability to work (i.e., exert a force over distance). Energy is measured in calories, joules, KWH, BTUs, MW-hours, and average MWs.
Enhancement -- Emphasis on improving the value of particular aspects of water and related land resources.
Entrainment -- (Streams) The incidental trapping of fish and other aquatic organisms in the water, for example, used for cooling electrical power plants or in waters being diverted for irrigation or similar purposes.
Ephemeral Streams -- Streams which flow only in direct response to precipitation and whose channel is at all times above the water table.
Epilimnion -- The upper region of a thermally stratified lake, above the thermocline, and generally warm and well oxygenated.
Erosion -- Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.
Escapement (Spawning) -- The portion of a fish population that survives sources of natural mortality and harvest to reach its natal spawning grounds.
ESU -- "Evolutionarily Significant Unit; a ""distinct"" population of Pacific salmon, and hence a species, under the Endangered Species Act."
Eutrophic -- Usually refers to a nutrient-enriched, highly productive body of water.
Eutrophication -- The process of enrichment of water bodies by nutrients.
Evaporation -- The physical process by which a liquid (or a solid) is transformed to the gaseous state. In Hydrology, evaporation is vaporization that takes place at a temperature below the boiling point.
Evolutionarily significant unit (ESU) -- "A definition of ""species"" used by NMFS in administering the Endangered Species Act. An ESU is a population (or groups of populations) that (1) is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species."
Exotic species -- Introduced species not native to the place where they are found (e.g., Atlantic salmon to Oregon or Washington).
Extinction -- The natural or human induced process by which a species, subspecies or population ceases to exist.

F

Fauna -- (1) A term used to describe the animal species of a specific region or time. (2) All animal life associated with a given habitat, country, area, or period.
Federal land managers -- This category includes the Bureau of Indian Affairs; the Bureau of Land Management; the National Park Service, all part of the U.S. Department of the Interior; and the Forest Service, U.S. Department of Agriculture.
Federal project operators and regulators -- Federal agencies that operate or regulate hydroelectric projects in the Columbia River Basin. They include the Bonneville Power Administration, the Bureau of Indian Affairs, the Bureau of Reclamation, the Corps of Engineers and the Federal Energy Regulatory Commission.
Fill -- (Geology) Any sediment deposited by any agent such as water so as to fill or partly fill a channel, valley, sink, or other depression.
Fine Sediment: Sand, silt and organic material that have a grain size of 6.4 mm or less.
Fingerling -- Refers to a young fish in its first or second year of life.
Fire Regime: The frequency, extent, intensity and severity of naturally occurring seasonal fires in an ecosystem.
Fish and wildlife agencies -- This category includes the Fish and Wildlife Service, U.S. Department of the Interior; the Idaho Department of Fish and Game; the Montana Department of Fish, Wildlife and Parks; the National Marine Fisheries Service, U.S. Department of Commerce; the Oregon Department of Fish and Wildlife; and the Washington Department of Fish and Wildlife.
Fishery -- The act, process, or occupation of attempting to catch fish, which may be retained or released.
Fitness -- The relative ability of an individual (or population) to survive and reproduce (pass on it's genes to the next generation) in a given environment.
Flash Flood -- A sudden flood of great volume, usually caused by a heavy rain. Also, a flood that crests in a short length of time and is often characterized by high velocity flows. It is often the result of heavy rainfall in a localized area.
FLIR Thermal Imagery: Forward looking infrared radiometer thermal imagery is a direct measure of the longer wavelengths emitted by all bodies. The process by which bodies emit longwave radiation is described by the Stefan-Boltzmann 4^{th} Order Radiation Law. FLIR monitoring produces spatially continuous stream and stream bank temperature information. Accuracy is limited to $0.5^{o}C$. FLIR thermal imagery often displays heating processes as they are occurring and is particularly good at displaying the thermal impacts of shade, channel morphology and groundwater mixing.
Flood Plain: Strips of land (of varying widths) bordering streams that become inundated with floodwaters. Land outside of the stream channel that is inside a perimeter of

the maximum probable flood. A flood plain is built of sediment carried by the stream and deposited in the slower (slack waters) currents beyond the influence of the swiftest currents. Flood plains are termed “living” if it experiences inundation in times of high water. A “fossil” flood plain is one that is beyond the reach of the highest current floodwaters.
Floodplain (100-year) -- The area adjacent to a stream that is on average inundated once a century.
Flood Plain Roughness: Reflects the ability of the flood plain to dissipate erosive flow energy during high flow events that over-top streams banks and inundate the flood plain.
Flora -- (1) A term used to describe the entire plant species of a specified region or time. (2) The sum total of the kinds of plants in an area at one time. All plant life associated with a given habitat, country, area, or period. Bacteria are considered flora.
Flow -- The amount of water passing a particular point in a stream or river, usually expressed in cubic-feet per second (cfs).
Flow augmentation -- Increased flow from release of water from storage dams.
Fluvial -- Migrating between main rivers and tributaries. Of or pertaining to streams or rivers.
Forest canopy -- The cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth.
Forest fragmentation -- The change in the forest landscape, from extensive and continuous forests of old-growth to mosaic of younger stand conditions.
Forest land -- Land that is now, or is capable of becoming, at least 10 percent stocked with forest trees and that has not been developed for nontimber use.
Forest landscape -- Land presently forested or formerly forested and not currently developed for nonforest use.
Fragmentation -- The process of reducing size and connectivity of stands that compose a forest.
Freshet -- A rapid temporary increase in stream flow due to heavy rains or snow melt.
Fry -- A stage of development in young salmon or trout. During this stage the fry is usually less than one year old, has absorbed its yolk sac, is rearing in the stream, and is between the alevin and parr stage of development.

G

Gabion -- A wire basket or cage that is filled with gravel and generally used to stabilize stream banks and improve degraded aquatic habitat.
Gaging station -- A particular site in a stream, lake, reservoir, etc., where hydrologic data are obtained.
Gallery -- "(1) A passageway within the body of a dam or abutment; hence the terms ""grouting gallery,"" ""inspection gallery,"" and ""drainage gallery."" (2) A long and rather narrow hall; hence the following terms for a power plant: ""valve gallery,"" ""transformer gallery,"" and ""busbar gallery."""
Gallons per minute (Gpm) -- A unit used to measure water flow.
Gap Analysis -- A method for determining spatial relationships between areas of high biological diversity and the boundaries of National Parks, National Wildlife Refuges (NWR), and other preserves.
Geographic information system (GIS) -- A computer system capable of storing and manipulating spatial (i.e., mapped) data.
Glide -- A section of stream that has little or no turbulence.
Gradient -- Vertical drop per unit of horizontal distance.
Grass/Forb -- An early forest successional stage where grasses and forbs are the dominant vegetation.
Gravel -- See cobble.
Gray Water -- Waste water from a household or small commercial establishment which specifically excludes water from a toilet, kitchen sink, dishwasher, or water used for washing diapers.
Groundwater -- Subsurface water and underground streams that can be collected with wells, or that flow naturally to the earth's surface though springs.

H

Habitat -- The local environment in which a organism normally lives and grows.
Habitat conservation plan (HCP) -- An agreement between the Secretary of the Interior and either a private entity or a state that specifies conservation measures that will be implemented in exchange for a permit that would allow taking of a threatened or endangered species.
Habitat diversity -- The number of different types of habitat within a given area.
Habitat fragmentation -- The breaking up of habitat into discrete islands through modification or conversion of habitat by management activities.
Hazardous materials -- Anything that poses a substantive present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.
Headwater -- Referring to the source of a stream or river
Healthy stock -- A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.
Heavy metals -- Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.
Herbaceous -- Vegetation or parts of plants with little or no woody tissue.
Homing -- The ability of a salmon or steelhead to correctly identify and return to their natal stream, following maturation at sea.
Hydraulic head -- The vertical distance between the surface of the reservoir and the surface of the river immediately downstream from the dam.
Hydric -- Wet.
Hydrologic unit -- A distinct watershed or river Basin defined by an 8-digit code.
Hydrology -- The scientific study of the water of the earth, its occurrence, circulation and distribution, its chemical and physical properties, and its interaction with its environment, including its relationship to living things.

Hypolimnion -- The lower zone of a thermally stratified lake, below the thermocline, and usually depleted in oxygen during summer stagnation.
Hyporheic zone -- The area under the stream channel and floodplain that contributes to the stream.

I

Impact -- A spatial or temporal change in the environment caused by human activity.
Impoundment -- A body of water formed behind a dam.
Impaired waterbody: Any waterbody of the United States that does not attain water quality standards (designated uses, numeric and narrative criteria and antidegradation requirements defined at 40 CFR 131), due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.
In-situ -- In place. An in-situ environmental measurement is one that is taken in the filed, without removal of a sample to the laboratory.
Incidental take -- """Take"" of a threatened or endangered species that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."
Incipient Lethal Limit: Temperature levels that cause breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation.
Incised River -- A river which cuts its channel through the bed of the valley floor, as opposed to one flowing on a floodplain; its channel formed by the process of degradation.
Indicator (Organism) -- (Water Quality) An organism, species, or community that shows the presence of certain environmental conditions.
Indicator Species: Used for development of Oregon's water temperature standard as sensitive species that if water temperatures are reduced to protective levels will protect all other aquatic species.
Indigenous -- Existing naturally in a region, state, country, etc.
Infiltration (soil) -- The movement of water through the soil surface into the soil.
Inflow -- Water that flows into a reservoir or forebay during a specified period.
Instantaneous flows -- The velocity of a volume of water.
Instantaneous Lethal Limit: Temperature levels where denaturing of bodily enzymes occurs.
Instantaneous Rate Of Mortality -- The natural logarithm (with sign changed) of the survival rate. The ratio of number of deaths per unit of time to population abundance during that time, if all deceased fish were to be immediately replaced so that population does not change. Also called; *coefficient of decrease.
Instream cover -- The layers of vegetation, like trees, shrubs, and overhanging vegetation, that are in the stream or immediately adjacent to the wetted channel.
Instream Roughness: Refers to the substrate (both organic and inorganic) that is found in the stream bank.
Instream flow work group -- An interagency group that simulated the effects of various fish flow regimes by using hydropower regulation computer models. The group was composed of technical experts and water resource managers from the fish and wildlife agencies, federal dam operators and regulators, and state water management agencies.
Instream flows -- See flows.
Intermittent Flow: Stream flow that ceases seasonally, at least once a year.
Intermittent stream -- Any nonpermanent flowing drainage feature having a definable channel and evidence of scour or deposition. This includes what are sometimes referred to as ephemeral streams if they meet these two criteria.
Irrigation diversion -- Generally, a ditch or channel that deflects water from a stream channel for irrigation purposes.
Isolation -- Absence of genetic crossing among populations because of distance or geographic barriers.

J

Jeopardy -- A finding made through consultation under the Endangered Species Act that the action of a federal agency is likely to jeopardize the continued existence of a threatened or endangered species.
Juvenile -- Fish from one year of age until sexual maturity.

K

Key watershed -- As defined by National Forest and Bureau of Land Management District fish biologists, a watershed containing (1) habitat for potentially threatened species or stocks of anadromous salmonids or other potentially threatened fish, or (2) greater than 6 square miles with high-quality water and fish habitat.
Kilowatt (KW) -- The electrical unit of power which equals 1,000 watts or 1.341 horsepower.
Kilowatt-hour (kWh) -- A basic unit of electrical energy that equals one kilowatt of power applied for one hour.

L

Landing -- Any place on or adjacent to the logging site where logs are assembled for further transport.
Landscape -- A heterogenous land area with interacting ecosystems that are repeated in similar form throughout.
Landscape diversity -- The size, shape, and connectivity of different ecosystems across a large area.
Landscape features -- The land and water form vegetation, and structures that compose the characteristic landscape.
Landslide -- A movement of earth down a steep slope.
Large woody debris -- Pieces of wood larger than 10 feet long and 6 inches in diameter, in a stream channel.
Langley: A unit of solar radiation equivalent to one gram calorie per square centimeter of irradiated surface.
Late seral stage forest -- Stage in forest development that includes mature and old-growth forest.
Leave strips -- Generally narrow bands of forest trees that are left along streams and rivers to buffer aquatic habitats from upslope forest management activities.

Legacy Condition: Past land management and historical disturbance affect the conditions that are currently observed in a stream channel. Present conditions may reflect chronic or episodic events that no longer occur.
Levee -- An embankment constructed to prevent a river from overflowing (flooding).
Limiting factor -- "A requirement such a food, cover or spawning gravel that is in shortest supply with respect to all resources necessary to sustain life and thus ""limits"" the size or retards production of a fish population."
Limnetic -- Referring to a standing water Ecosystem (ponds or lakes).
Limnology -- The study of lakes, ponds and streams.
Litter layer -- The loose, relatively undercomposed organic debris on the surface of the forest floor made up typically of leaves, bark, small branches, and other fallen material.
Littoral zone -- The region of land bordering a body of water.
Load Allocation (LA): A term referred to in the Clean Water Act that refers to the portion of the receiving waters loading capacity attributed to either to one of its existing or future non-point sources of pollution or to natural background sources.
Loading Capacity: A term referred to in the Clean Water Act that establishes an accepted rate of pollutant introduction to a waterbody that is directly related to water quality standard compliance.

M

Macroinvertebrate -- Invertebrates visible to the naked eye, such as insect larvae and crayfish.
Mainstem -- The principle channel of a drainage system into which other smaller streams or rivers flow.
Managed forest -- Any forestland that is treated with silvicultural practices and/or harvested.
Margin of safety – When establishing the loading capacity a portion may be reserved (i.e. not allocated to non-pointed or point sources of pollution) so that the allowed pollutant loading becomes conservative.
Mass movement -- The downslope movement of earth caused by gravity. Includes but is not limited to landslides, rock falls, debris avalanches, and creep. It does not however, include surface erosion by running water. It may be caused by natural erosional processes, or by natural disturbances (e.g., earthquakes or fire events) or human disturbances (e.g., mining or road construction).
Maximum Sustainable Yield -- The largest average catch or yield that can continuously be taken from a stock under existing environmental conditions. (For species with fluctuating recruitment, the maximum might be obtained by taking fewer fish in some years than in others.) Also called; maximum equilibrium catch ; maximum sustained yield; sustainable catch.
Mean (μ): Refers to the arithmetic mean:

$$\mu = \frac{1}{n} \cdot \sum x_i \ .$$

Mean Seal Level (MSL) -- A measure of elevation above sea level.
Measured Daily Solar Radiation Load: The rate of heat energy transfer originating from the sun as determined by using a Solar Pathfinder©.
Median: A value in the data in which half the values are above and half are below.
Megawatt-hour (MWh) -- A unit of electrical energy equal to one megawatt or power applied for one hour.
Megawatts (MW) -- A megawatt is one million watts or one thousand kilowatts, a measure of electrical power or generating capacity. A megawatt will typically serve about 1,000 people. The Dalles Dam produces an average of about 1,000 megawatts.
Mesic -- Moderately wet.
Migrant -- Life stage of anadromous and resident fish species which moves from one locale, habitat or system (river or ocean) to another.
Migrating -- Moving from one area of residence to another.
Minimum spanning tree -- A means of depicting nearest genetic neighbors. The tree is an undirected network of smallest genetic distances between genetic samples superimposed on multidimensional scaling graphs to reveal local distortion (pairs of points which look close together in one dimension, but which are far apart in other dimensions).
Mitigating measures -- Modifications of actions that (1) avoid impacts by not taking a certain action of parts of an action; (2) minimize impacts by limiting the degree or magnitude of the action and its implementation; (3) rectify impacts by repairing, rehabilitating, or restoring the affected environment; (4) reduce or eliminate impacts over time by preservation and maintenance operations during the life of the action; or (5) compensate for impacts by replacing or providing substitute resources or environments.
Mitigation -- The act of alleviating or making less severe. Generally refers to efforts to alleviate the impacts of hydropower development to the Columbia Basins salmon and steelhead runs.
Monitor -- To systematically and repeatedly measure conditions in order to track changes.
Morphology -- The structure, form and appearance of an organism.
Mortality -- The number of fish lost or the rate of loss.

N

Natal stream -- Stream of birth.
Native stock -- An indigenous stock of fish that has not been substantially affected by genetic interactions with non-native stocks or by other factors, and is still present in all or part of its original range.
Natural Mortality -- Deaths in a fish stock caused by predation, pollution, senility, etc., but not fishing.
Natural selection -- Differential survival and reproduction among members of a population or species in nature; due to variation in the possession of adaptive genetic traits.
Natural Sources of Pollution: Pollutant delivered to a water body that is directly related to processes that are inherent to normal processes unaffected by humans.

Naturally spawning populations -- Populations of fish that have completed their entire life cycle in the natural environment without human intervention.
Near Stream Disturbance Zone – The distance between shade producing near stream vegetation. This dimension is measured from digital orthophoto quads (DOQs) images at less than 1:5,000 scales. Where near stream vegetation is absent, the near stream boundary is used, as defined by armored streambanks or where near stream areas are unsuitable for vegetation growth due to external factors (i.e. roads, railroads, building, rock surfaces, etc.)
Non-point source pollution -- Pollution that does not originate from a clear or discrete source.

O

Off-channel area -- Any relatively calm portion of a stream outside of the main flow.
Old-growth associated species -- Plant and animal species that exhibit a strong association with old-growth forests.
Old-growth forest -- A forest stand usually at least 180-220 years old with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; high incidence of large trees; some with broken tops and other indicators of old and decaying wood (decadence); numerous large snags; and heavy accumulations of wood, including large logs on the ground.
On-site -- Usually refers to projects or activities designed to address harm caused to fish and wildlife at the site of the harm.
Outfall -- The mouth or outlet of a river, stream, lake, drain or sewer.
Outmigration -- The migration of fish down the river system to the ocean.
Overstory -- Trees that provide the uppermost layer of foliage in a forest with more that one roughly horizontal layer of foliage.
Oxbow -- An abandoned meander in a river or stream, caused by neck cutoff. Used to describe the U-shaped bend in the river or the land within such a bend of a river.

P

Parameter -- "A ""constant"" or numerical description of some property of a population (which may be real or imaginary). Cf. statistic."
Pathogens -- Any agent that causes disease, such as a virus, protozoan, bacterium or fungus.
Peak flow -- Refers to a specific period of time when the discharge of a stream or river is at its highest point.
Perennial Flow: Stream flow that persists throughout all seasons, yearlong.
Perennial streams -- Streams which flow continuously.
Physiological -- Pertaining to the functions and vital processes of living organisms and the organs within them.
Phytoplankton -- Microscopic floating plants, mainly algae, that live suspended in bodies of water and that drift about because they cannot move by themselves or because they are too small or too weak to swim effectively against a current.
Plankton -- Minute floating forms of microscopic plants and animals in water which cannot get about to any extent under their own power. They form the important beginnings of food chains for larger animals.
Plume -- The area of the Pacific Ocean that is influenced by discharge from the Columbia River, up to 500 miles beyond the mouth of the river.
Pluvial -- Of rain, formed by the action of rain, for example a body of water.
Point Source (PS) -- (1) A stationary or clearly identifiable source of a large individual water or air pollution emission, generally of an industrial nature. (2) Any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations, or vessels. Point source is also legally and more precisely defined in federal regulations. Contrast with Non-point Source (NPS) Pollution.
Point Source (PS) Pollution -- Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types. See Non-Point Source (NPS) Pollution.
Pollutant -- (1) Something that pollutes, especially a waste material that contaminates air, soil, or water. (2) Any solute or cause of change in physical properties that renders water unfit for a given use.
Pool -- A reach of stream that is characterized by deep low velocity water and a smooth surface.
Pool/riffle ratio -- The ratio of surface area or length of pools to the surface area or length of riffles in a given stream reach; frequently expressed as the relative percentage of each category. Used to describe fish habitat rearing quality.
Population -- A group of individuals of the same species occupying a defined locality during a given time that exhibit reproductive continuity from generation to generation.
Population density -- Number of individuals of a species per unit of area.
Population dynamics -- The aggregate of changes that occur during the life of a population.
Population viability -- Probability that a population will persist for a specified period across its range despite normal fluctuations in population and environmental conditions.
Potential Daily Solar Radiation Load: Based on the Julian calendar, for any particular location on earth, there exists a potential rate of heat energy transfer originating from the sun.
Primary Channel Length: Length of the primary channel located in the survey reach. Units are meters.
Primary Channel Width: Bankfull width of a stream reported in meters.
Productivity -- A measure of the capacity of a biological system. Also used as a measure of the efficiency with which a biological system converts energy into growth and production.

R

Range (of a species) -- The area or region over which an organism occurs.
Rate: A measurable occurrence over a specified time interval.
Reach -- A section of stream between two defined points.
Reach Averaged: An average that is based on the occurrence of a property weighted by the occurrence frequency over perennial stream length.
Rearing habitat -- Areas in rivers or streams where juvenile salmon and trout find food and shelter to live and grow.
Recovery -- Action that is necessary to reduce or resolve the threats that caused a species to be listed as threatened or endangered.
Recovery/restoration -- The reestablishment of a threatened or endangered species to a self-sustaining level in its natural ecosystem (i.e., to the point where the protective measures of the Endangered Species Act are no longer necessary).
Redd -- A nest of fish eggs covered with gravel.
Redd Counts -- A spawning female salmon prepares a series of nests, called a redd, in suitable areas of streams by turning onto her side and beating her caudal fin up and down. Primary factors affecting suitability of spawning habitat include the size of rocks in the substrate and stream flow (high enough to provide adequate aeration for the eggs; low enough to prevent erosion of the nest). A completed redd is a shallow depression in the stream bottom with a rim extending to the downstream end. During spawning, the female continuously digs upstream, covering previously deposited eggs with gravel. Most redds occur in predictable areas and are easily identified by an experienced observer by their shape, size, and color (lighter than surrounding areas because silt has been cleaned away). Redd counts are conducted annually in certain heavy use areas of streams called index streams, which are usually surveyed repeatedly through the spawning season. Colored flags are sometimes placed on nearby trees to identify redds so that they will not be counted repetitively. Annual redd counts are used to compare the relative magnitude of spawning activity between years.
Rehabilitation -- Short-term management techniques that restore fish stocks decimated or destroyed by natural or man-made events.
Reservoir -- A body of water collected and stored in an artificial lake behind a dam.
Restoration -- The renewing or repairing of a natural system so that its functions and qualities are comparable to its original, unaltered state.
Riffle -- A reach of stream that is characterized by shallow, fast moving water broken by the presence of rocks and boulders.
Riparian area -- An area of land and vegetation adjacent to a stream that has a direct effect on the stream. This includes woodlands, vegetation, and floodplains.
Riparian habitat -- The aquatic and terrestrial habitat adjacent to streams, lakes, estuaries, or other waterways.
Riparian vegetation -- The plants that grow rooted in the water table of a nearby wetland area such as a river, stream, reservoir, pond, spring, marsh, bog, meadow, etc.
Riprap -- Usually refers to rocks or concrete structures used to stabilize stream or river banks from erosion.
River Channels -- Natural or artificial open conduits which continuously or periodically contain moving water, or which forms a connection between two bodies of water.
River Kilometer (RKm) -- Distance, in kilometers, from the mouth of the indicated river. Usually used to identify the location of a physical feature, such as a confluence, dam, or waterfall.
River miles (RM) -- Miles from the mouth of a river to a specific destination or, for upstream tributaries, from the confluence with the main river to a specific destination.
River Reach -- Any defined length of a river.
River Stage -- The elevation of the water surface at a specified station above some arbitrary zero datum (level).
Riverine -- Relating to, formed by, or resembling a river including tributaries, streams, brooks, etc.
Riverine habitat -- The aquatic habitat within streams and rivers.
Rock -- See cobble.
Rootwad -- The mass of roots associated with a tree adjacent or in a stream that provides refuge and nutrients for fish and other aquatic life.
Run (in stream or river) -- A reach of stream characterized by fast flowing low turbulence water.
Runoff -- Water that flows over the ground and reaches a stream as a result of rainfall or snowmelt.

S

Salmonid -- Fish of the family Salmonidae, that includes salmon and steelhead.
Sand -- Small substrate particles, generally referring to particles less than 2 mm in diameter. Sand is larger than silt and smaller than cobble or rubble.
Scour -- The erosive action of running water in streams, which excavates and carries away material from the bed and banks. Scour may occur in both earth and solid rock material.
Secchi Depth -- A relatively crude measurement of the turbidity (cloudiness) of surface water. The depth at which a Secchi Disc (Disk), which is about 10-12 inches in diameter and on which is a black and white pattern, can no longer be seen.
Secchi Disc -- A circular plate, generally about 10-12 inches (25.4-30.5 cm) in diameter, used to measure the transparency or clarity of water by noting the greatest depth at which it can be visually detected. Its primary use is in the study of lakes.
Sediment -- The organic material that is transported and deposited by wind and water.
Sedimentation -- Deposition of sediment.
Self-sustaining population -- "A population that perpetuates itself, in the absence of (or despite) human intervention, without chronic decline, in its natural ecosystem. A self-sustaining population maintains itself at a level above the threshold for listing under the

Endangered Species Act. In this document, the terms ""self- sustaining"" and ""viable"" are used interchangeably."
Sensitive species -- Those species that (1) have appeared in the Federal Register as proposed for classification and are under consideration for official listing as endangered or threatened species or (2) are on an official state list or (3) are recognized by the U.S. Forest Service or other management agency as needing special management to prevent their being placed on federal or state lists.
Seral Stage: Refers to the age and type of vegetation that develops from the stage of bare ground to the climax stage.
Seral Stage - Early: The period from bare ground to initial crown closure (grass, shrubs, forbs, brush).
Seral Stage - Mid: The period of a forest stand from crown closure to marketability (young stand of trees from 25 to 100 years of age, includes hardwood stands).
Seral Stage - Late: The period of a forest stand from marketability to the culmination of the mean annual increment (mature stands of conifers and old-growth).
Shear Stress: The erosive energy associated with flowing water.
Silt -- Substrate particles smaller than sand and larger than clay.
Siltation -- The deposition or accumulation of fine soil particles.
Silviculture -- The science and practice of controlling the establishment, composition, and growth of the vegetation of forest stands.
Sinuosity -- The amount of bending, winding and curving in a stream or river.
Site Potential: Physical and biological conditions that are at maximum potential, taking into account local natural environmental constraints and conditions.
Slope -- The side of a hill or mountain, the inclined face of a cutting, canal or embankment or an inclination from the horizontal.
Slope stability -- The resistance of a natural or artificial slope or other inclined surface to failure by landsliding (mass movement).
Slough -- A shallow backwater inlet that is commonly exposed at low tide.
Sluiceway -- An open channel inside a dam designed to collect and divert ice and trash in the river (e.g., logs) before they get into the turbine units and cause damage. (On several of the Columbia River dams, ice and trash sluiceways are being used as, or converted into, fish bypass systems.)
Smolt -- Refers to the salmonid or trout developmental life stage between parr and adult, when the juvenile is at least one year old and has adapted to the marine environment.
Snag -- Any standing dead, partially dead, or defective (cull) tree at least 10 inches in diameter at breast height and at least 6 feet tall.
Soft Water -- Water that contains low concentrations of metal ions such as calcium and magnesium. This type of water does not precipitate soaps and detergents. Compare to Hard Water.
Soil Compaction: Activities/processes, vibration, loading, pressure, that decrease the porosity of soils by increasing the soil bulk density $\left(\frac{\text{Weight}}{\text{UnitVolume}}\right)$.
Spawn -- The act of reproduction of fishes. The mixing of the sperm of a male fish and the eggs of a female fish.
Spawning surveys -- Spawning surveys utilize counts of redds and fish carcasses to estimate spawner escapement and identify habitat being used by spawning fish. Annual surveys can be used to compare the relative magnitude of spawning activity between years.
Species -- A group of closely related individuals that can interbreed and produce fertile offspring.
Spill -- Releasing water through the spillway rather than through the turbine units.
Spillway -- "The channel or passageway around or over a dam through which excess water is released or ""spilled"" past the dam without going through the turbines. A spillway is a safety valve for a dam and, as such, must be capable of discharging major floods without damaging the dam, while maintaining the reservoir level below some predetermined maximum level."
Standard Deviation (σ): The measure of how widely values are dispersed from the mean (μ).

$$\sigma = \sqrt{\frac{n \cdot \sum x^2 - \left(\sum x\right)^2}{n \cdot (n-1)}}.$$

Standardization -- The procedure of maintaining methods and equipment as constant as possible.
State water management agencies -- State government agencies that regulate water resources. They include the Idaho Department of Water Resources; the Montana Department of Natural Resources and Conservation; the Oregon Water Resources Department; and the Washington Department of Ecology.
Steelhead -- The anadromous form of the species Oncorhynchus mykiss. Anadromous fish spend their early life history in fresh water, then migrate to salt water, where they may spend up to several years before returning to fresh water to spawn. Rainbow trout is the nonanadromous form of Oncorhynchus mykiss.
Stock -- A specific population of fish spawning in a particular stream during a particular season.
Stock status -- The current condition of a stock, which may be based on escapement, run size, survival, or fitness level.
Stone -- Rock fragments larger than 25.4 cm (10 inches) but less than 60.4 cm (24 inches).
Stream -- A general term for a body of flowing water; natural water course containing water at least part of the year. In Hydrology, the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, as in the term Stream Gaging, it is applied to the water flowing in any channel, natural or artificial.
Stream Bank Erosion: Detachment, entrainment, and transport of stream bank soil particles via fluvial processes (i.e. local water velocity and shear stress).
Stream Bank Failure: Gravity related collapse of the stream bank by mass movement.

Stream Bank Retreat: The net loss of stream bank material and a corresponding widening of the stream channel that accompanies stream bank erosion and/or stream bank failure.
Stream Bank Stability: Measure of detachment, entrainment, and transport of stream bank soil particles by local water velocity and shear stress.
Stream Channel -- The bed where a natural stream of water runs or may run; the long narrow depression shaped by the concentrated flow of a stream and covered continuously or periodically by water.
Stream gradient -- A general slope or rate of change in vertical elevation per unit of horizontal distance of the water surface of a flowing stream.
Stream morphology -- The form and structure of streams.
Stream order -- A hydrologic system of stream classification. Each small unbranched tributary is a first order stream. Two first order streams join to make a second order stream. A third order stream has only first and second order tributaries, and so forth.
Stream reach -- An individual first order stream or a segment of another stream that has beginning and ending points at a stream confluence. Reach end points are normally designated where a tributary confluence changes the channel character or order.
Stream type -- Stream-type chinook salmon populations emigrate to the ocean as one- and two-year-old smolts. As juveniles, stream-type fish exhibit behavioral and morphological characteristics consistent with establishing and maintaining territories in freshwater systems (aggressive behavior, and larger, more colorful, fins). Little is known about the oceanic migration patterns of stream-type chinook salmon.
Streambank erosion -- The wearing away of streambanks by flowing water.
Streambank stabilization -- Natural geological tendency for a stream to mold its banks to conform with the channel of least resistance to flow. Also the lining of streambanks with riprap, matting, etc., to control erosion.
Streambed -- The channel through which a natural stream of water runs or used to run, as a dry streambed.
Streamflow -- The rate at which water passes a given point in a stream or river, usually expressed in cubic feet per second (cfs).
Sub-Lethal Limit: Temperature levels that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supplies, and increased competition from warm water tolerant species.
Sub-basin -- Major tributaries to and segments of the Columbia and Snake rivers.
Subdrainage -- A land area (basin) bounded by ridges or similar topographic features, encompassing only part of a watershed, and enclosing on the order of 5,000 acres; smaller than, and part of, a watershed.
Substrate -- The composition of a streambed, including either mineral or organic materials.
Succession -- A series of dynamic changes by which one group of organisms succeeds another through stages leading to potential natural community or climax.
Surface erosion -- The detachment and transport of soil particles by wind, water, or gravity. Or a groups of processes whereby soil materials are removed by running water, waves and currents, moving ice, or wind.
Surface Water -- All waters whose surface is naturally exposed to the atmosphere, for example, rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc., and all springs, wells, or other collectors directly influenced by surface water.
Surrogate Measures (Load Allocation): A term referenced in the Clean Water Act that refers to "other appropriate measures" that can be allocated to meet an established and accepted pollutant loading capacity.
Survival Rate -- Number of fish alive after a specified time interval, divided by the initial number. Usually on a yearly basis.
Suspended sediment -- Sediment suspended in a fluid by the upward components of turbulent currents, moving ice, or wind.

T

Take -- Under the Endangered Species Act, take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect an animal, or to attempt to engage in any such conduct.
Temperature Limited Waterbody: Refers to a stream or river that has been placed on the §303(d) list for violating water quality numeric criteria based on measured data.
Tempertaure Statistic: The maximum seasonal seven (7) day moving average of the daily maximum stream tempertaures.
Thalweg -- (1) The lowest thread along the axial part of a valley or stream channel. (2) A subsurface, ground-water stream percolating beneath and in the general direction of a surface stream course or valley. (3) The middle, chief, or deepest part of a navigable channel or waterway.
Thermocline -- That layer of water in a lake in which the temperature changes 10C with each meter increase in depth.
Threatened Species: Species that are likely to become endangered through their normal range within the foreseeable future.
Threatened waterbody: Any waterbody of the United States that currently attains water quality standards (designated uses, numeric and narrative criteria and antidegradation requirements defined at 40 CFR 131), but for which existing and readily available data and information on adverse declining trends or anticipated load measures indicate that water quality standards will likely be exceeded by the time the next list is required to be submitted to EPA.
Total Maximum Daily Load (TMDL): TMDLs are written plans and analyses established to ensure that the waterbody will attain and maintain water quality standards. The OAR definition is "The sum of the individual WLAs for point sources and LAs for non-point sources and background. If a receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any non-point

sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. If Best Management Practices (BMPs) or other non-point source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for non-point source control tradeoffs" (340-04l-006(21))
Torrent -- (1) A turbulent, swift-flowing stream. (2) A heavy downpour; a deluge.
Toxic Materials -- Any liquid, gaseous, or solid substance or substances in a concentration which, when applied to, discharged to, or deposited in water or another medium may exert a poisonous effect detrimental to people or to the propagation, cultivation, or conservation of animals, or other aquatic life.
Travel corridors -- Paths animals use during their migrations.
Trend -- (1) A statistical term referring to the direction or rate of increase or decrease in magnitude of the individual members of a time series of data when random fluctuations of individual members are disregarded. (2) A unidirectional increasing or decreasing change in the average value of a variable.
Tributary -- A stream that flows into another stream, river, or lake.
Turbidity -- "The term ""turbid"" is applied to waters containing suspended matter that interferes with the passage of light through the water or in which visual depth is restricted."

U

Urban runoff -- Storm water from city streets and gutters that usually contains a great deal of litter and organic and bacterial wastes into the sewer systems and receiving waters.

V

Velocity -- In this concept, the speed of water flowing in a watercourse, such as a river.
Viscosity -- A measure of the resistance of a fluid to flow. For liquids, viscosity increases with decreasing temperature.

W

Warmwater fish -- A broad classification on non-salmonid fish that generally have at least one spiny ray, have pelvic and pectoral fins located behind the gills, and are usually suited for water that consistently exceeds 70 degrees F.
Wash -- (1) To carry, erode, remove, or destroy by the action of moving water. To be carried away, removed, or drawn by the action of water. Removal or erosion of soil by the action of moving water. (2) A deposit of recently eroded debris. (3) Low or marshy ground washed by tidal waters. A stretch of shallow water. (4) (Western United States) The dry bed of a stream, articularly a watercourse associated with an alluvial fan, stream, or river channel. Washes are often associated with arid environments and are characterized by large, high energy discharges with high bed-material load transport. Washes are often intermittent and their beds sparsely vegetated. (5) Turbulence in air or water caused by the motion or action of an oar, propeller, jet, or airfoil.
Washout -- (1) Erosion of a relatively soft surface, such as a roadbed, by a sudden gush of water, as from a downpour or floods. (2) A channel produced by such erosion.
Wasteload Allocation (WLA): A term referenced in the Clean Water Act that refers to point source rates of pollutant delivery that can be specifically linked to an established and accepted pollutant loading capacity.
Wasteway -- An open ditch or canal that discharges excess irrigation water or power plant effluent into the river channel.
Water Conservation -- The physical control, protection, management, and use of water resources in such a way as to maintain crop, grazing, and forest lands, vegetative cover, wildlife, and wildlife habitat for maximum sustained benefits to people, agriculture, industry, commerce, and other segments of the national economy.
Water Pollution -- Generally, the presence in water of enough harmful or objectionable material to damage the water's quality.
Water quality -- A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water Quality Limited: Can mean one of the following categories: (a) A receiving stream which does not meet in-stream water quality standards during the entire year or defined season even after the implementation of standard technology; (b) A receiving stream which achieves and is expected to continue to achieve in-stream water quality standard but utilizes higher than standard technology to protect beneficial uses; (c) A receiving stream for which there is insufficient information to determine if water quality standards are being met with higher than standard treatment technology or where through professional judgment the receiving stream would not be expected to meet water quality standards during the entire year or defined season without higher than standard technology. (OAR 340-04l-006(30))
Water Resources -- The supply of groundwater and surface water in a given area.

Water rights -- "Priority claims to water. In western States, water rights are based on the principle ""first in time, first in right,"" meaning older claims take precedence over newer ones."
Water yield -- The quantity of water derived from a unit area of watershed.
Waterfall -- A sudden, nearly vertical drop in a stream, as it flows over rock.
Watershed restoration -- Improving current conditions of watersheds to restore degraded fish habitat and provide long-term protection to aquatic and riparian resources.
Watt -- A measure of the rate at which energy is produced, exchanged, or consumed.
Wet meadow -- Areas where grass predominate. Normally waterlogged within a few inches of the ground surface.
Width:Depth Ratio: The width of bankfull divided by the average depth in the survey reach of a stream.
Wildfall -- Trees or parts of trees felled by high winds.
Windthrow -- A tree or trees uprooted or felled by the wind.
Woody debris -- Referring to wood in streams.

Acronym List

BLM – Bureau of Land Management

CFR - Code of Federal Regulations

cfs - cubic feet per second

CSRI - Coastal Salmon Restoration Initiative

CWA - Clean Water Act

DBH - Diameter at Breast Height

DEM - Digital Elevation Model

DEQ - Department of Environmental Quality (Oregon)

DOQ - Digital Orthophoto Quad

DOQQ - Digital Orthophoto Quarter Quad

EPA - (United States) Environmental Protection Agency

EQC - Environmental Quality Commission

FLIR - Forward Looking Infrared Radiometry

FPA - Forest Practices Act

GPS - Geographic Positioning System

HUC - Hydrologic Unit Code

LA - Load Allocation

LC - Loading Capacity

MOS - Margin of Safety

NPDES - National Pollutant Discharge Elimination Program

NSDZ - Near-Stream Disturbance Zone

NTU - Nephelometric Turbidity Units

OAR - Oregon Administrative Rules

ODA - Oregon Department of Agriculture

ODEQ - Oregon Department of Environmental Quality

ODF - Oregon Department of Forestry

ODFW - Oregon Department of Fish and Wildlife

ORS - Oregon Revised Statutes

OWRD - Oregon Water Resources Department

RM - River Mile

SE - Standard Error

SSCGIS - State Service Center for Geographic Information Systems

TMDL - Total Maximum Daily Load

TSS - Total Suspended Solids

USBR (US BOR) - United States Bureau of Reclamation

USDA - United States Department of Agriculture

USFS - United States Forest Service

USGS - United States Geological Survey

W:D - Width to Depth (ratio)

WLA - Waste Load Allocation

WQMP - Water Quality Management Plan

WQS - Water Quality Standard

WWTP - Waste Water Treatment Plant

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