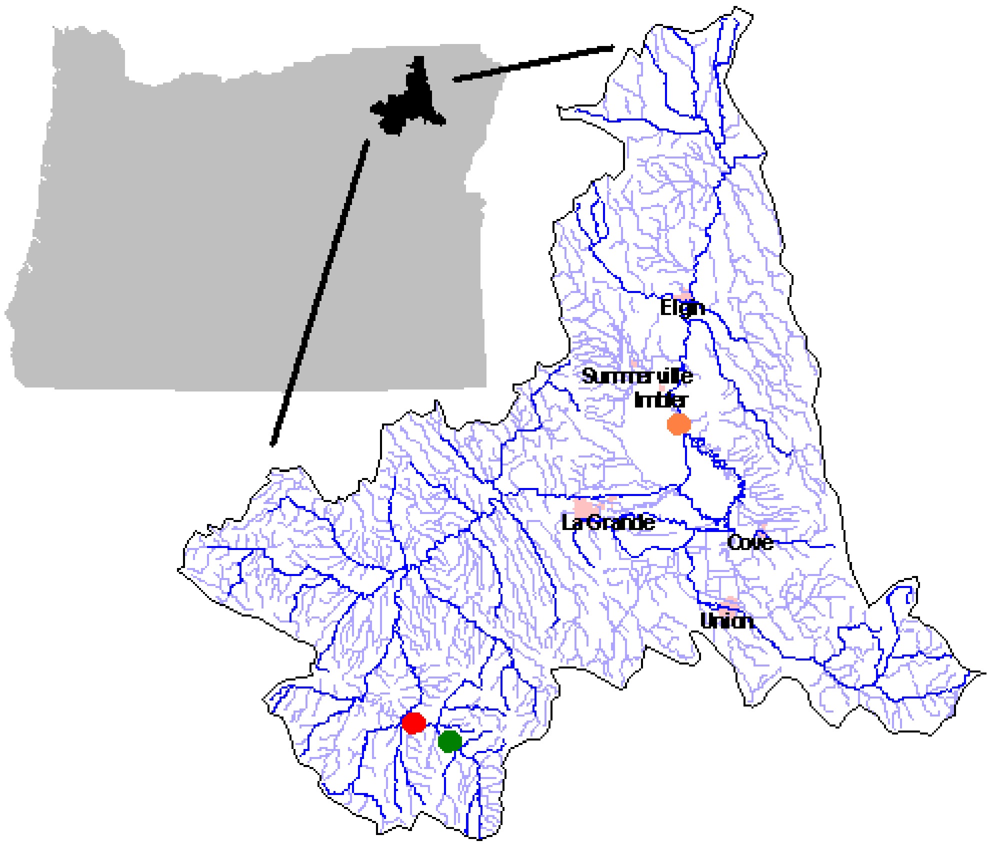
UPPER GRANDE RONDE RIVER SUB-BASIN

TOTAL MAXIMUM DAILY LOAD (TMDL)



Oregon Department of Environmental Quality

April, 2000

Page Left Blank Intentionally

We descend a very steep hill in coming into Grande Ronde, at the foot of which is a beautiful cluster of pitch and spruce pine trees, but no white pine like that I have been accustomed to see at home. Grande Ronde is indeed a beautiful place. It is a circular plain, surrounded by lofty mountains, and has a beautiful stream coursing through it, skirted with quite large timber. The scenery while passing through it is quite delightful in some places. We nooned upon Grande Ronde river.

-The Letters and Journals of Narcissa Whitman

August 28th, 1836

Page Left Blank Intentionally

Date: April 24, 2000
To: Interested Parties
Subject: Upper Grande Ronde River Sub-Basin Total Maximum Daily Load (TMDL) & Water Quality Management Plan (WQMP)

The Upper Grande Ronde River Sub-Basin includes all lands draining to the Grande Ronde River upstream of its confluence with the Wallowa River. Many of these streams do not meet state water quality standards. As a result, a Total Maximum Daily Load (TMDL) and a Water Quality Management Plan (WQMP) have been developed and submitted to EPA. The TMDL sets targets for attaining water quality standards and the WQMP outlines the management steps necessary to attain TMDL targets. To be properly understood, the documents should be reviewed together.

Total Maximum Daily Load (TMDL)

The TMDL analyzes the factors affecting water quality and identifies the amount of pollution that can be present without causing state water quality standards to be violated. The standards of concern include stream temperature, dissolved oxygen, and pH. The pollutants responsible for these water quality problems include excess heat, nutrients and sediments that enter the streams as a result of human induced changes to streamside vegetation and stream channel changes. The TMDL establishes targets (allocations) for reducing these pollutants so that water quality standards can be achieved. DEQ scientists, with the assistance of technical specialists from a variety of agencies produced the TMDL as required by the federal Clean Water Act.

Water Quality Management Plan (WQMP)

The WQMP report describes the actions that will be taken to reduce the pollutant loads identified in the TMDL. A local group, the Grande Ronde Water Quality Committee, produced the WQMP. This committee included representatives of “stakeholder” groups from within the Upper Grande Ronde Sub-Basin. Representation included forestry, agriculture, local government, transportation, environmental interests, business, and tribal. The committee, appointed jointly by DEQ and The Grande Ronde Model Watershed Program, identified priorities for management categories that will be implemented to improve water quality. The highest priorities included improving riparian vegetation, in-stream flow, and stream channel characteristics. Management measures are identified for point sources and for four categories of nonpoint sources: transportation, municipal, forestry and agriculture. Implementation of the plan, including periodic reviews and revisions, is expected to lead to attainment of the water quality standards. The DEQ would like to thank the committee for two years of precedent-setting cooperation in developing the WQMP.

Public Review

A formal public comment period on the draft TMDL and WQMP was opened on December 10, 1999. There was considerable press coverage throughout the development of the TMDL and WQMP as well as during the comment period. A public information open house was held on January 13, 2000. A formal public hearing was held on February 2, 2000. The close of the public comment period was March 3, 2000. The Department received written and oral comments from 37 individuals or organizations. The Department carefully considered all comments and questions and made appropriate revisions to the draft TMDL and WQMP prior to finalizing the documents. The Response to Comment document is available from DEQ.

Page Left Blank Intentionally

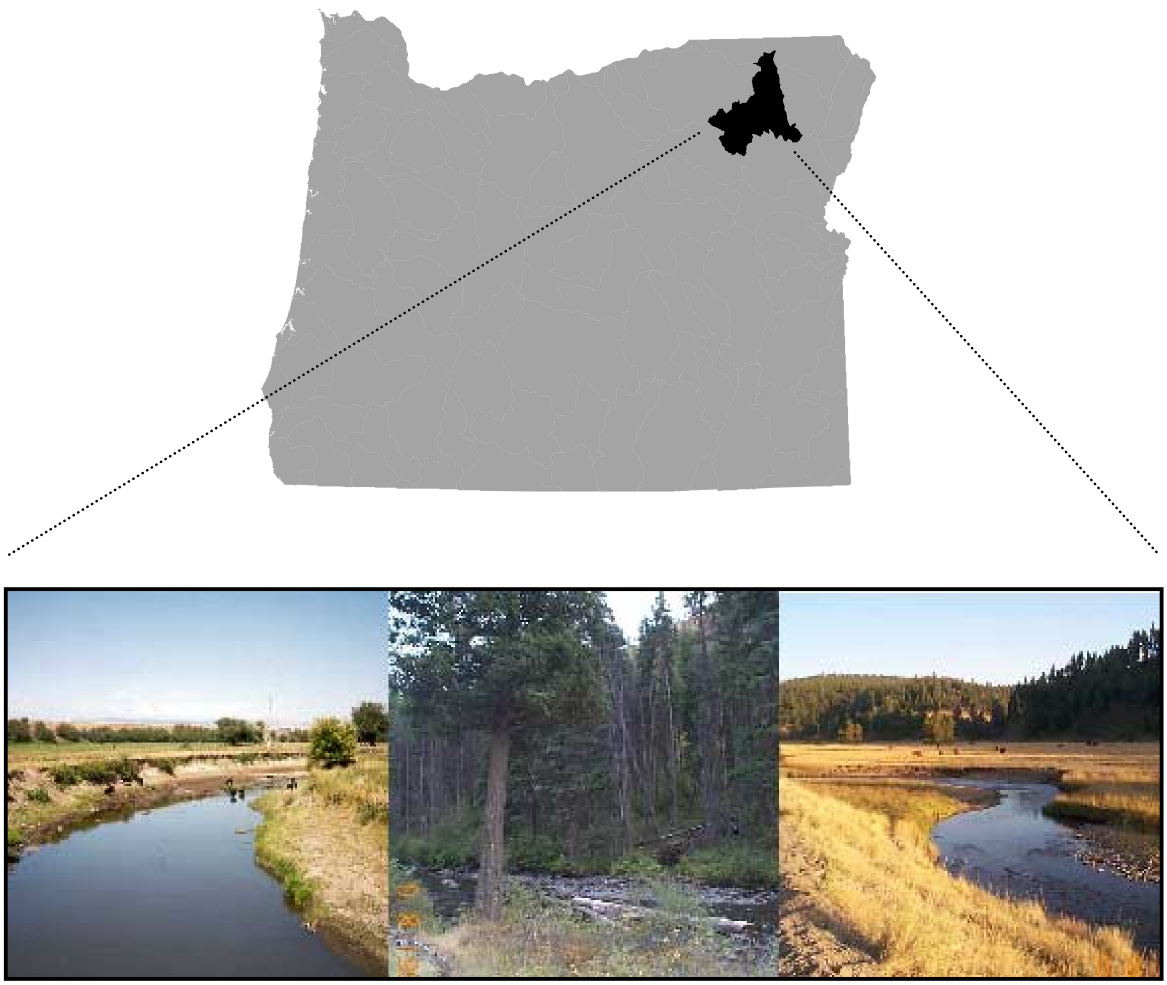
UPPER GRANDE RONDE RIVER SUB-BASIN

TOTAL MAXIMUM DAILY LOAD (TMDL)

Prepared by:

Oregon Department of Environmental Quality

April 2000



Page Left Blank Intentionally

Upper Grande Ronde Sub-Basin Total Maximum Daily Load (TMDL)

Table of Contents

Table 1. Upper Grande Ronde Sub-Basin TMDL Components	
State/Tribe: Oregon Waterbody Name(s): Perennial streams within the 4th field HUC (hydrologic unit code) 17060104. Point Source TMDL: X Nonpoint Source TMDL: X (check one or both) Date: 11/22/99	
Component	***Comments***
Pollutant Identification	*Pollutants:* Radiant Heat Energy (Temperature) and Nutrients (DO/pH) *Anthropogenic Contribution:* Increased Radiant Energy and Nutrient Input
Target Identification *CWA 303(d)(1)* *40 CFR 130.2(f)*	*Applicable Water Quality Standards*: see Appendix D *Loading Capacities* *Temperature:* No increases in radiant energy above site potentials and maximum discharge temperatures listed in **Table 15**. *Nutrient/pH/Dissolved Oxygen*: Instream nutrient concentrations listed in **Tables 18**, **19, 20,** and **21**.
Existing Sources *CWA 303(d)(1)*	Forestry, Agriculture, Transportation, Rural Residential, Urban, Industrial Discharge, Waste Water Treatment Facilities
Seasonal Variation *CWA 303(d)(1)*	*Temperature*: Peak temperatures occur throughout June to October *pH*: Peak pH values occur during July, August and September *Dissolved Oxygen*: Lowest dissolved oxygen values occur during July, August and September
TMDL Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Temperature* *Waste Load Allocations (Point Sources)*: No measurable increase over site potential water temperatures. *Load Allocations (Background/Non-Point Sources)*: 100% of Loading Capacity allocated to natural sources. *Nutrient/pH/Dissolved Oxygen* *Waste Load Allocations (Point Sources)*: Listed orthophosphate and dissolved inorganic nitrogen reductions (see Wasteload Allocations for Point Sources, pages 28-31) *Load Allocations (Background/Non-Point Sources)*: Percent reduction in instream nutrient concentrations listed in **Tables 19**, **20, 21** and **22**.
Margins of Safety *CWA 303(d)(1)*	*Temperature*: Margins of Safety demonstrated in critical condition assumptions. *Nutrient/pH/Dissolved Oxygen:* 1. Modeling pH in addition to dissolved oxygen. Since pH was found to control the load allocations, this approach resulted in more stringent load allocations, 2. Applying 8.7 as a maximum pH standard rather than 9.0, and, 3. Ignoring potential benefits of width reductions expected for site potential conditions when establishing load allocations.
Water Quality Standard Attainment Analysis *CWA 303(d)(1)*	• Analytical modeling demonstrates that allocated loads will attain water quality standards • In areas where numeric criteria are not met, analytical assessments demonstrate that allocated loads represent a pollutant loading condition where anthropogenic contributions are minimized to the extent possible. • A Water Quality Management Plan (WQMP) is developed to implement measures that attain load/wasteload allocations.
Public Notice *40 CFR 25*	Completed by Oregon Department of Environmental Quality

Introduction

The Upper Grande Ronde sub-basin is home to productive forested and agriculture lands and has the distinction of containing streams with historically viable salmonid populations. Interactions between multiple land uses (i.e., agriculture, forestry, transportation, rural residential and urban) and imperiled salmonid fisheries in the Upper Grande Ronde sub-basin have prompted extensive data collection and study of the interaction between land use and water quality. The knowledge derived from these data collection efforts and academic study, some of which is presented in this document, will be used to design protective and enhancement strategies that address water quality issues.

This document presents a Total Maximum Daily Load (TMDL) that addresses salmonid fisheries concerns for all streams in the Upper Grande Ronde sub-basin (see **Table 1**). Water quality impairments in tributaries and mainstem reaches throughout the Upper Grande Ronde sub-basin have reduced the extent of spawning and rearing habitat for chinook salmon, steelhead trout and bull trout. Primary watershed disturbance activities contributing to increased surface water temperatures and other water quality impairments include forest disturbances within and outside the riparian zone, agricultural riparian and upland disturbances, road construction and maintenance, and rural residential and urban development near streams and rivers. As a result of water quality standards (WQS) violations, waters in the Upper Grande Ronde sub-basin are included on Oregon's 1998 § 303(d) list. Load allocations associated with this TMDL are designed to reduce the input of pollutants into streams.

Several agencies have developed management strategies for the Upper Grande Ronde sub-basin. Water quality management plans (WQMPs) have been developed for forested, agricultural and urban lands that address both non-point and point sources of pollution. This TMDL builds upon the current land management programs in the Upper Grande Ronde sub-basin, and will be the basis for the development and/or alteration of water quality management efforts, including:

- ✓ Oregon's Forest Practices Act (state and private forest lands),
- ✓ Senate Bill 1010 (agricultural lands), and
- ✓ Oregon Plan (all lands).

This TMDL should be used to evaluate long-term improvements in water quality, in-stream physical parameters and landscape conditions that occur over time as WQMPs are implemented. Planned management practices should be evaluated in terms of their adequacy in improving water quality, meeting in-stream targets (i.e. load allocations), and protecting beneficial uses.

Existing Water Quality Programs

Oregon's Total Maximum Daily Load Program

Section 303(d) of the Federal Clean Water Act requires that a list be developed of all impaired or threatened waters within the State (§ 303(d) List). The principal agency responsible for monitoring the quality of Oregon's streams, lakes, estuaries and groundwater is the Department of Environmental Quality (ODEQ). The information collected by ODEQ, as well as other agencies, is used to determine whether water quality standards are being violated and, consequently, whether the *beneficial uses* of the waters are being threatened. *Beneficial uses* include fisheries, aquatic life, drinking water, recreation and irrigation. Applicable State and Federal laws and regulations that protect beneficial uses include the *Clean Water Act* and its applicable regulations (40 *Codified Federal Regulations* 131, **40 CFR 131**), and *Oregon's Administrative Rules* (**OAR Chapter 340**) and *Oregon's Revised Statutes* (**ORS Chapter 468**).

The State must establish a *Total Maximum Daily Load* (*TMDL)* for any waterbody designated as *water quality limited* (with a few exceptions, such as in cases where violations are due to natural causes). The term *water quality limited* is applied to streams and lakes where violations of State water quality standards occur. TMDLs are written plans and analyses established to ensure that waterbodies will attain and maintain water quality standards. TMDLs must contain the following elements: (1) identification of the pollutant and quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards; (2) identification of the amount or degree by which the pollutant load in the waterbody deviates from the target representing attainment or maintenance of water quality standards; (3) identification of source categories, source subcategories or individual sources of the pollutant for which wasteload and load allocations are being established; (4) wasteload allocations for pollutants from point sources; (5) load allocations for pollutants from non-point sources; (6) a margin of safety; (7) consideration of seasonal variation; (8) an allowance for future growth which accounts for reasonably foreseeable increases in pollutant loads; and (9) an implementation plan.

The total allowable pollutant load is allocated to point, non-point, background, and future sources of pollution. *Wasteload Allocations* are portions of the total allowable pollutant load that are allocated to point sources of pollution, such as wastewater treatment plants or industries. They are used to establish effluent limits in discharge permits. *Load allocations* are portions of the total allowable pollutant load that are allocated to non-point sources, such as agriculture or forestry activities, and natural background sources. 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 developed *allocations*.

Oregon's Forest Practices Act

The Oregon Forest Practices Act (FPA, 1994) contains regulatory provisions that include the following objectives: 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 clearly 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 allows 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. The Water Quality Management Plan should be crafted in such a way that landowners in the local area can prevent and control 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 Water Quality Management Plans on a voluntary basis. Senate Bill 1010 allows the ODA to use civil penalties when necessary to enforce against agriculture activity that is found to transgress parameters of an approved Water Quality Management Plan. The ODA has expressed a desire to work with the local stakeholders and other State and Federal agencies to formulate and enforce approved Water Quality Management Plans.

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. 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. Specifically, the Oregon Plan is designed to build on existing State and Federal water quality programs, namely: Coastal Zone Non-point Pollution Control Programs, the Northwest Forest Plan, Oregon's Forest Practices Act, Oregon's Senate Bill 1010 and Oregon's Total Maximum Daily Load Program.

Implementation and Adaptive Management Issues

a) 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 nonpoint sources are the main concern, but implementation must commence as soon as possible.

b) Total Maximum Daily Loads (TMDLs) are numerical loading that are set to limit pollutant levels such that in-stream water quality standards are met. The Department 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 and accurate prediction of how streams and other waterbodies will respond to the application of various management measures. It is for this reason that the TMDL has been established with a margin of safety.

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

d) The Department also recognizes that, despite the best and most sincere of 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.

e) In some cases in this TMDL, pollutant surrogates have been defined as alternative targets for meeting the TMDL. The purpose of the surrogates is not to bar or eliminate human access or activity in the basin or its riparian areas. It is the expectation, however, that WQMPs will address how human activities will be managed to achieve the surrogates.

f) If a nonpoint 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.

g) The Department intends to regularly review progress of WQMPs to achieve TMDLs. If and when the Department determines that WQMP 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, the Department shall reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary.

h) The implementation of TMDLs and the associated management plans is generally enforceable by the Department, 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 standards.

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

   1. Subject to available resources, on a five year basis, the Department intends to review the progress of the TMDL and the WQMP.

   2. In conducting this review, the Department will evaluate the progress towards achieving the TMDL (and water quality standards) and the success of implementing the WQMP.

   3. The Department 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.

   4. As implementation of the WQMP proceeds, DEQ expects that management agencies will develop bench marks for attainment of TMDL surrogates which can then be used to measure progress.

   5. 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.

   6. 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.

Scope

The area covered by the Upper Grande Ronde sub-basin TMDL corresponds to hydrologic unit code (HUC) 17060104, which includes all lands that drain to Grande Ronde River upstream of the confluence with the Wallowa River at Rondowa. The Upper Grande Ronde River sub-basin is approximately 1,640 square miles, bordered by the Blue Mountains to the west/northwest, the Elkhorn Range to the southwest and the Wallowa Mountains to the east/southeast. Elevations vary from 2,300 feet to 7,800 feet. Lower elevations generally receive 12 to 25 of rainfall equivalent precipitation annually. Higher elevations commonly receive up to 50 inches of annual rainfall equivalent precipitation, most of which is received as snowfall. Highest flows are associated with rain on snowpack events. Low stream flows are generally associated with a long summertime drought and complete melt of the winter received snowpack.

Land ownership in the Upper Grande Ronde sub-basin is equally divided between private and federal land, with small tracts of land owned/managed by the State of Oregon and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Total distributions of ownership/management are displayed in **Figure 1**, while spatial distributions of land ownership is displayed in **Image 1**. ***This TMDL does not apply to Confederated Tribes of the Umatilla Indian Reservation (CTUIR) lands.***

Figure 1. Land Ownership/Management Distribution

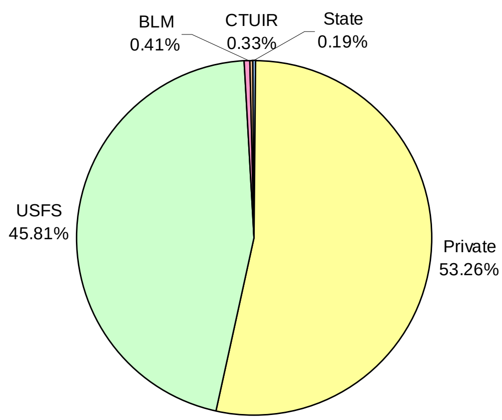
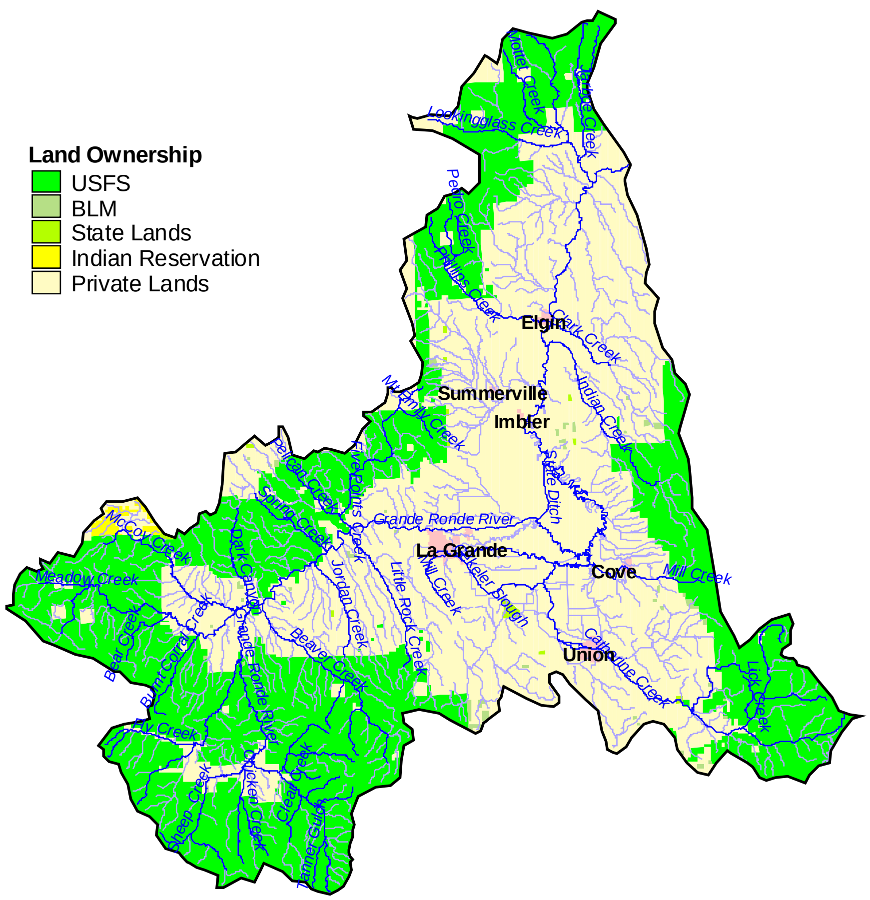


Image 1. Land Ownership/Management Spatial Distribution



Beneficial Uses

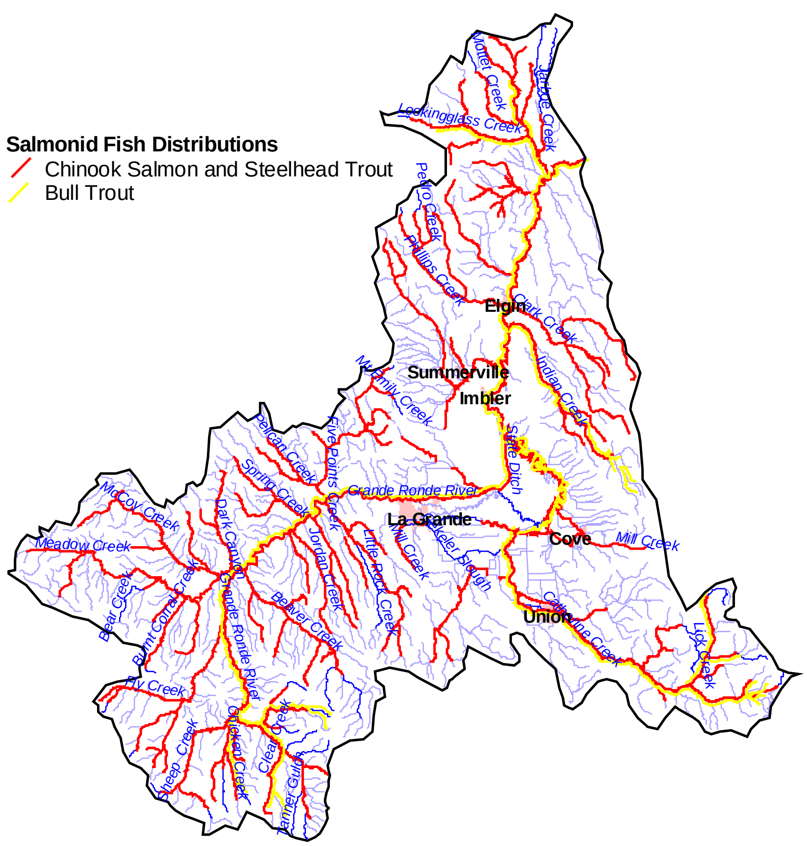
Oregon Administrative Rules (**OAR Chapter 340, Division 41, Table 13**) lists the designated beneficial uses for which water is to be protected in the Upper Grande Ronde sub-basin. Designated beneficial uses are presented in **Table 2.** (Temperature, dissolved oxygen, and pH sensitive beneficial uses are marked in gray.) Numeric and narrative water quality standards are designed to protect the most sensitive *beneficial uses*. In the Upper Grande Ronde sub-basin, resident fish and aquatic life, salmonid spawning, rearing and migration (i.e., anadromous fish passage) are designated the most sensitive *beneficial uses* (**Image 2**).

Table 2. Designated Beneficial Uses Occurring in the Upper Grande Ronde Sub-Basin *(OAR 340-41-722)*

Temperature, dissolved oxygen and pH 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	

Image 2. Sensitive Beneficial Uses – Salmonid Migration, Spawning and Rearing



Water Quality Impairments and Target Identification - *CWA 303(d)(1)*

Monitoring shows that water quality in the Upper Grande Ronde sub-basin frequently violates numeric criteria contained in State water quality standards (WQS)[1]. Applicable water quality standards for the Grande Ronde Sub-Basin are presented in **Appendix D**. Section 303(d) of the Federal Clean Water Act requires that water bodies that violate water quality standards, and thereby fail to fully protect *beneficial uses*, be identified and placed on the § 303(d) list of impaired or threatened waters. Following further assessment, the Act requires that *Total Maximum Daily Loads* (TMDL) and *Water Quality Management Plans* (WQMP) be developed and implemented to restore water quality. WQMPs must include long-term monitoring plans and adaptive management strategies to insure that water quality standards are achieved (DEQ WQMP guidance 1997). Grande Ronde sub-basin water quality parameters included in the 1998 § 303(d) list are presented below.

Temperature

Aquatic life is sensitive to water temperature. Salmonid fishes, often referred to as cold water fish, and some amphibians are 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.

The two *indicator species*, Chinook salmon and bull trout, that are referenced in Oregon's water temperature standard have, coincidentally, been allotted protection (listed) under the Endangered Species Act (ESA, 1972) in the Upper Grande Ronde sub-basin. Further, Snake River steelhead trout (*Oncorhynchus mykiss*) are listed as *threatened* in the Upper Grande Ronde sub-basin. Snake River fall and spring Chinook salmon are designated under ESA as *threatened species*.

If stream temperatures become too hot, fish die almost instantaneously due to denaturing of critical enzyme systems in their bodies (Posser, 1967; Hogan, 1970). The ultimate *instantaneous lethal limit* occurs in high temperature ranges (upper-90°F).

More common and widespread, is the occurrence of temperatures in the mid- to high- 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 a 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 and on particular development life-stages. 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). Brett (1952) reported an incipient lethal limit of 77°F (25°C) for spring Chinook salmon. Similarly, Bell (1986) reported an incipient lethal limit for Chinook salmon of 77°F (25°C). The Environmental Protection Agency (EPA) and National Marine Fisheries Service (NMFS) reported 50% mortality to adult salmon and steelhead trout with a constant water temperature of 70°F (21°C).

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 fungi), 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 3** summarizes the modes of cold water fish mortality.

---

[1] For detailed analytical information pertaining to Upper Grande Ronde sub-basin water temperatures, see **Appendix A**.

Table 3. 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 to 77°F 21°C to 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 to 74°F 20°C to 23°C	Weeks to Months

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 indication of water quality standard compliance. Unless specifically allowed under a Department-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 (see **Appendix D**). The numeric criteria adopted in Oregon's water temperature standard rely on the biological temperature limitations considering sensitive *indicator species* is presented in **Table 3**. 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°F standard. Specifically for the Grande Ronde Basin OAR states at 340-041-0725:

(A) To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-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:***

(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 waters and periods of the year determined by the Department 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);

(iii) In waters determined by the Department 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);

(iv) In waters determined by the Department to be ecologically significant cold-water refugia;

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

(vi) 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 subbasin;

(vii) In natural lakes.

As a result of water quality standards (WQS) exceedances for temperature, thirty-eight stream segments in the Upper Grande Ronde sub-basin are included on Oregon's 1998 § 303(d) list. **Image 3** displays 1998 § 303(d) listed stream segments for temperature violations, while **Table 4** lists the reaches § 303(d) listed for temperature and the applicable criterion that is exceeded. In addition, this TMDL addresses potential water quality impairment for streams within the Upper Grande Ronde River sub-basin that are not currently on Oregon's 1998 § 303(d) list.

Image 3. 1998 § 303(d) Listings for Temperature

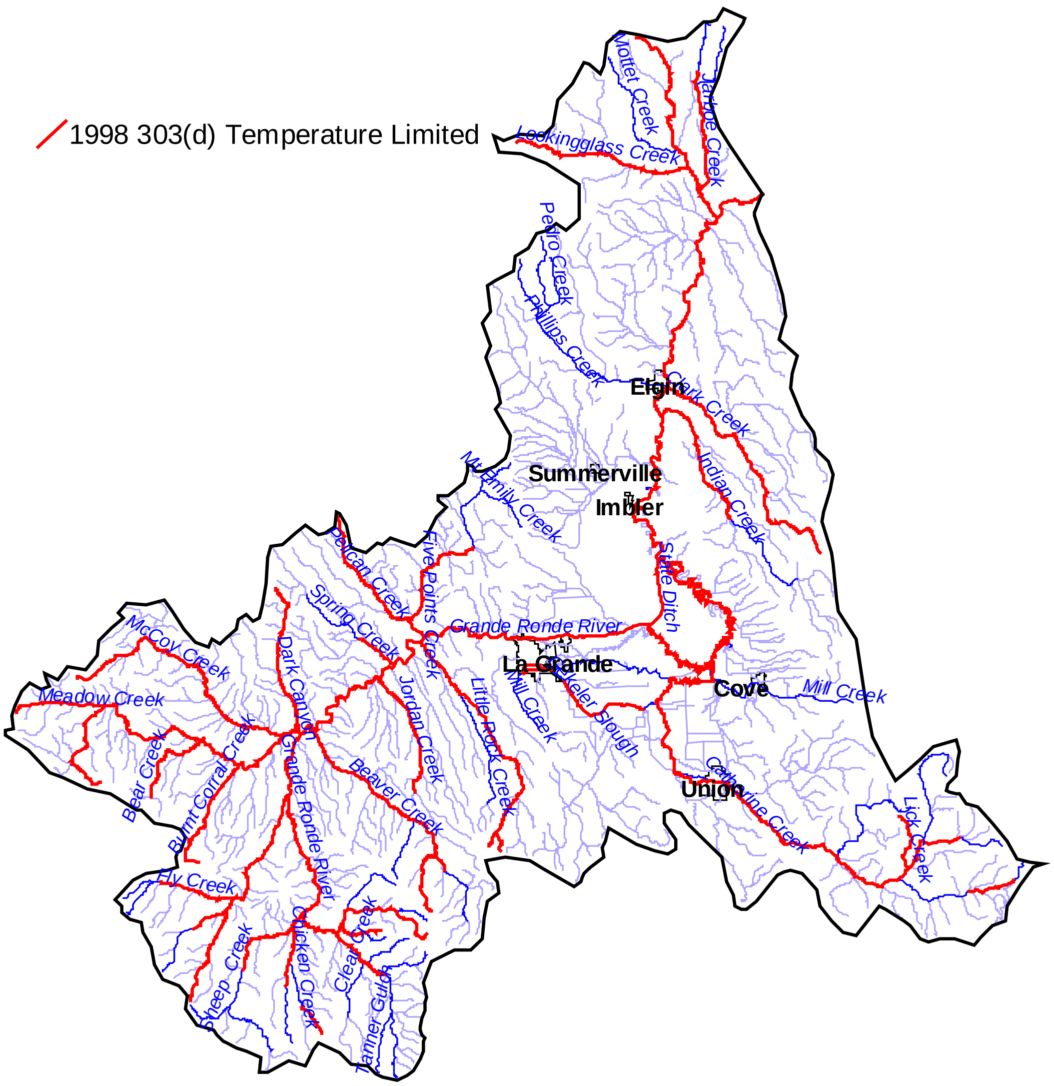


Table 4. 1998 § 303(d) Listed Segments and Applicable Numeric Criterion
OAR 340-41-725(2)(b)(A)

Time Period:
- Rearing: July 1 through September 30
- Spawning Through Fry Emergence: October 1 through June 30 or waterbody specified as identified by ODFW biologist.

Supporting Data:
- ODEQ (1991 – 1998)
- USFS (1992 – 1998)

Stream	***Segment***	***Criterion***
Bear Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Beaver Cr.	Mouth to La Grande Reservoir	Rearing 64°F (17.8°C)
Burnt Corral Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Catherine Cr.	Mouth to Union Dam	Rearing 64°F (17.8°C)
Catherine Cr.	Union Dam to N.F./S.F. Catherine Cr.	Oregon Bull Trout 50°F (10°C)
Catherine Cr., M.F.	Mouth to Squaw Cr.	Oregon Bull Trout 50°F (10°C)
Catherine Cr., N.F.	Mouth to M.F. Catherine Cr.	Oregon Bull Trout 50°F (10°C)
Catherine Cr., S.F.	Pole Cr. to S. Catherine Ditch Diversion	Oregon Bull Trout 50°F (10°C)
Chicken Cr.	Mouth to West Chicken Cr.	Rearing 64°F (17.8°C)
Chicken Cr., West	Mouth to end of meadow in Section 15	Rearing 64°F (17.8°C)
Clark Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Dark Canyon Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Fivepoints Cr.	Mouth to Tie Cr.	Rearing 64°F (17.8°C)
Fly Cr.	Mouth to Umapine Cr.	Rearing 64°F (17.8°C)
Fly Cr., Little	Mouth to Headwater	Rearing 64°F (17.8°C)
Grande Ronde R.	Limber Jim Cr. To Clear Cr.	Oregon Bull Trout 50°F (10°C)
Grande Ronde R.	Wallowa R to Five Points Cr.	Rearing 64°F (17.8°C)
Grande Ronde R.	Five Points Cr. to Limber Jim Cr.	Rearing 64°F (17.8°C)
Indian Cr.	Mouth to Little Indian Cr.	Rearing 64°F (17.8°C)
Indiana Cr.	Mouth to Headwaters	Oregon Bull Trout 50°F (10°C)
Jarboe Cr.	Mouth to FSR 6413	Rearing 64°F (17.8°C)
Lick Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Limber Jim Cr.	Mouth to Marion Cr.	Rearing 64°F (17.8°C)
Limber Jim Cr.	Marion Cr. to Headwaters	Oregon Bull Trout 50°F (10°C)
Limber Jim Cr., S.F.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Lookingglass Cr.	Mouth to Luger Springs (RM 7)	Oregon Bull Trout 50°F (10°C)
Lookingglass Cr., Little	Mouth to Headwaters	Oregon Bull Trout 50°F (10°C)
Lookout Cr.	Mouth to Forest Boundary at Section 35	Rearing 64°F (17.8°C)
McCoy Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Meadow Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Mill Cr. (La Grande)	Mouth to La Grande City Limits	Rearing 64°F (17.8°C)
Pelican Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Rock Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)
Sheep Cr.	Mouth to Warm Mineral Springs	Rearing 64°F (17.8°C)
Sheep Cr., E.F.	Mouth to headwaters	Rearing 64°F (17.8°C)
Spring Cr.	Mouth to South Fork	Rearing 64°F (17.8°C)
State Ditch	Mouth to Headwaters	Rearing 64°F (17.8°C)
Waucup Cr.	Mouth to Headwaters	Rearing 64°F (17.8°C)

Dissolved Oxygen and pH

The Grande Ronde River and Catherine and Meadow Creeks experience dissolved oxygen and pH water quality standards violations related to excessive periphyton growth. The excessive growth is due to a number of factors including elevated nutrient concentrations, high water temperatures, excessive solar radiation, high width to depth ratios, and inadequate stream flow rates. This excessive periphyton activity causes large diel dissolved oxygen and pH fluctuations which result in dissolved oxygen standards violations at night and pH standards violations during the day.

For **dissolved oxygen**, the applicable standard depends on whether the most sensitive species present are cold water (salmonid) or cool water (non-salmonid) species and on whether salmonid spawning and egg incubation occurs. Waterbodies identified as providing for cold-water aquatic life are those in which salmon, trout, cold-water invertebrates, and other native cold-water species exist throughout all or most of the year (OAR 340-41-455 Table 21) and in which juvenile anadromous salmonids may rear throughout the year. All reaches in the upper Grande Ronde sub-basin have been identified as providing for cold-water aquatic life at all times of the year and for salmonid spawning and egg incubation during the fall, winter and spring months from October 1 through June 30.

For time periods identified as providing for salmonid spawning and egg incubation, the applicable water column standard is 95% of saturation. For a 3000 ft. elevation, which is roughly the average elevation of the reaches modeled, 95% saturation at $10^{o}C$ (bull trout temperature criteria) is 9.7 mg/L and at $12.8^{o}C$ (salmonid spawning temperature criteria) is 9.1 mg/L.

For reaches and time periods identified as providing for cold water aquatic life, including salmonids (other than during spawning and egg incubation), two sets of standards are specified:

1) 8.0 mg/L as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of 8.0 mg/L, dissolved oxygen shall not be less than 90% of saturation. This set of standards applies when only limited data is available.

2) 8.0 mg/L as a minimum 30-day average, 6.5 mg/L as a minimum 7-day average of the daily minimums, and 6.0 mg/L as an absolute minimum. This set of standards applies at the discretion of the Department when the Department determines that adequate information exists.

Due to the large amount of continuous monitoring data available in the Upper Grande Ronde sub-basin, the second set of standards has been applied.

For **pH**, Oregon Administrative Rule specifies that the pH ($-\log_{10}\{H^{+}\}$) shall not fall outside of the range 6.5 to 9.0. The OAR further requires that when greater than 25% of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin.

In order to provide for additional margins of safety when establishing load allocations, targets for dissolved oxygen and pH have been set to levels more stringent than the standards require**.** For dissolved oxygen, targets for non-salmonid spawning periods have been set to 6.5 mg/L as an absolute minimum (rather than as a 7-day average of the daily minimums) and 8.0 mg/L as a minimum 30-day average. For spawning periods, the 95% of saturation criterion has been applied. For pH, targets have been set to 8.7 as an absolute maximum, and 6.5 as an absolute minimum.

Tables 5 through **12** and **Images 4** through **11** display reaches in the sub-basin included in the 1998 § 303(d) list for violating water quality standards. Stream segments included in the § 303(d) list for dissolved oxygen violations are displayed in **Image 6** and **Table 7**. Those listed for pH violations are displayed in **Image 10** and **Table 11**.

Aquatic Weeds or Algae

Table 5. Segments on the 1998 §303(d) List for Aquatic Weeds or Algae

Waterbody Name	Boundaries
Catherine Creek	Mouth to Union Dam
Grande Ronde River	Wallowa R to Five Points Cr
State Ditch	Mouth to Headwaters

Bacteria

Table 6. Segments on the 1998 §303(d) List for Bacteria

Waterbody Name	Boundaries
Grande Ronde River	Wallowa R to Five Points Cr

Dissolved Oxygen (DO)

Table 7. Segments on the 1998 §303(d) List for Dissolved Oxygen (DO)

Waterbody Name	Boundaries
Catherine Creek	Mouth to Union Dam
Grande Ronde River	Wallowa R to Five Points Cr

Flow Modification

Table 8. Segments on the 1998 §303(d) List for Flow Modification

Waterbody Name	Boundaries
Catherine Creek	Mouth to Union Dam
Grande Ronde River	Wallowa R to Five Points Cr
State Ditch	Mouth to Headwaters

Habitat Modification

Table 9. Segments on the 1998 §303(d) List for Habitat Modification

Waterbody Name	Boundaries
Catherine Creek	Mouth to Union Dam
Chicken Creek	Mouth to West Chicken Creek
Dark Canyon Creek	Mouth to Headwaters
Fly Creek	Mouth to Umapine Creek
Grande Ronde River	Wallowa R to Five Points Cr
Grande Ronde River	Five Points Cr to Tanner Gulch
Grande Ronde River	Tanner Gulch to Headwaters
Jordan Creek	Mouth to National Forest Boundary
Limber Jim Creek	Mouth to North Fork
Little Fly Creek	Mouth to Headwater
Little Lookingglass Creek	Mouth to Headwaters
Lookingglass Creek	Mouth to Headwaters
McCoy Creek	Mouth to Headwaters
McIntyre Creek	Mouth to Headwaters
Meadow Creek	Mouth to Headwaters
Rock Creek	Mouth to Headwaters
Sheep Creek	Mouth to Warm Mineral Springs
Sheep Creek	Warm Mineral Springs to Headwaters
State Ditch	Mouth to Headwaters

Nutrients

Table 10. Segments on the 1998 §303(d) List for Nutrients

Waterbody Name	Boundaries
Catherine Creek	Mouth to Union Dam
Grande Ronde River	Wallowa R to Five Points Cr
State Ditch	Mouth to Headwaters

pH

Table 11. Segments on the 1998 §303(d) List for pH

Waterbody Name	Boundaries
Catherine Creek	Mouth to Union Dam
Grande Ronde River	Five Points Cr to Tanner Gulch
Grande Ronde River	Wallowa R to Five Points Cr
Meadow Creek	Mouth to Headwaters
State Ditch	Mouth to Headwaters

Sedimentation

Table 12. Segments on the 1998 §303(d) List for Sedimentation

Waterbody Name	Boundaries
Beaver Creek	Mouth to La Grande Reservoir
Catherine Creek, North Fork	Mouth to Middle Fork
Catherine Creek, South Fork	Mouth to South Catherine Ditch Diversion
Chicken Creek	Mouth to West Chicken Creek
Clear Creek	Mouth to Headwaters
Dark Canyon Creek	Mouth to Headwaters
Fly Creek	Mouth to Umapine Creek
Grande Ronde River	Wallowa R to Five Points Cr
Grande Ronde River	Five Points Cr to Tanner Gulch
Grande Ronde River	Tanner Gulch to Headwaters
Jordan Creek	Mouth to National Forest Boundary
Limber Jim Creek	Mouth to North Fork
Little Catherine Creek	Mouth to Headwaters
Little Fly Creek	Mouth to Headwater
Lookingglass Creek	Mouth to Headwaters
Lookout Creek	Mouth to Forest Boundary at Section 35
McCoy Creek	Mouth to Headwaters
McIntyre Creek	Mouth to Headwaters
Meadow Creek	Mouth to Headwaters
Mottet Creek	Mouth to Headwaters
Sheep Creek	Mouth to Warm Mineral Springs
Sheep Creek	Warm Mineral Springs to Headwaters

Image 4. Segments on the 1998 §303(d) List for Aquatic Weeds or Algae

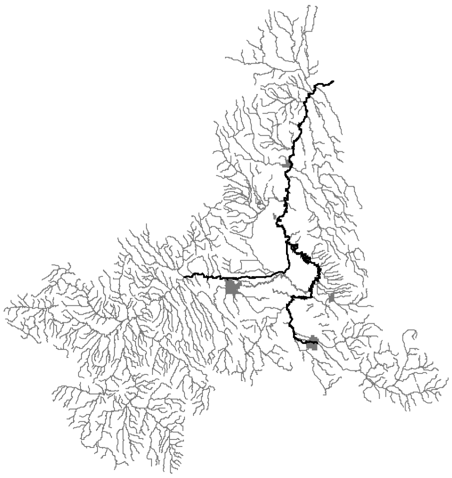


Image 5. Segments on the 1998 §303(d) List for Bacteria

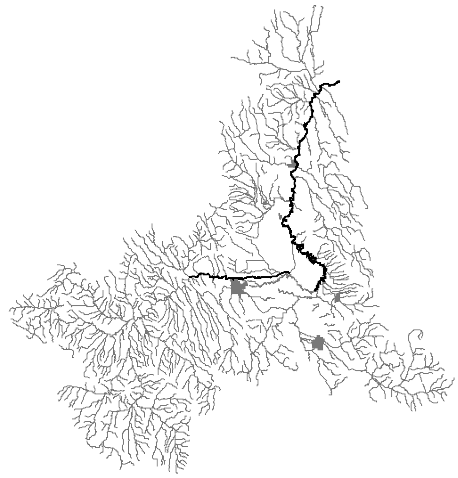


Image 6. Segments on the 1998 §303(d) List for Dissolved Oxygen (DO)

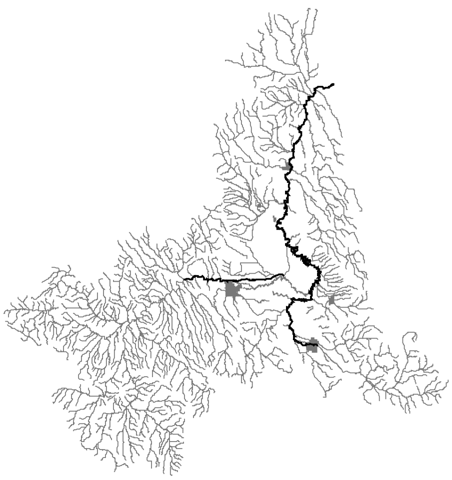


Image 7. Segments on the 1998 §303(d) List for Flow Modification

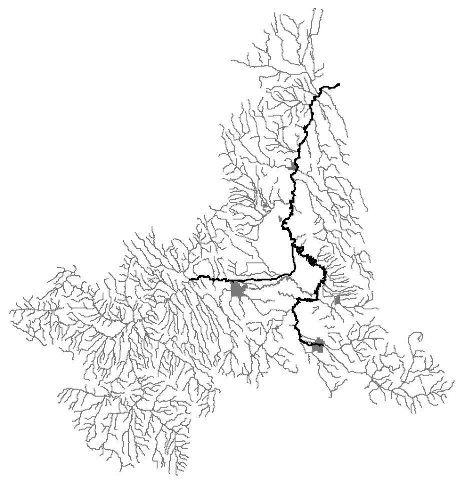


Image 8. Segments on the 1998 §303(d) List for Habitat Modification

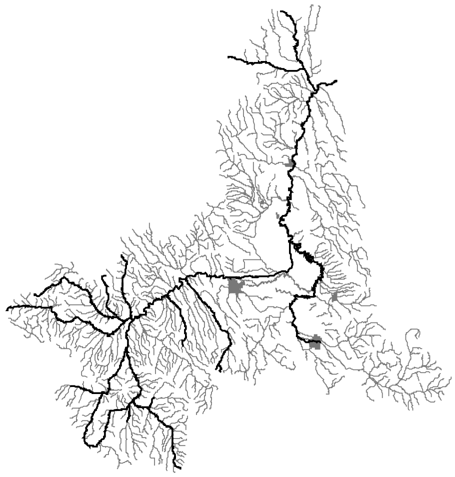


Image 9. Segments on the 1998 §303(d) List for Nutrients

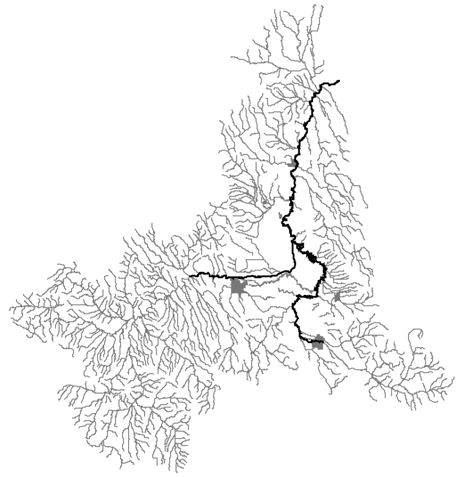


Image 10. Segments on the 1998 §303(d) List for pH

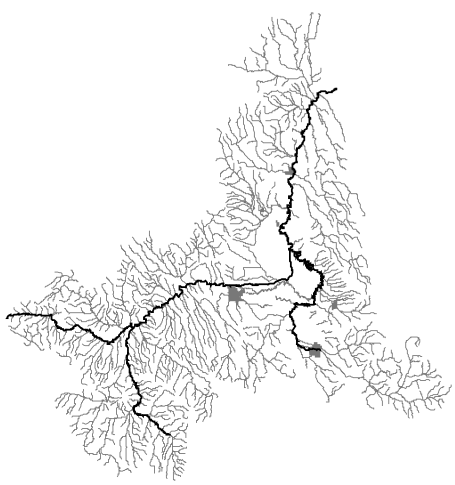
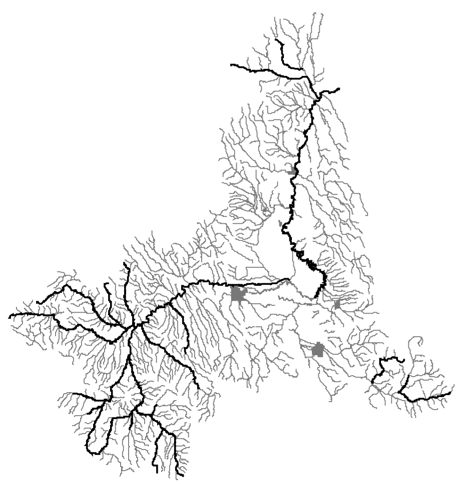


Image 11. Segments on the 1998 §303(d) List for Sedimentation



Total Maximum Daily Loads (TMDLs)

Temperature

Pollutant Identification

Human caused increases solar radiation loading, 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 violating 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 point source discharges.

Existing Sources - *CWA §303(d)(1)*

Non Point Sources

Elevated summertime stream temperatures attributed to sources in the Upper Grande Ronde River sub-basin result primarily from riparian vegetation disturbance. Reduction in stream surface shading (via decreased riparian vegetation height, width and/or density and increased channel width) increases the amount of solar radiation reaching the stream surface. Non point source contributions to pollutant loading are discussed in detail within **Appendix A**.

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. Specifically, the elevated summertime stream temperatures attributed to anthropogenic sources in the Upper Grande Ronde sub-basin result from the following:

1. Riparian vegetation disturbance reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface,
2. Channel widening (increased width to depth ratios) increases the stream surface area exposed to energy processes, namely solar radiation,
3. Reduced summertime saturated riparian soils that reduce the overall watershed ability to capture and slowly release stored water, and
4. Reduced summertime base flows may result from instream withdrawals.

Human activities that contribute to the factors that degrade water quality conditions (listed above #1 to #4) in the Upper Grande Ronde sub-basin include timber harvest, as well as road, agriculture and rural and urban residential related riparian disturbances.

Point Sources

Three NPDES permitted facilities discharge surface water to the Grande Ronde River and tributaries during the critical summertime temperature period.

The locations of the NPDES cooling water and general NPDES permitted discharge points are mapped in **Figure 2**. There are five permitted facilities within the Upper Grande Ronde sub-basin, three of which discharge during critical summertime periods. Facilities that discharge are listed in **Table 13**. Discharge temperatures are as high as 73°F. Discharge rates are generally very low.

Figure 2. NPDES Permitted Point Sources

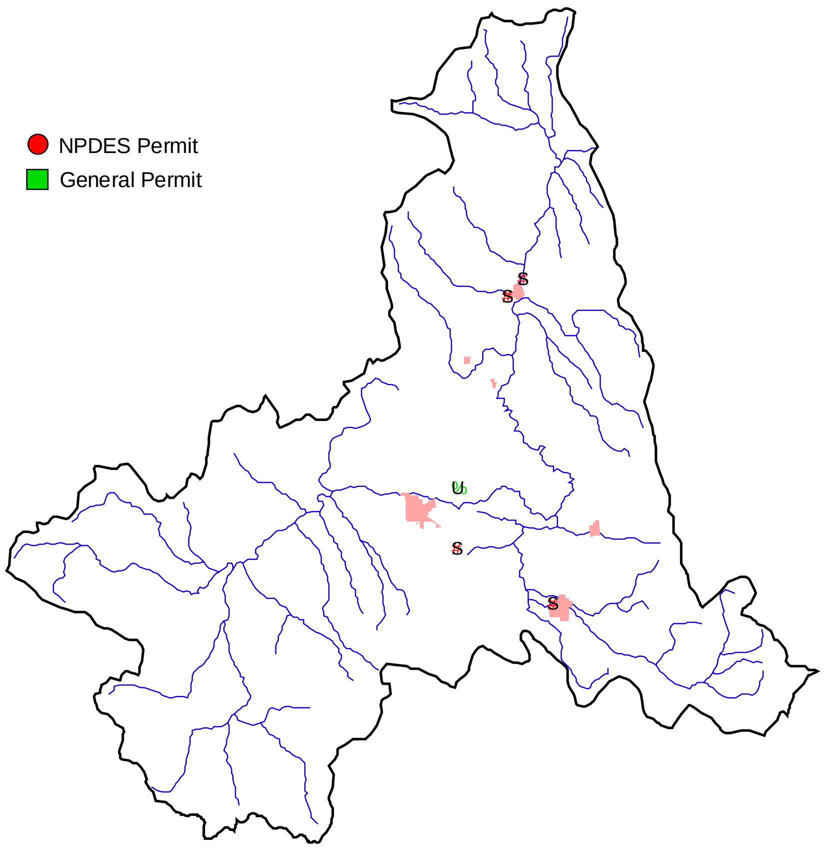


Table 13. NPDES Permitted Facilities

Facility Name	City	Receiving Water	River Mile	Permit Type	Ave. August Temp. (°F)
Elgin STP	Elgin	Grande Ronde R.	198.0	NPDES	*
La Grande STP	La Grande	Grande Ronde R.	158.0	NPDES	73.2
Union STP	Union	Catherine Cr.	18.0	NPDES	No Data
Boise Cascade -Elgin Complex	Elgin	Phillips Cr.	1.0	NPDES	*
Island City Particleboard	Island City	Grande Ronde R.	158.5	GEN01	No Data

**Currently does not discharge during critical summertime period.*

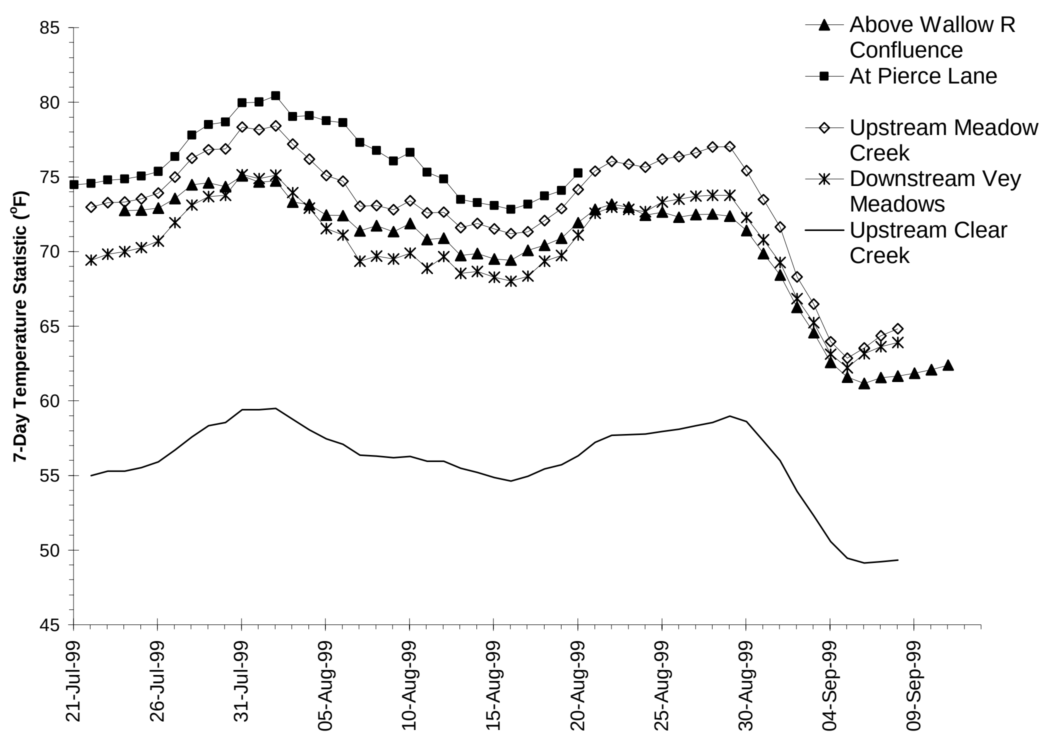
Seasonal Variation - *CWA 303(d)(1)*

Critical temperature period spans June, July, August, September and October.

Section 303(d)(1) requires this TMDL to be "established at a level necessary to implement the applicable water quality standard with seasonal variations." Both stream temperature and flow vary seasonally from year to year. Water temperatures are coolest in winter and early spring months. Stream temperatures exceed State water quality standards in summer and early fall months (June, July, August, September and October) (**Figure 3**). Warmest stream temperatures correspond to prolonged solar radiation exposure, warm air temperature, low flow conditions and decreased groundwater contribution. These conditions occur during summer and early fall. The analysis presented in this TMDL is concerned with summertime periods in which stream temperatures are most critical.

Figure 3. Critical Period Summertime 7-Day Temperature Statistic

(ODEQ data, 1999)



Loading Capacities - *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.*** This condition is termed ***Site Potential*** and is achieved when (1) non-point source solar radiation loading is representative of a riparian vegetation condition without human disturbance and (2) point source discharges cause no measurable 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 as identified states that ***no measurable surface water temperature increase resulting from anthropogenic activities*** is allowed in the Grande Ronde River and tributaries (OAR 340-41-722(2)(b)(A)).
- The pollutants as identified are human increases in solar radiation loading (non-point sources) and warm water discharge (point sources).

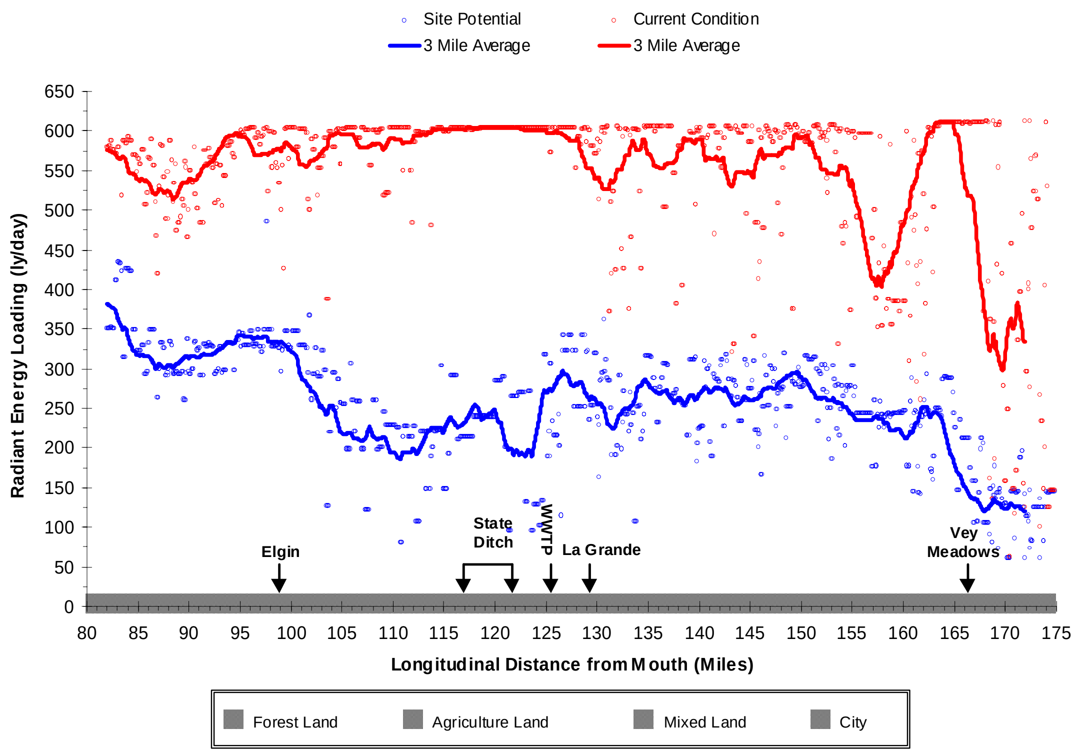
Loading capacities in the Upper Grande Ronde sub-basin consist of (1) solar radiation loading profiles for the mainstem Grande Ronde River (expressed as Langleys per day) based on potential near stream vegetation characteristics without anthropogenic disturbance and (2) NPDES permitted point source effluent discharge temperature limits. **Appendix A** describes the modeling results that lead to the loading capacities.

Under the current regulatory framework for development of TMDLs, identification of the loading capacity is an important first step. The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. **Figure 4** contrasts the longitudinal profile of the current radiant energy load with the longitudinal profile of the site potential radiant energy load. **The site potential radiant energy load is the loading capacity.**

Non Point Sources

Analysis/simulation of heat transfer processes indicate that water temperatures increase above natural daily fluctuations when the heat load from solar radiation is above those allowed by site potential riparian vegetation conditions. Further, peer reviewed stream temperature research specifically pertaining to Grande Ronde River temperature has implicated solar radiation loading as the primary source of pollutant delivery (Bohle, 1994 and Chen, 1996).

Figure 4. Loading Capacity for Non Point Sources - Solar Radiation Load[2]



[2] See **Appendix A** for information regarding derivation of loading capacities and Site Potential.

Point Sources

System potential temperatures during the critical condition in August result when the non point source loading capacity is achieved throughout the Upper Grande Ronde sub-basin. These system potential temperatures were developed using computer modeling (see **Appendix A**) and used to assign the wasteload allocations to the point sources. System potential temperatures and waste load allocations were derived by DEQ for all point sources.

Table 14. Loading Capacity for Point Sources (NPDES Permitted Facilities)

Facility Name, City	Receiving Water	River Mile	Current Condition August Dishcharge Temp. (°F)	Wasteload Allocation Max. Dishcarge Temp. (°F)	Percent Reduction
Elgin STP, Elgin	Grande Ronde R.	198.0	*	65.7	*
La Grande STP, La Grande	Grande Ronde R.	158.0	73.2	68.0	7.6%
Union STP, Union	Catherine Cr.	18.0	No Data	64.0	
Boise Cascade -Elgin Complex, Elgin	Phillips Cr.	1.0	*	64.0	*
Island City Particleboard, Island City	Grande Ronde R.	158.5	No Data	67.5	

**Currently does not discharge during critical period.*

Load Allocations/Wasteload Allocations – *40 CFR 130.2(g), 40 CFR 130.2(h)*

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.

Wasteload Allocations (Point Sources) - Surface water discharges into Grande Ronde River sub-basin receiving waters must not exceed the system potential temperatures listed in **Table 15**.

By definition, TMDLs are the sum of the allocations [40 CFR 130.2(i)]. Allocations are defined as the portion of a receiving water loading capacity that is allocated to point or non-point sources and natural background. 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)) Please recall that unless specifically allowed under a Department-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 Oregon waters determined out of compliance with the temperature standard.

A *Load Allocation* (LA) is the amount of pollutant that non-point sources can contribute to the stream without exceeding state water quality standards. A *Waste Load Allocation* (WLA) is the amount of pollutant that a point source can contribute to the stream without violating water quality criteria. **Table 15** lists load allocations and wasteload allocations for the Upper Grande Ronde sub-basin according to land-use.

Table 15. Allocations ***Load Allocations (Non-point Sources)***	
Non Point Source	Load Allocation (Distributed Radiant Energy Load Capacity)
Natural Sources	100%
Agriculture	0%
Forestry	0%
Urban	0%
Future Sources	0%
Waste Load Allocations (Non-point Sources)	
Point Source	Waste Load Allocation (Maximum Discharge Temperature)
All Point Sources	No measurable increase over site potential water temperatures during the critical temperature period (June to October). **Table 15** lists specific waste load allocations for each NPDES permitted facility

Surrogate Measures - *40 CFR 130.2(i)*

The Upper Grande Ronde sub-basin 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, the Upper Grande Ronde sub-basin TMDL allocates "*other appropriate measures*" (or surrogates measures) as provided under EPA regulations [40 CFR 130.2(i)].

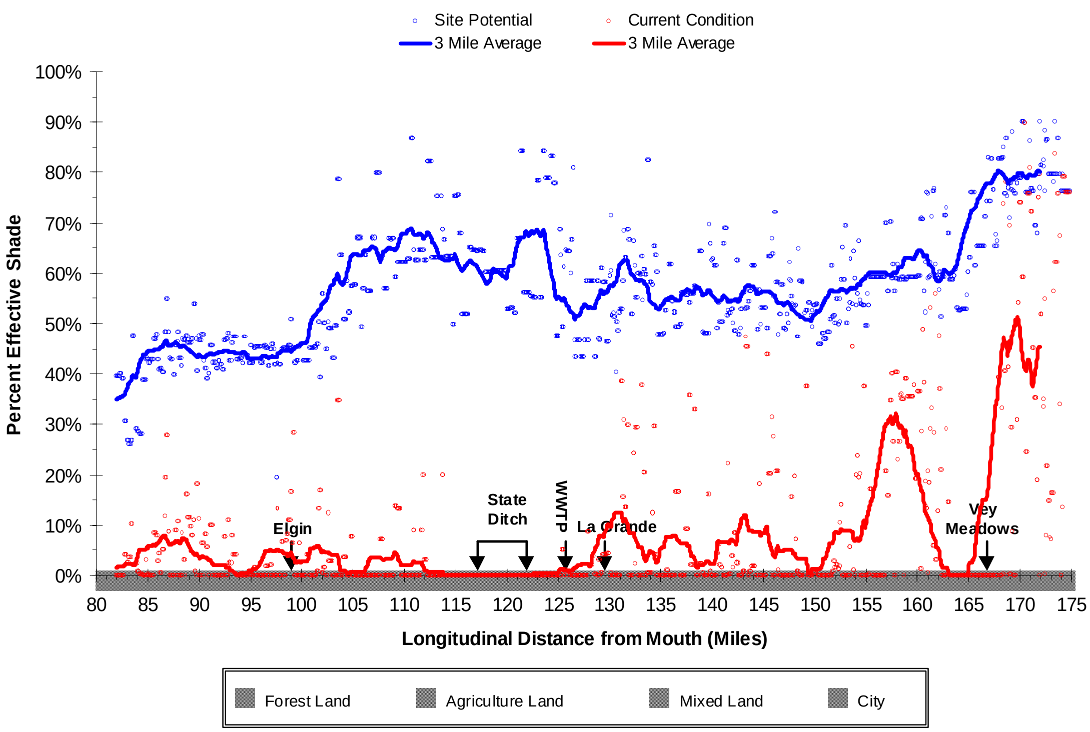
The *Report of Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program"* (FACA Report, July 1998) offers a discussion on the use of surrogate measures for TMDL development. The FACA Report indicates:

"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.

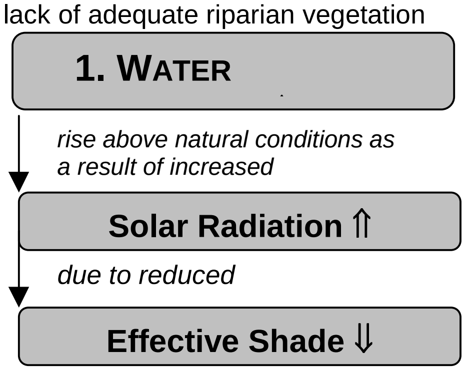
If they are used, surrogate environmental indicators should be clearly related to the water quality standard that the TMDL is designed to achieve. Use of a surrogate environmental parameter should require additional post-implementation verification that attainment of the surrogate parameter results in 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."

As mentioned above, a loading capacity 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 5** displays the percent effective shade values that correspond to the current condition and the loading capacity (i.e., site potential).

Figure 5. Percent Effective Shade Surrogate Measures[3]



As discussed, water temperature warms as a result of increased solar radiation loads. A loading capacity for 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. Decreased effective shade levels result from the lack of adequate riparian vegetation available to reduce sunlight (i.e., incoming solar radiation). The definition of effective shade allows direct measurement of the solar 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, reduce stream bank erosion, and stabilize channels. Likewise, narrower channels still require riparian vegetation to provide channel stability and shade, thus reducing heat loads (unless confined by canyon walls or shaded by

[3] See **Appendix A** for information regarding derivation of effective shade values.

topography). 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 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.

Site potential effective shade and solar radiation loading were simulated for various channel widths and channel aspects for different physiographic units. Site potential vegetation is assumed to correlate to the late seral/staged indigenous riparian vegetation communities detailed in **Appendix A**. *Potential effective shade* and daily solar radiation loading for all channel width and stream orientation combinations were calculated based on these late seral/staged indigenous riparian vegetation communities. **Figures 7, 8, 9, and 10** illustrate the simulated percent effective shade and solar radiation loading that potentially may occur in the Upper Grande Ronde sub-basin. The effective shade curves are useful for determining the potential effective shade at a given channel width and channel aspect for each physiographic unit.

Surrogate Measure #1: Along the Grande Ronde mainstem attain site potential effective shade levels specified in **Figure 5** between Tanner Gulch (i.e., Headwaters) and the Wallowa River confluence.

Surrogate Measure #2: Along tributaries attain site potential effective shade levels provided in **Figures 7, 8, 9, and 10** for the appropriate physiographic unit (listed in **Figure 6**). Shade curves are provided.

Figure 6. Physiographic Units of the Upper Grande Ronde Sub-Basin

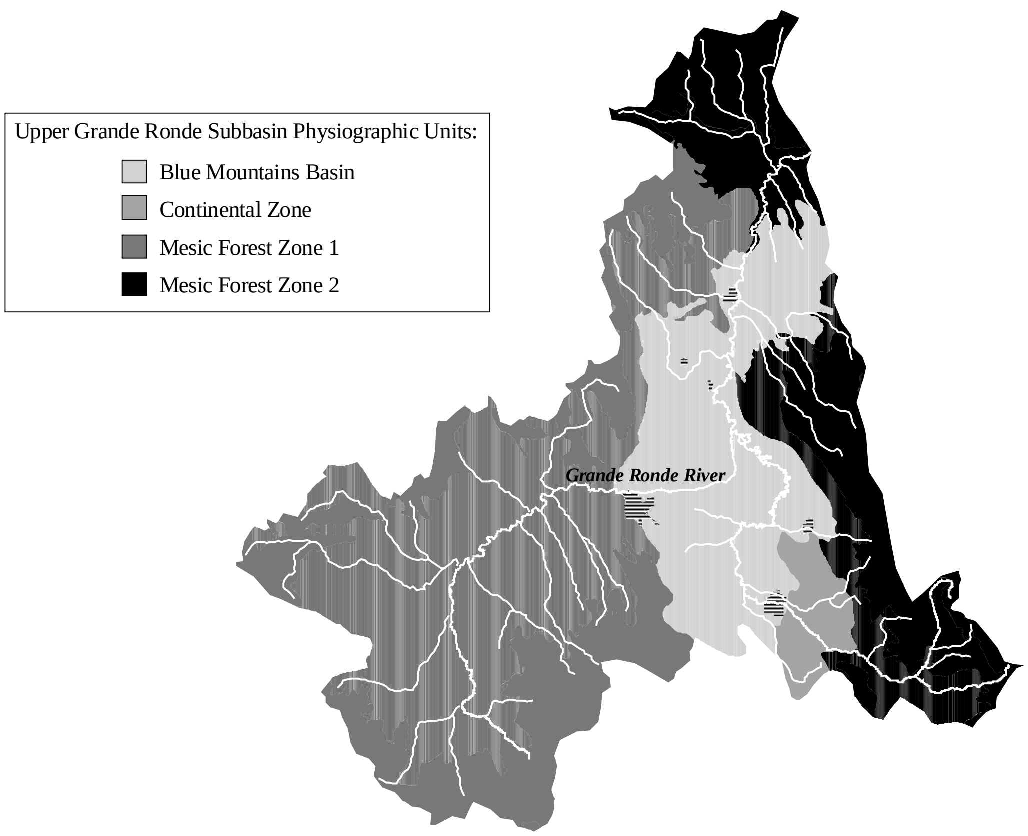


Figure 7. Continental Zone/Blue Mountain Basin Zone Effective Shade Curves

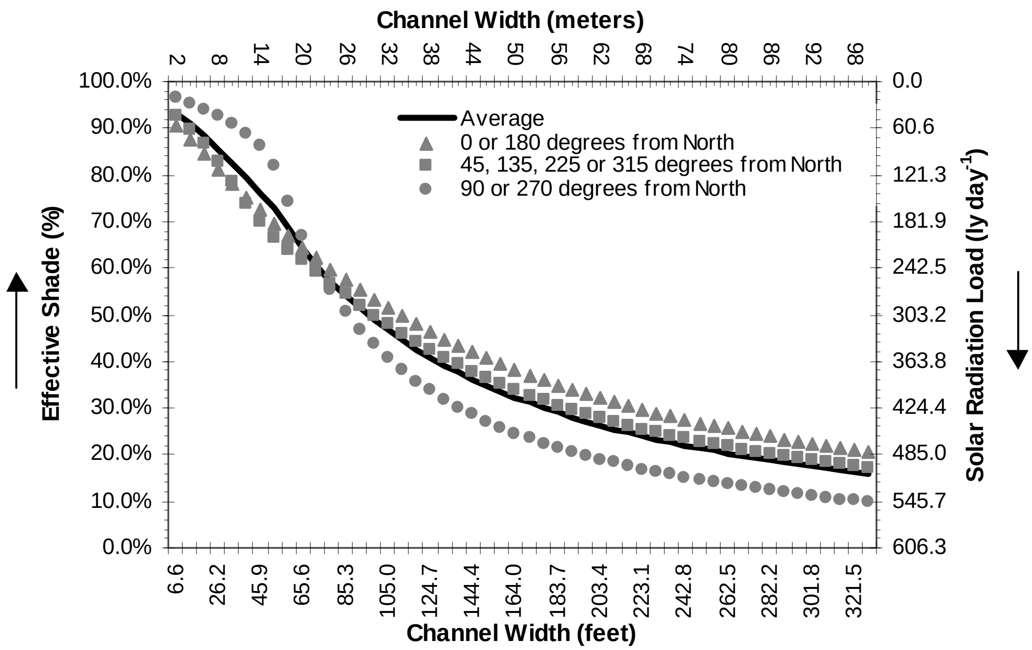


Figure 8. Mesic Forest Zone 1 (*Below 4,800 Feet*) Effective Shade Curves

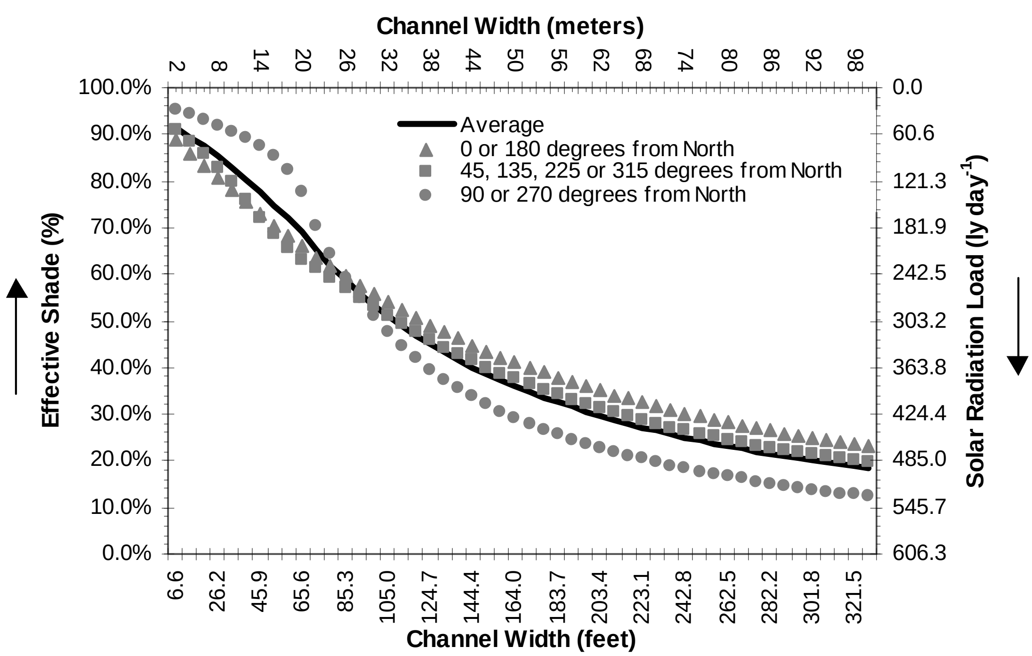


Figure 9. Mesic Forest Zone 1 (*Above 4,800 Feet*) Effective Shade Curves

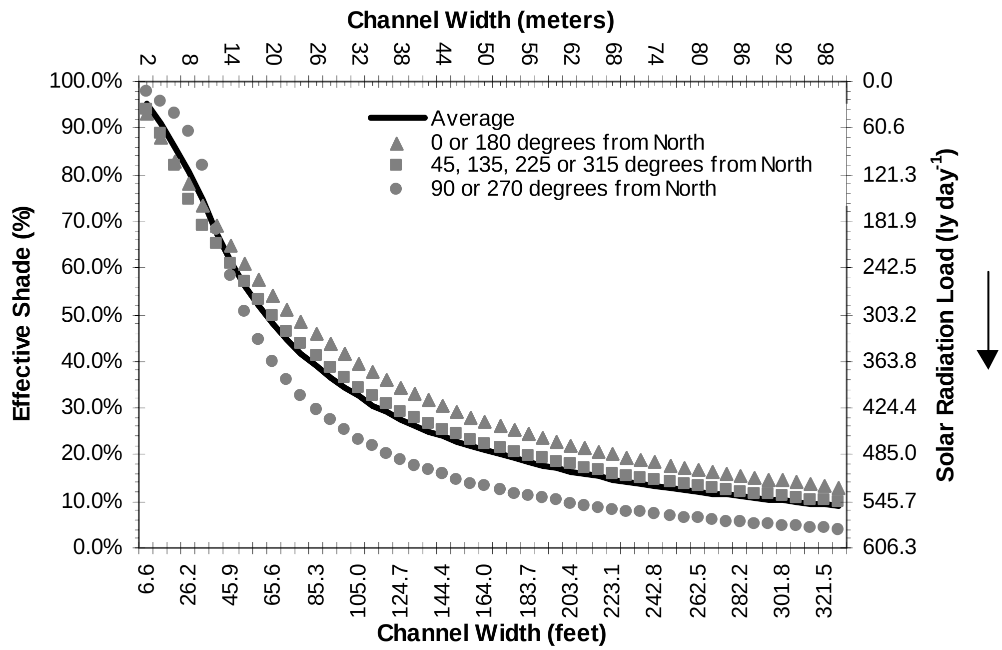
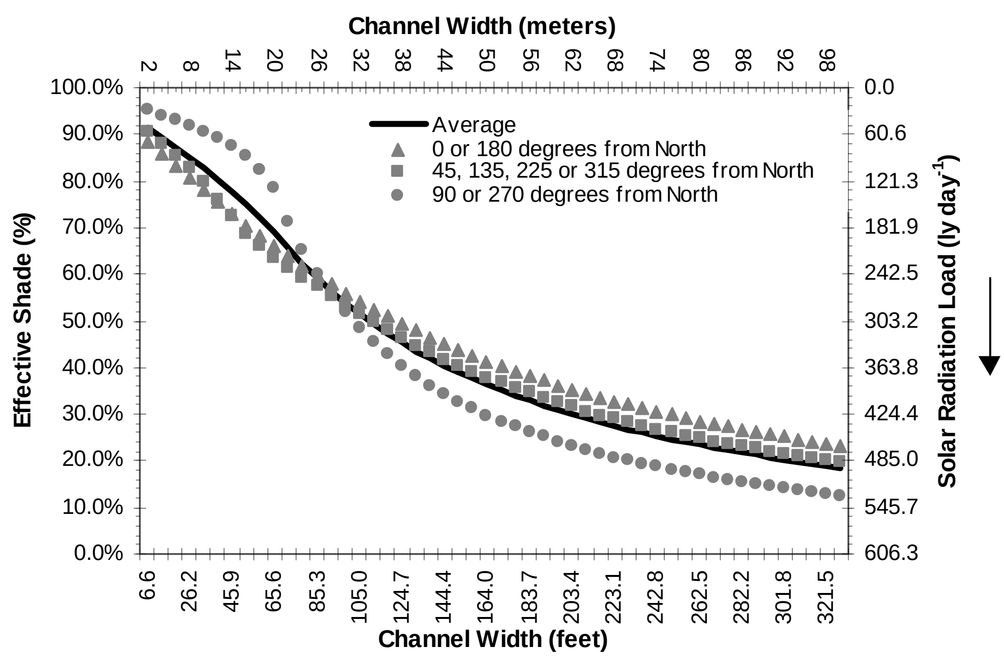


Figure 10. Mesic Forest Zone 2 (*Below 4,800 Feet*) Effective Shade Curves



Surrogate Measure #3: Grande Ronde mainstem channel widths should be reduced to values listed in **Table 16** when exceeding these values.

Table 16. Grande Ronde River Channel Width Reductions	
Grande Ronde Mainstem Reaches	Maximum Channel Channel Width
Tanner Gulch to Sheep Cr. Confluence	65 feet
Sheep Cr. to Fly Cr. Confluence	82 feet
Fly Cr. to Indian Cr. Confluence	98 feet
Indian Cr. to Lookingglass Cr. Confluence	115 feet
Lookingglass Cr. to Wallowa R. Confluence	131 feet

Surrogate Measure #4: Increase sinuosity in unconfined channels until either sinuosity equals 1.7 (i.e., stream length/valley length) or wetted width to depth ratio is 20 or less.

Table 17. Grande Ronde River Unconfined Channels (McIntosh (1992)	
Grande Ronde Mainstem Reaches	Distance from Mouth (miles)
Vey Meadow	169.2 to 163.8
Upstream Meadow Cr.	154.0 to 150.9
Downstream Beaver Cr.	149.3 to 146.7
Upstream Jordan Cr.	144.8 to 142.4
Downstream Jordan Cr.	140.6 to 140.0
Upstream Five Points Cr.	138.3 to 136.5
Grande Ronde Valley	130.8 to 104.4
Lower Valley	102.6 to 95.1

Surrogate Measure #5: Where width to depth ratios are greater than 30, decrease wetted widths until width to depth ratios equal 30 or less.

Surrogate Measure #6: Where feasible, maintain/increase instream flows during the critical temperature periods (July to September).

Surrogate Measures #1 and *#2* primary and the main measure achieving the temperature standard. Surrogate Measures *#3*, *#4*, and *#5* are secondary and should only be applied when active channel restoration is occurring.

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 margin of safety 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 margin of safety 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).

The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, WLAs, and LAs. The margin of safety 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 margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources. **Table 18** presents six approaches for incorporating a margin of safety into TMDLs.

Table 18. 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	4. Conservative assumptions in derivation of numeric targets. 5. Conservative assumptions when developing numeric model applications. 6. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

The following factors may be considered in evaluating and deriving an appropriate margin of safety:

- ✓ 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 margin of safety (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.

Implicit Margins of Safety

Description of the margin of safety for the Upper Grande Ronde sub-basin Temperature TMDL begins with a statement of assumptions. A margin of safety has been incorporated into the temperature assessment methodology. 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. 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 margin of safety 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 site potential conditions. It is illogical to presume that anything more than site potential riparian conditions are possible, feasible or reasonable.

Adaptive Management

The Upper Grande Ronde sub-basin Temperature TMDL is intended to be adaptive in management implementation, allowing for future changes in loading capacities and surrogate measures (load allocations) in the event that scientifically valid reasons demand alterations. It is important to recognize the continual study and progression of understanding of water quality parameter is addressed in this TMDL/WQMP (stream temperature). In the event that data collected in the future show that changes are warranted in the Upper Grande Ronde sub-basin Temperature TMDL or WQMP, these changes will be made by Oregon DEQ.

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

Maximum daily temperatures (displayed in **Figure 11**) represent the system potential when ***no measurable surface water temperature increase resulting from anthropogenic activities*** is allowed.

Simulations were performed to calculate the 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.

Approximately 95 river miles of the Grande Ronde River were analyzed and simulated during the critical period (August 20, 1999). **Figure 11** compares the current Grande Ronde River temperatures with the river temperatures that result at site potential conditions. The site potential river temperatures directly correlate to the loading capacity (i.e., they are the temperatures that result when the loading capacity is met).

Generally speaking, the Grande Ronde River currently experiences critical condition maximum daily temperatures in the mid-70^{o}F to mid-80^{o}F range. Under the allocated system potential condition, maximum daily temperatures shifted to the mid-50^{o}F to upper 60^{o}F range. In 1999, 92% of the stream network had critical condition maximum daily temperatures greater than 64^{o}F. Under the system potential, 48% of the stream network experience maximum daily temperatures greater than 64^{o}F. The most noticeable difference between the current and allocated conditions is the complete removal of incipient lethal temperatures (greater than 70^{o}F). Under the allocated condition, 97% of the Grande Ronde River daily maximum temperature are below 68^{o}F.

Figure 11. Grande Ronde River Temperatures at Current Conditions and Site Potential

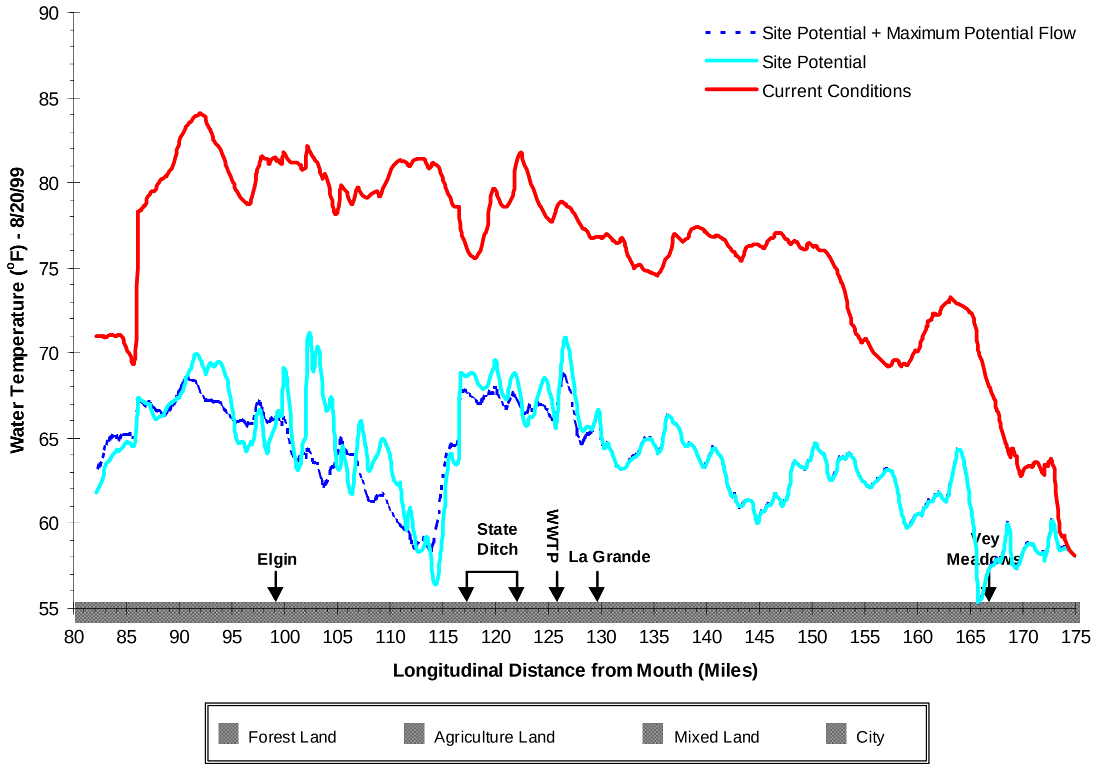
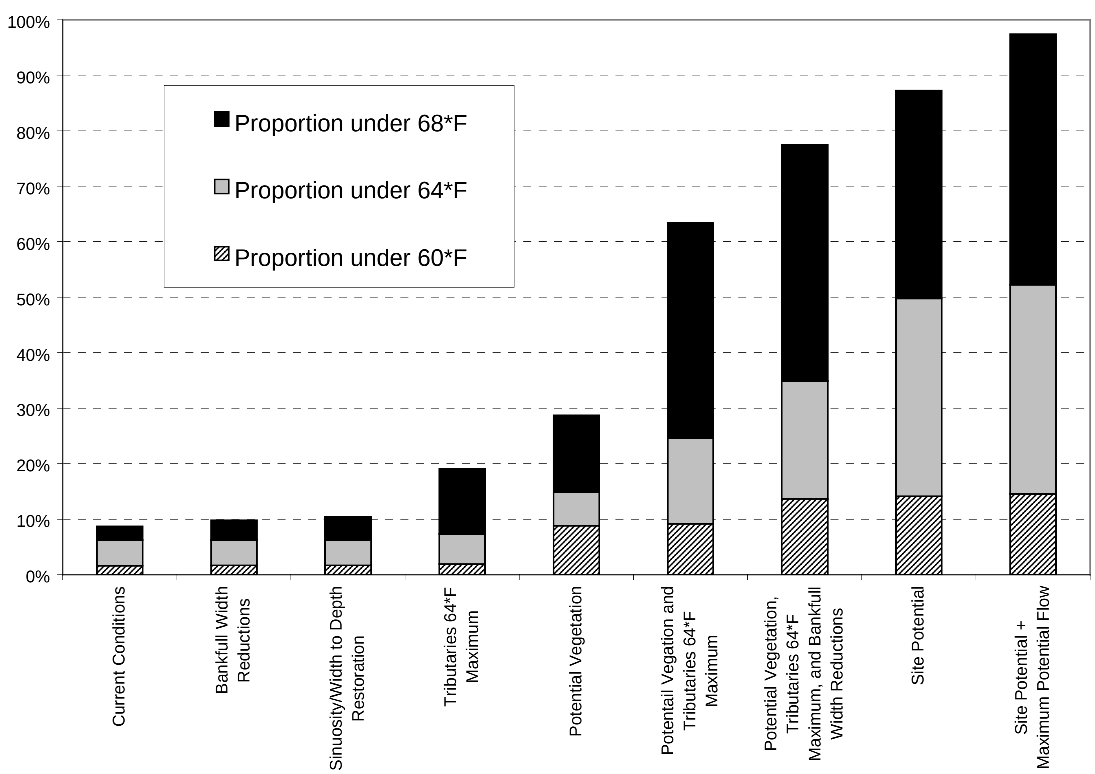


Figure 12. Percent of River Temperatures Below Specified Temperature



Dissolved Oxygen and pH

The Grande Ronde River, Catherine Creek, Meadow Creek, and the State Ditch experience dissolved oxygen and pH water quality standards violations related to excessive periphyton growth. Excessive growth is due to a number of factors including elevated nutrient concentrations, high water temperatures, excessive solar radiation, high width to depth ratios, and inadequate stream flow rates. Excessive periphyton activity causes large diel dissolved oxygen and pH fluctuations which result in dissolved oxygen standards violations at night and pH standards violations during the day.

Periphyton impact pH and dissolved oxygen levels as they grow and respire (see Appendix B). During the day, when algae perform photosynthesis and grow, carbon dioxide is consumed and oxygen produced. At night respiration dominates and carbon dioxide is produced and oxygen consumed. Carbon dioxide affects pH because it combines with water to form carbonic acid. Therefore, during the day as algae consume carbon dioxide the pH increases, while at night as algae produce carbon dioxide the pH declines. Through this process algae can cause large diel fluctuations in dissolved oxygen and pH which may result in water quality standards violations. Low oxygen levels can suffocate aquatic organisms, while excessively high or low pH levels can cause toxic effects ranging from growth and reproduction limitations to death.

In order to address dissolved oxygen and pH standards violations and concerns regarding excessive nutrient concentrations and quantities of aquatic weeds and algae, Load Allocations are provided below for both nitrogen and phosphorus. The methodology employed to derive the allocations is described in detail in Appendix B.

Since not all nitrogen and phosphorus in a stream is available for algal growth, Nutrient Load Allocations are provided in terms of the reactive inorganic forms. For nitrogen this is the dissolved inorganic nitrogen (DIN), which includes ammonia, nitrite and nitrate. For phosphorus it is the dissolved orthophosphate (equivalent to soluble reactive phosphorus or SRP).

Nutrient Load Allocations have been provided for two sets of conditions:

(1) existing riparian conditions with associated high stream temperatures and solar radiation, and

(2) site potential riparian conditions of reduced stream temperatures and solar radiation.

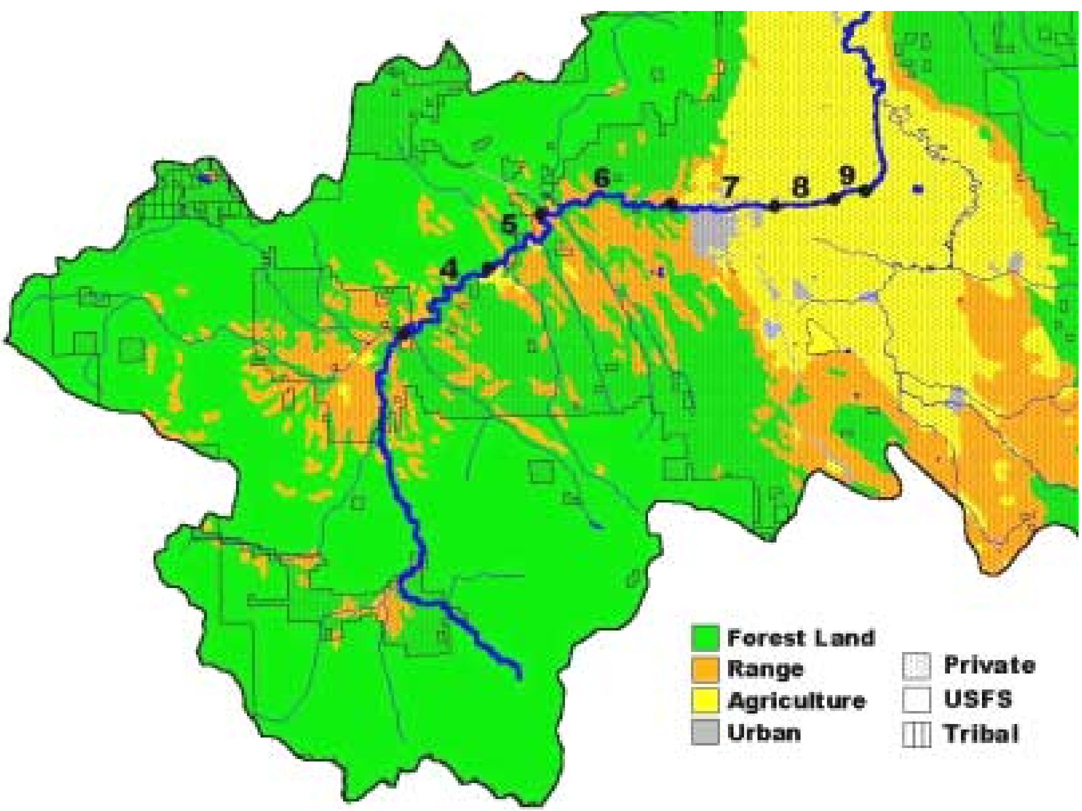
Load allocations for both sets of conditions will be adequate to meet all applicable pH and dissolved oxygen standards and address concerns regarding excessive nutrient concentrations and quantities of aquatic weeds and algae. The first set of load allocations would apply if no efforts were made to control sources of stream heating. As described below, large nutrient load reductions will be needed if solar radiation loads and temperatures are not reduced. However, since the percent shade allocations proposed to meet the temperature standard will result in significant solar radiation and temperature reductions, the second set of nutrient load allocations is the nutrient TMDL for the system. As described below, nutrient load reductions needed to meet pH and dissolved oxygen standards for this second set of conditions are considerably more modest than for the first. However, if sufficient steps are not taken to reduce temperatures in the system, then the first set of load reductions will be needed for pH and dissolved oxygen standards to be met.

Sources of Nutrients in the Grande Ronde Sub-Basin

Nutrients enter the system from both point and non-point sources, with the non-point nutrient loads being functions of land use. Above Grande Ronde River MP 160, the basin is comprised mostly of forested public lands. In the Grande Ronde valley below MP 160, the basin is comprised mostly of privately owned agricultural and urban lands. While the valley constitutes less than seven percent of the land in the basin, it contains most of the human population (more than 60 percent) and the vast majority of the crop agriculture in the basin. Forestry and grazing land uses predominate above the valley, while agriculture, urban and grazing land uses predominate within the valley. Significant point sources in the sub-basin include the La Grande wastewater treatment plant, which discharges to the Grande Ronde River, and the City of Union WWTP, which discharges to Catherine Creek. The La Grande WWTP serves a population of approximately 12,900, including the cities of La Grande and Island City. It is the only point source in the sub-basin classified as a “major” facility. The Union WWTP serves a population 1,915 and is classified as a “minor” facility. The City of Elgin has a wastewater treatment plant but it does not discharge during summer low flow months. There are three additional incorporated communities within the valley: Cove (pop. 545), Imbler (pop. 311), and Summerville (pop. 145). None of these discharge wastewater during summer low flow months.

Figure 13 overlays land use information and modeling segments. As shown, reaches 4, 5 and 6 (MP 166.9 and above) are mixed forest and rangeland. Therefore, all load reductions for these reaches will be allocated to these uses. Reach 7 (MP 166.9-160.1) receives nutrient loads which enter from upstream that are associated with forest and range land uses and loads which enter within the reach that are associated with urban and agricultural land uses. Reach 8 (160.1-153.8) receives non-point source (NPS) loads which enter from upstream that are associated with all of the above and loads which enter within the reach that are primarily associated with agricultural land uses. Reach 9 (153.8-State Ditch) receives non-point source loads from all the above, plus the point source load from the La Grande WWTP.

Figure 13. Land Use Relative to Modeled Grande Ronde Reaches



Nutrient Loading Capacities and Load Allocations – Current Riparian Conditions

The Grande Ronde River is listed for pH and dissolved oxygen (DO) due to excessive periphyton activity. The allocations presented below are designed to achieve pH levels within the range 6.5 to 8.7 and dissolved oxygen concentrations greater than 6.5 mg/L. The pH target of 8.7 is more stringent than the maximum pH of 9.0 allowed by the standard, thus providing for a margin of safety. The DO target of 6.5 mg/L is more stringent than the minimum of 6.0 mg/L allowed by the standard. This also provides a margin of safety. Water quality modeling using the periphyton model PCM (**Appendix B**) indicates that the allocations are pH controlled (i.e., the pH standard is more difficult to achieve in the Grande Ronde River than the DO standard). Because of this, allocations which result in the pH target of 8.7 being met are calculated by the model to result in DO concentrations significantly greater than 6.5 mg/L. Such allocations will result in the 30-day average standard of 8.0 mg/L being met in all reaches. ***Nutrient load allocations*** in terms of percent reductions from current levels are presented in **Table 19**, along with corresponding ***loading capacities***. Nutrient load allocations apply to non-point source (NPS) pollution loads.

Table 19. Nutrient Allocations for Current Riparian Conditions - Grande Ronde River

Reaches	Milepoints	Nutrient Load Allocations (% Reductions)	Loading Capacities (Water Column Concentrations as Monthly Medians)	
			Dissolved Inorganic Nitrogen µg/L, as N	Dissolved Orthophosphate µg/L, as P
MS4	Headwaters–182.0	20%	16	8
MS5	182.0-173.0	50%	15	5
MS6	173.0-166.9	35%	23	7
MS7	166.9-160.1	20%	32	12
MS8	160.1-153.8	60%	26	6
MS9	153.8-State Ditch	60% (60% reduction in NPS loads plus summer point source removal)	26	6
	State Ditch - Mouth	60% (60% reduction in NPS loads plus summer point source removal)	26	6

Table 19 presents nutrient load allocations and loading capacities for both nitrogen and phosphorus. However, only nitrogen concentrations directly impact the pH and dissolved oxygen concentrations calculated by the model. This is because the system is nitrogen limited and since the growth rate limitation due to nutrients in the model is controlled only by the nutrient in lowest supply relative to cellular requirements (see **Appendix B**). However, to derive loading capacity concentrations for phosphorus, the same percent reductions required for nitrogen have been applied. This is because the same measures that reduce nitrogen are likely to provide similar reductions in phosphorus. In addition, in low nitrogen, high phosphorus aquatic environments nuisance bluegreen algae (cyanobacteria) which can fix nitrogen may become established. Therefore, it is important to reduce both nitrogen and phosphorus concentrations.

Note that in some cases the above dissolved orthophosphate loading capacities may be less than natural background levels. However, it is unclear what the natural background concentrations are, since all reaches in the sub-basin likely receive some degree of anthropogenic nutrient loading. However, it appears that natural background concentrations for dissolved orthophosphate are on the order of about 10 ug/L as P. Therefore, dissolved orthophosphate concentrations less than 10 ug/L as P may not be achievable. Due to uncertainty regarding natural background concentrations, the above loading capacities should be treated only as targets, not standards. Compliance should be based on whether existing standards for dissolved oxygen and pH are achieved, rather than on the above targets for dissolved orthophosphate and DIN.

Catherine Creek is listed for pH and DO due to excessive periphyton activity. Explicit modeling was not performed for Catherine Creek. However, the portion of Catherine Creek located within the Grande Ronde valley was determined to have similar characteristics as the Grande Ronde River within the Grande Ronde valley. Therefore, the nutrient load allocations developed for the Grande Ronde River within this area have been applied to Catherine Creek within the Grande Ronde valley. These are presented in **Table 20**. Meadow Creek is another stream listed for pH violations on the 1998 § 303(d) list. Meadow Creek is a tributary to the Grande Ronde River, with its confluence at Grande Ronde River MP 180. It has similar characteristics and nutrient loads as the Grande Ronde River in this area. Consequently, the nutrient load allocations that apply to Grande Ronde River MP 180 have been applied to Meadow Creek (also shown in Table 19).

Table 20. Nutrient Allocations for Current Riparian Conditions - Catherine and Meadow Creeks

Reaches	**Milepoints**	**Nutrient Load Allocations (% Reductions)**	**Loading Capacities (Water Column Concentrations as Monthly Medians)**	
			Dissolved Inorganic Nitrogen µg/L as N	Dissolved Orthophosphate µg/L as P
Meadow Creek	Mouth to Headwaters	50%	15	5
Catherine Creek	Mouth to Union Dam	60% (60% reduction in NPS loads plus summer point source removal)	26	6

Nutrient Load Allocations and Loading Capacities – Site Potential Riparian Conditions

A scenario was modeled using the site potential vegetative community (potential natural community). For this site potential condition, the physiographic vegetative community for the Grande Ronde sub-Basin (from Crowe and Clausnitzer, 1997) was used to calculate the late sera/staged indigenous riparian vegetation communities (see **Appendix A**). Modeling was conducted at a climax riparian tree height. Outside of modifying the riparian community composition, the same model assumptions were used for both current condition and site potential modeling scenarios.

Water quality modeling indicates that shade levels produced at site potential conditions will result in significant dissolved oxygen and pH improvements. The modeling indicates that the DO target of 6.5 mg/L will be met in all reaches without additional nutrient reductions. The pH target of 8.7 will be met in most reaches above MP 160, except for Reach MS5 (MP 182.0-173.0). The modeling indicated that a 25% nutrient load reduction from current levels is needed in Reach MS5 to meet the pH target. Below MP 160, significant nutrient reductions are required. Nutrient load allocations for the site potential scenario are provided in **Table 21**. Nutrient load allocations and loading capacities for Meadow Creek and Catherine Creek for site potential riparian vegetation conditions are presented in **Table 22**.

Table 21. Nutrient Allocations for Site Potential Riparian Conditions - Grande Ronde River

Reaches	Milepoints	Nutrient Load Allocations (% Reductions)	Loading Capacities (Water Column Concentrations as Monthly Medians)	
			Dissolved Inorganic Nitrogen µg/L as N	Dissolved Orthophosphate µg/L as P
MS4	Headwaters–182.0	0	20	10
MS5	182.0-173.0	25%	23	7
MS6	173.0-166.9	0%	35	10
MS7	166.9-160.1	0%	40	15
MS8	160.1-153.8	50%	33	7
MS9	153.8-State Ditch	50% (50% reduction in NPS loads plus summer point source removal)	33	7
	State Ditch – Mouth	50% (50% reduction in NPS loads plus summer point source removal)	33	7

Table 22. Nutrient Allocations for Site Potential Riparian Conditions (Catherine Creek and Meadow Creek)

Reaches	Milepoints	Nutrient Load Allocations (% Reductions)	Loading Capacities (Water Column Concentrations as Monthly Medians)	
			Dissolved Inorganic Nitrogen µg/L as N	Dissolved Orthophosphate µg/L as P
Meadow Creek	Mouth to Headwaters	25%	23	7
Catherine Creek	Mouth to Union Dam	50% (50% reduction in NPS loads plus summer point source removal)	33	7

Wasteload Allocations for Point Sources

Permitted point sources in the Grande Ronde River Basin are regulated by either individual or general National Pollutant Discharge Elimination System (NPDES) permits or by Water Pollution Control Facilities (WPCF) permits. WPCF permits do not allow direct wastewater discharge to surface waters. The City of La Grande wastewater treatment plant is the only major NPDES permitted point source discharging to surface water in the Grande Ronde Valley. In addition, there are five minor point source permits: the City of Union wastewater treatment plant, Boise Cascade (2 plants), Fleetwood Travel Trailers, and Union Pacific Railroad. There are no permitted point sources discharging effluent upstream of the Grande Ronde Valley.

The wastewater treatment plants (WWTPs) for the cities of La Grande and Union have been shown to be major contributors to nutrient loads in the Grande Ronde River and Catherine Creek, respectively. In the case of the La Grande plant, violations of water quality standards occur upstream of the effluent discharge, but violations are much more severe and frequent downstream of the outfall as a result of the nutrient load contributed by the plant. In the case of Union, violations of standards for dissolved oxygen and pH are generally not seen above the treatment plant discharge. Violations begin to occur immediately below the discharge and continue all the way to the confluence with the Grande Ronde River. The Boise Cascade particleboard plant has been shown to be a minor, but not insignificant, contributor of nutrients to the Grande Ronde River.

City of La Grande Wastewater Treatment Plant

Upstream of the La Grande Wastewater Treatment Plant, nutrient concentrations in the Grande Ronde River exceed recommended targets for orthophosphate and dissolved inorganic nitrogen. These concentrations are significantly increased by the La Grande discharge. Since target concentrations are already exceeded upstream of the discharge, the river has no capacity to assimilate loads from La Grande and the discharge exacerbates already excessive pH and DO fluctuations and standards violations.

Several options exist for mitigating the impact of the La Grande discharge on the Grande Ronde. One option is setting wasteload allocations equal to the lowest levels achievable by available municipal wastewater treatment technology. Concentrations achievable using advanced treatment are <1 mg/L (<1000 µg/L) for orthophosphate and 3-5 mg/L (3000-5000 µg/L) for dissolved inorganic nitrogen (Metcalf & Eddy, 1991). Effluent concentrations of 1.0 mg/L for orthophosphate and 5 mg/L for DIN would result in the following in-stream concentrations (for the dry weather effluent flow of 4.2 cfs, the 7Q10 river flow of 14 cfs, and background river concentrations equal to 15 µg/L for orthophosphate and 33 µg/L for DIN):

Orthophosphate: 242 µg/L
Dissolved Inorganic Nitrogen: 1,179 µg/L

Clearly, even with advanced treatment, nutrient concentrations downstream of the discharge would far exceed target concentrations. Even with advanced treatment, nutrient loads due to the La Grande discharge could be 20-45 times greater than background loads.

A second option is to impose limits adequate to insure that the La Grande discharge does not increase nutrient concentrations in the river beyond the target concentrations. Wasteload allocations for this option would be set equal to river target concentrations of < 10 µg/L for orthophosphate and 26-33 µg/L DIN. Since such stringent limits could not be met using available municipal wastewater treatment technology, this is equivalent to a “no discharge” allocation. This is the most conservative option and is the only option that will insure that nutrient concentrations are not increased by the La Grande discharge and will result in an immediate improvement in downstream pH and dissolved oxygen concentrations.

In the Grande Ronde basin, viable options to river discharge exist for effluent disposal. Non-river effluent disposal in this region is very cost-competitive with advanced treatment. Therefore, since the no discharge option is cost-competitive with advanced treatment and since it will result in the greatest improvement in water quality, no discharge during the critical summer time period is the recommended alternative being pursued by the city.

This no discharge option would remove the effluent during periods of extended low flow when algae are expected to significantly influence water quality. The removal of the point source would not influence the algae growth problems occurring upstream of the discharge nor would it address nutrients which enter the river from non-point source contributions either upstream or downstream of the discharge. The no discharge option would, however, eliminate any further exacerbation of algae growth problems resulting from nutrient contributions of the La Grande waste water treatment plant.

In order to determine when the critical, no discharge time period occurs, water quality data was analyzed (Schnurbusch 1996b, see Appendix). The analysis demonstrates that no discharge should be allowed during the months of July, August, and September. The months of June and October are transitional periods. It has been shown that in June there is a relationship between flow and pH. Standard violations begin to occur in June when the river flow falls below 150 - 200

CFS. Therefore, discharge would need to be discontinued in June when the average daily flow falls below 200 CFS.

During October there is a strong relationship between temperature and pH. Violations of the water quality standard for pH cease when maximum daily stream temperature falls below 15 C. Therefore the wastewater treatment plant would be allowed to resume discharge to the river in October when the maximum daily stream temperature has dropped to the point where it is consistently below 15 C. Alternatively, direct measurement of late afternoon pH could be used as the criteria for resumption of discharge. In October, when the late afternoon pH downstream of the discharge point has reached a level that would provide confidence that no violations of the pH standard would occur, discharge could be resumed. Therefore, it is recommended that discharge not occur in October unless the maximum daily stream temperature is less than 15^0C or the daily maximum pH is less than 8.7.

This "no discharge" option makes the establishment and adoption of WLA for the La Grande treatment plant irrelevant because the plant will contribute no nutrient load to the river during the critical low flow period.

Ammonia toxicity criteria are also exceeded in the Grande Ronde River during the summer months. This is related to the high pH and high water temperature that occurs in the river during these months. Ammonia toxicity will be eliminated following cessation of summer discharge. However, there is still potential for ammonia toxicity during other months of the year. As a result, the permit limitations for the La Grande wastewater treatment plant must include ammonia limitations that will prevent ammonia toxicity and meet DEQ standards for both chronic and acute toxicity (Schnurbusch 1996a, see Appendix).

City of Union Wastewater Treatment Plant

The City of Union wastewater treatment plant discharges to Catherine Creek and significantly increases in-stream nutrient concentrations. The flow in Catherine Creek is greatly influenced by irrigation withdrawals. While minimum (7-day average) flows upstream of the irrigation withdrawal have varied from 10 - 35 cfs since 1930, flows at the Union discharge can be less than 1 cfs. Therefore, even though the Union discharge is only 0.47 cfs, which is small relative to many other treatment plants, it is the dominant source of nutrients to Catherine Creek.

In order to evaluate the impact of the Union discharge on Catherine Creek, a "mixing zone" analysis was performed (Baumgartner, 1996). The focus of the analysis was the derivation of wasteload allocations that would minimize the impact of the Union discharge on the stream.

Two principle options are available for mitigating the impact of the Union discharge on Catherine Creek. The first option is to allow continued discharge during the summer but with stringent advanced treatment wasteload allocations. The second is no discharge. The mixing zone analysis indicated that the wasteload allocations described in the **Table 23** would confine excessive periphyton impacts to a limited area and be sufficient to prevent ammonia toxicity.

Table 23. City of Union - Potential Waste Load Allocations (WLA) for Dissolved Ortho-Phosphate (d-ortho-P) and Dissolved Inorganic Nitrogen (DIN)

Upstream Flow Cfs	**d-Ortho-P** mg/L as P	**d-Ortho-P WLA** lbs/d as P	**DIN** mg/L as N	**DIN WLA** lbs/d as N
1	0.27	0.68	1.8	4.6
5	0.94	2.4	6.6	16.9
10	1.79	4.6	12.7	32.2
15	2.64	6.7	18.7	47.6

These nutrient limits were estimated using the water quality model QUAL2E (Baumgartner, 1996). The upstream dissolved orthophosphate concentration was assumed to be 20 µg/L, and the dissolved inorganic nitrogen concentration was assumed to be 30 µg/L. The in-stream concentrations predicted downstream of the discharge were 100 µg/L of orthophosphate and 600 µg/L of dissolved inorganic nitrogen. Clearly, these nutrient concentrations are far in excess of algae growth requirements and would result in excessive periphyton growth immediately below the discharge. However, these impacts would be limited to a zone which would no longer extend into the area of currently observed highest periphyton growth, since the nutrients are expected to be incorporated into benthic algae prior to reaching this area. However, the analysis did not assess the effects of nutrient recycle. In addition, the effect of changes in production rates and stream flow on uptake rates was not assessed.

These wasteload allocations would be very difficult to meet with available municipal wastewater technology when stream flows are less than 5 cfs. Therefore, for such flows, they are essentially no discharge allocations.

As with La Grande, the no discharge option is cost-competitive with the advanced treatment alternative. Therefore, since the no discharge option is cost-competitive with advanced treatment and since it will result in the greatest improvement in water quality, no discharge during the critical summer time period is the recommended alternative being pursued by the city.

There is little information available to determine when the summer low flow period occurs. It is reasonable to assume that the change from spring to summer conditions occurs during nearly the same June - July period as the Grande Ronde River. This period would be coincident with the irrigation season, and may be related to irrigation. Although insufficient data is available to clearly define the stream flow below which discharge should cease, it is recommended that no discharge occur in June when the flow is less than 15 cfs and that no discharge occur in July, August, or September. The summer to fall transition is somewhat better defined by the limited October monitoring data. Assuming that available October water quality data is reasonably representative of typical fall conditions, the Union WWTP should be able to discharge at current mass loads in October once stream flow exceeds 15 cfs and maximum daily stream temperature does not exceed 12°C. Although little data is available for November, it is reasonable to assume that seasonal conditions are similar to the Grande Ronde and that discharge could occur at current loads without standards violations. The likelihood of standards being met will be improved by the implementation of a summer no discharge period, since there will be less periphyton biomass produced during the summer which will reduce the likelihood of excessive diurnal DO variation in the Fall.

Wasteload Allocations for Minor Permitted Industrial Point Sources

In addition to the City of Union wastewater treatment plant, there are four minor industrial point sources in the basin. The only minor industrial source of potential concern is the Boise Cascade particleboard plant in Island City, which discharges to the Grande Ronde River.

Available data on the Boise Cascade Island City particleboard plant's permitted discharge effluent quality is very limited. Sampling performed during the 1993 survey showed that, although the discharge flow rate was low, the effluent contained high concentrations of total phosphorus (2.9 - 5.3 mg/L) compared to in-stream concentrations. Only one sample of the Island City effluent was analyzed for nitrogen. This had an inorganic nitrogen concentration of 0.21 mg/L and a Kjeldahl nitrogen (organic + ammonia) concentration of 2.1 mg/L. The flow rate was estimated to be 0.3 cfs.

Observed nitrogen concentrations in the Grande Ronde River near the outfall varied between 60 and 100 µg/L during the summer low flow surveys. These exceed the target for DIN of 33 µg/L. If the background DIN concentration equaled 33 µg/L, a 0.3 cfs discharge with 0.21 mg/L DIN would increase the in-stream concentration about 3.7 µg/L. This is a relatively small increase.

While this increase in DIN would likely increase periphyton growth, it is unlikely that the increased periphyton growth or its impact on pH and DO would be measurable.

For phosphorus, based on an effluent flow rate of 0.3 cfs, an effluent concentration of 5.3 mg/L, and a river flow rate of 14 cfs, the discharge would increase the in-stream total phosphorus concentration over 100 µg/L. This is a significant increase. Because phosphorus concentrations in the vicinity of the Boise discharge currently exceed the loading capacity, there currently is no capacity available for assimilating the load. Since the system is generally nitrogen limited in the vicinity of the Boise discharge, it is possible that the facility could discharge some phosphorus without measurably increasing periphyton activity. The in-stream dissolved orthophosphate (as P) concentrations that would result from several potential effluent concentrations are as follows (assuming an upstream concentration of 10 ug/L):

Effluent dissolved orthophosphate concentration ***mg/L as N***	**Downstream dissolved orthophosphate concentration** ***µg/L as P***
1.0	30.8
0.5	20.3
0.1	11.9

It is likely that only an effluent dissolved orthophosphate concentration significantly less than 0.5 mg/L as P would produce no measurable increase in periphyton activity. Such a low effluent concentration would likely be difficult to achieve on a consistent basis using available treatment technology. Unless it were demonstrated that such a low concentration could be consistently met and that it would have no measurable impact on periphyton growth, it is recommended that the facility cease discharge during the critical summer period. This is the alternative being pursued by the facility.

Spawning and Egg Incubation Periods

The above allocations were designed to allow pH and DO standards to be met during critical summertime conditions. During fall, winter and spring (October 1 through June 30), the most stringent beneficial use is salmonid spawning and egg incubation, and the applicable water column standard is 95% of saturation. For a 3000 ft. elevation, which is roughly the average elevation of the reaches modeled, 95% saturation at 10°C (Bull Trout temperature std) is 9.7 mg/L, at 12.8°C (salmonid spawning temperature std) is 9.1 mg/L, and at 17.8°C (salmonid rearing std) is 8.1 mg/L.

The non-point source control measures needed to meet the above allocations will apply year round and should result in the 95% of saturation standard being met during all spawning and egg incubation periods. This is because the allocations were designed to meet the stringent pH standard of 8.7. DO is well above the DO standard whenever the pH standard is met. Therefore, the proposed allocation should result in applicable pH and DO standards being met year-round.

After flows increase in October, the La Grande and Union WWTPs will be permitted to discharge at their current secondary permit limits through May 31. During this period flow rates are much higher than in the summer, and solar radiation and temperatures much lower. Therefore, periphyton activity is minimal during this period. In addition, dilution is quite high, which results in no significant impacts due to effluent BOD loads. Therefore, standards for pH and DO should be met during this period, even with the La Grande and Union WWTPs discharging at current permit limits.

Margin of Safety – Nutrient TMDLs

A margin of safety has been provided for in the load allocations by:

(1) Modeling both DO and pH, rather than taking the traditional approach of simply modeling DO. Since pH was found to control the load allocations, this approach resulted in more stringent load allocations;

(2) Applying 8.7 as the pH standard rather than 9.0; and

(3) Ignoring the benefits of width reductions in site potential riparian condition scenarios. Restoring the river to site potential conditions will likely result in reduced bank full and wetted widths, increased depths, increased shade, and reduced temperatures. These improvements will reduce diel pH and DO fluctuations beyond that predicted by modeling for the scenario and will provide additional margin of safety that standards will be met.

The combined margin of safety provided by the above will ensure that the load allocations proposed will result in the attainment of water quality standards for both pH and dissolved oxygen.

Sedimentation

Fine sediments can adversely affect fish and other aquatic organisms by: 1) killing salmonids or reducing growth or reducing disease resistance; 2) interfering with the development of eggs and larvae; 3) modifying natural movements and migration of salmonids, and 4) reducing the abundance of food organisms (Newcombe and McDonald 1991, see Appendix A). Sedimentation of redds has been shown to significantly impair the success of juvenile emergence. Numerous streams in the Upper Grande Ronde subbasin, including all reaches of the Grande Ronde River within the subbasin, are included on the §303(d) list due to water quality concerns related to excessive sedimentation. Listed streams are presented in **Table 13**.

In the Grande Ronde River from the Wallowa River confluence (River Mile 82.2) to the Five Points Creek confluence (RM 156.7), cobble embeddedness and fine sediment have been identified in the §303(d) list as limiting factors for salmonid rearing. In addition, fine sediment in the Grande Ronde River mainstem have been identified as being excessive from the Five Points Creek confluence (RM 156.7) to the Headwaters.

Water Quality Standard Identification

Oregon water quality standards related to sedimentation include:

Sedimentation (OAR 340-41-722(2)(j) - "The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed."

Biological criteria (OAR 340-41-027) - "Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities."

Target Identification/Loading Capacity

The Environmental Protection Agency (EPA) and the State of Oregon do not have numeric water quality standards for streambed fines. However, excessive fine sediment is addressed through application of state narrative criteria. For listing purposes, the PACFISH target of 20% streambed fines was utilized as an indicator of fine sediment impairment to salmonids (the most sensitive "resident biological community"). Therefore, since a numeric target is needed to evaluate sediment for purposes of this TMDL, the target will be based on percent fine sediment which was used for 303(d) listing. Thus, the loading capacity for sedimentation will be defined as 20 percent streambed area fines. Long-term monitoring and the adaptive management nature of this TMDL will be used to evaluate this goal over time.

Loading Capacity

Identification of the instream sediment loading capacity is the first step for the development of TMDLs. The loading capacity is defined as the greatest amount of a pollutant that water can receive without exceeding water quality standards. As noted above, an instream streambed fines target of less than 20 percent streambed area fines has been established as an indicator of the amount of sediment loading which the waters in the Upper Grande Ronde sub-basin can receive without exceeding the state's narrative sedimentation criteria. Thus, the sediment loading capacity for all streams listed for sedimentation in the Upper Grande Ronde sub-basin is 20 percent streambed area fines.

Cobble embeddedness data collected by ocular assessment was also used as part of the §303(d) listing criteria. The Department is not aware of any other cobble embeddedness data for use in determining the sedimentation TMDL. The focus of this TMDL will be on meeting the percent fines criteria. The assumption is made that reducing fine sediment will result in a corresponding reduction in cobble embeddedness. Future monitoring as part of the adaptive management component of this TMDL will help to determine the validity of this assumption.

Load Allocations/Surrogate Measures

A *Load Allocation* (LA) is the amount of pollutant that nonpoint sources can contribute to a stream without exceeding state water quality standards. While load allocations are traditionally expressed as “mass per time”, the TMDL regulation also provides for the expression of allocations in “other appropriate measures”. It is not appropriate for streambed fines to be expressed as a load. Thus, another appropriate measure will be utilized in this TMDL.

As shown in **Figure 14**, percent streambed fines decreases with the increase in woody riparian vegetation. The observed data also indicate that when an established deciduous/mixed/conifer riparian community exists, the loading capacity of 20% streambed fines will be attained. Surrogate measures #1 and #2 developed in the temperature TMDL provide for the establishment of an established deciduous/mixed/conifer riparian community. Thus, these same surrogate measures can be utilized as load allocations for the sedimentation TMDL.

The load allocations for the mainstem Upper Grand Ronde River and for the tributaries to the Upper Grande Ronde River are those found in the temperature TMDL on page 23. The relationship between sediment and temperature is as follows:

<u>Surrogate Measures #1 and #2 in the Temperature TMDL</u> promote riparian conditions that will increase near-stream (stream bank) area resistance to erosive energy (shear stress) and may reduce local shear stress levels. Specifically, the restoration/protection of riparian areas called for in the temperature TMDL will serve to reduce stream bank erosion by increasing stream bank stability via rooting strength and near-stream roughness.

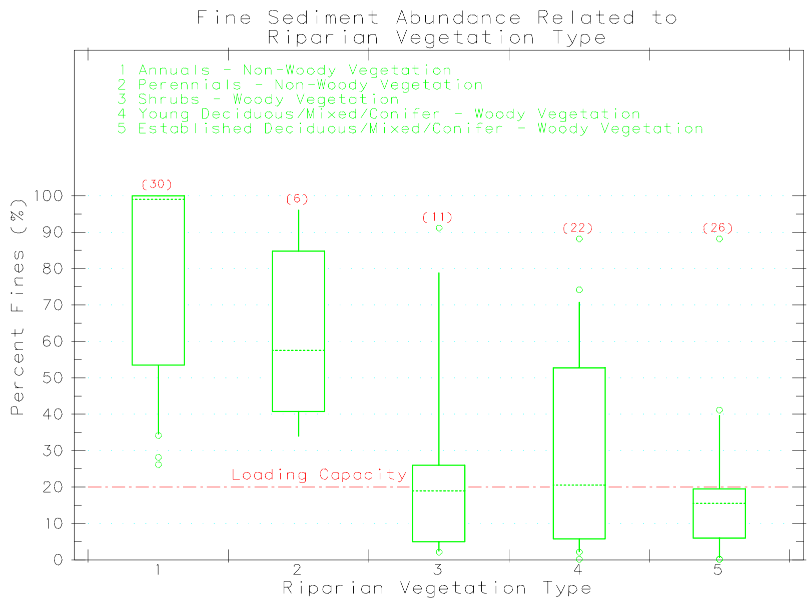
<u>Surrogate Measure #3 in the Temperature TMDL</u> targets a decrease in the near-stream disturbance zone dimension that relies primarily on passive stream narrowing via decreased stream bank erosion and increased naturally occurring stream bank building processes.

<u>Surrogate Measure #4 in the Temperature TMDL</u> targets an increase sinuosity in unconfined channels . Straighter river and creek channels (lower sinuosity) have steeper gradients and hence higher flow velocities. Increased flow velocity exerts more force on the banks, accelerating erosion and stream widening.

<u>Surrogate Measure #5 in the Temperature TMDL</u> targets decreased wetted width to depth ratio. Specifically, increased pool frequencies is an important component of instream habitat, healthy channel morphology and promotes reduced stream temperatures. And, reduced stream bank erosion and increased stream bank building processes are necessary to promote this condition. Further, reduced sedimentation (the accumulation of sediments in the stream channel) will assist pool development and maintenance.

These allocations apply to all nonpoint sources (agriculture, forestry, urban) in the watershed.

Figure 14. Stream Bed Percent Fines Related to Various Riparian Vegetation Types (ODFW data, 1996)



Wasteload Allocations

Wastewater treatment plants, and thus point sources in Upper Grande Ronde subbasin, are not considered a source of fine sediment and thus no wasteload allocations have been developed.

Seasonal Variation

The goal of this TMDL is for year-round achievement of the loading capacity. Due to the nature of the loading capacity and allocations assigned in this TMDL, a discussion of seasonal variations in sediment delivery and transport processes which may exist in the Upper Grande Ronde River subbasin was not necessary in developing the TMDL.

Margin of Safety

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS) to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. The TMDL also includes a long-term monitoring and adaptive management plan which, among other things, will evaluate the effectiveness of this target and provides a MOS.

Calculating a numeric margin of safety is not easily performed with the methodology presented in this document. The basis for the load allocations (surrogates) is the definition of site potential conditions. Thus, attainment of the load allocations will lead to the establishment of a mature riparian community and thus, sediment delivery rates which resemble those of the natural sources. It is illogical to presume that anything more than site potential riparian conditions are possible, feasible or reasonable. DEQ will utilize adaptive management to monitor whether the attainment of these surrogate measures are leading to the attainment of the applicable water quality standards.

Bacteria

The Grande Ronde River from the Wallowa River to Five Points Creek (River Mile 165.7, about 7 miles above the City of La Grande) is included in the § 303(d) list for bacteria standard violations. No other reaches in the Grande Ronde sub-basin are listed for bacteria. The Grande Ronde River is included in the § 303(d) list due to observed violations of the former bacteria standard, which was based on **fecal coliform**. This standard is as follows:

> *"Organisms of the coliform group where associated with fecal sources (MPN or equivalent MF using a representative number of samples.) A log mean of 200 fecal coliform per 100 milliliters based on a minimum of five samples in a 30-day period with no more than ten percent of the samples in the 30-day period exceeding 400 per 100 ml."*

The Grande Ronde River was listed based on data from two stations (Stations #402396 and #404200; River Mile 99.0 and 151.1, respectively). Twelve percent of observed values at River Mile 99.0 (3 of 25) and 11% at River Mile 151.1 (2 of 19) exceeded the 400 per 100 ml fecal coliform standard with a maximum value of 1600 between water years 1986 and 1995. These values only slightly exceeded the 10% violation criteria associated with the standard. Observed *E. coli* concentrations in the Grande Ronde River are presented in **Figure 15**.

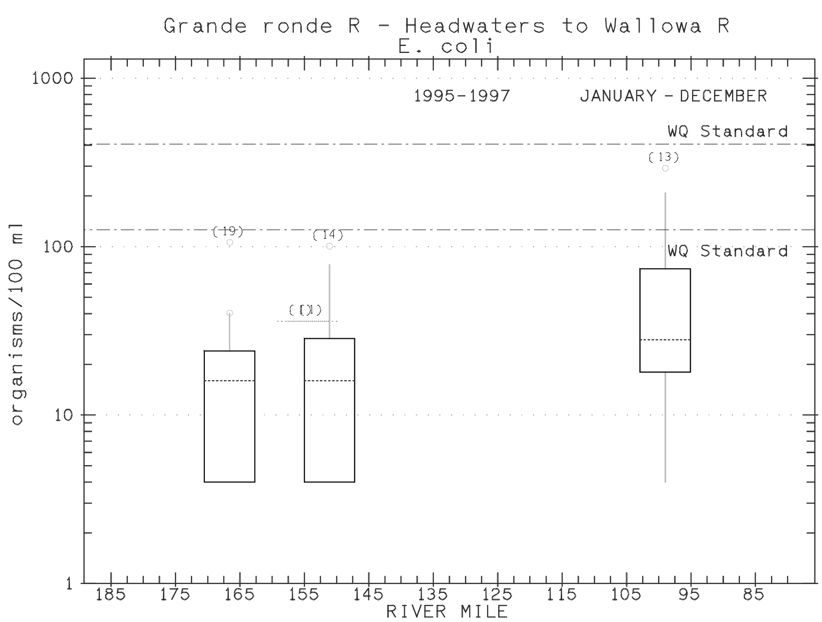
In accordance with U.S. Environmental Protection Agency recommendations, the State of Oregon recently revised its bacteria standards to be based on *Escherichia coli* (***E. coli***), rather than on fecal coliform. The applicable standard for bacteria (i.e., *E. coli*) in the Upper Grande Ronde sub-basin is now as follows:

> *"Numeric Criteria: Organisms of the coliform group commonly associated with fecal sources (MPN or equivalent membrane filtration using a representative number of samples) shall not exceed the criteria described in subparagraphs (i) and (ii) of this paragraph. Freshwaters:*

(i) A 30-day log mean of 126 E. coli organisms per 100 ml, based on a minimum of five samples;

(ii) No single sample shall exceed 406 E. coli organisms per 100 ml (OAR 340-41-725(2)(e)(A)).

Figure 15. Observed E. coli concentration in the Grande Ronde River.



10

As shown in **Figure 15**, only limited data is available on *E. coli*, and only from recent years. However, the available data does not show any violations of water quality standards. Observed median concentrations are well below the 30-day log mean standard of 126 *E. coli* organisms per 100 ml, and no observations exceeded the absolute maximum of 406, although one observation did come close. While no standards violations were observed, the data set is too limited to conclude that standards are being consistently met. It is possible that standards violations occur, particularly during rainfall events when accumulated surface organic matter is flushed into the streams.

As with sediment, it is quite likely that the load allocations provided to address temperature, pH and dissolved oxygen violations will also significantly reduce bacteria loads and reduce the likelihood of standard violations. Bacteria loads will be reduced by the filtering capability improvements that will result from the riparian vegetation improvements necessary to meet temperature surrogates. In addition, nutrient reductions resulting from the nutrient load allocations will result in bacteria load reductions, since much of the bacteria entering the streams is associated animal wastes, and animal wastes contain high levels of both nitrogen and phosphorus.

The OAR contains the following requirements intended to eliminate bacteria standard violations:

1) *Raw Sewage Prohibition: No sewage shall be discharged into or in any other manner be allowed to enter the waters of the State unless such sewage has been treated in a manner approved by the Department or otherwise allowed by these rules*. OAR 340-41-725 (2)(e)(B);

2) *Animal Waste: Runoff contaminated with domesticated animal wastes shall be minimized and treated to the maximum extent practicable before it is allowed to enter waters of the State.* OAR 340-41-725(2)(e)(C);

3) *Bacterial pollution or other conditions deleterious to waters used for domestic purposes, livestock watering, irrigation, bathing, or shellfish propagation, or otherwise injurious to public health shall not be allowed.* OAR 340-41-725 (2)(f); and

4) *In waterbodies designated by the Department as water quality limited for bacteria, and in accordance with priorities established by the Department, development and implementation of a bacteria management plan shall be required of those sources that the Department determines to be contributing to the problem. The Department may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited basin based on the contribution of the segment(s) to the problem. The bacteria management plans will identify the technologies, BMPs and/or measures and approaches to be implemented by point and nonpoint sources to limit bacterial contamination. For point sources, their National Pollutant Discharge Elimination System permit is their bacteria management plan. For nonpoint sources, the bacteria management plan will be developed by designated management agencies (DMAs) which will identify the appropriate BMPs or measures and approaches.* OAR 340-41-026 (3)(a)(I):

To insure that bacteria standards are met, monitoring for *E. coli* and fecal coliform will be continued in the basin. The adaptive management nature of the Plan will allow additional steps to be taken, as needed, to insure that standards are met and beneficial uses are protected.

Ammonia Toxicity

Ammonia toxicity is a potential concern in the Upper Grande Ronde sub-basin because of elevated pH and temperature levels. Ammonia is present in two states in natural waters: ammonium ion (NH_4^+) and un-ionized ammonia (NH_3). Un-ionized ammonia is much more toxic to aquatic life than the ammonia ion state. Since the fraction of ammonia that is un-ionized increases as pH increases, systems with high pH, such as the Grande Ronde River and Catherine Creek, are highly susceptible to ammonia toxicity. For a pH of 9.0 and a temperature of 25°C, the applicable total ammonia chronic standard (NH_4^+ plus NH_3) is 0.1 mg/L (0.0822 mg/L as nitrogen). The 4-day average ammonia concentration may not exceed this concentration more than once every 3 years on the average. For the same pH and temperature combination, the total ammonia acute standard is 0.72 mg/L (0.59 mg/L as nitrogen). The one hour average ammonia concentration may not exceed this concentration more than once every 3 years on the average.

Figures 16 and **17** present observed summer ammonia concentrations for the Grande Ronde River. Since ammonia toxicity is a function of pH and temperature, as pH and temperature is improved with implementation of the TMDL, the fraction un-ionized will decrease and the loading capacity for total ammonia will increase. The lower dashed line on these figures is a standard appropriate for current conditions (pH = 9.0, temperature=25°C), while the upper dashed line is a standard appropriate for the site potential condition (pH=8.7, temperature = 20°C).

As shown in **Figures 16** and **17**, for current conditions of temperature and pH the ammonia standard (lower dashed line) is occasionally exceeded, particularly downstream of the La Grande WWTP discharge which discharges at River Mile 153.8. For anticipated future temperature and pH conditions, the standard (upper dashed line) should rarely be exceeded, particularly since the La Grande WWTP will not be discharging during low flow summer conditions.

Figure 16. Upper Grande Ronde River observed Ammonia concentrations during the summer.

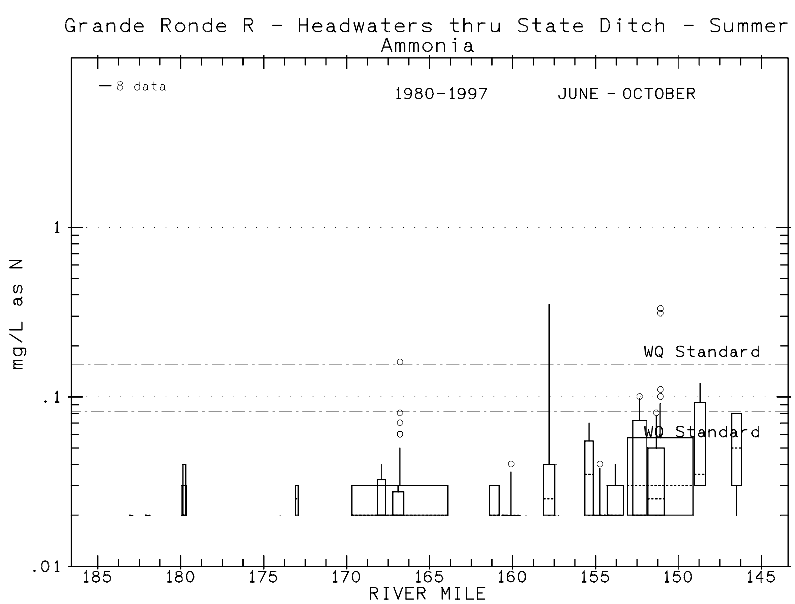
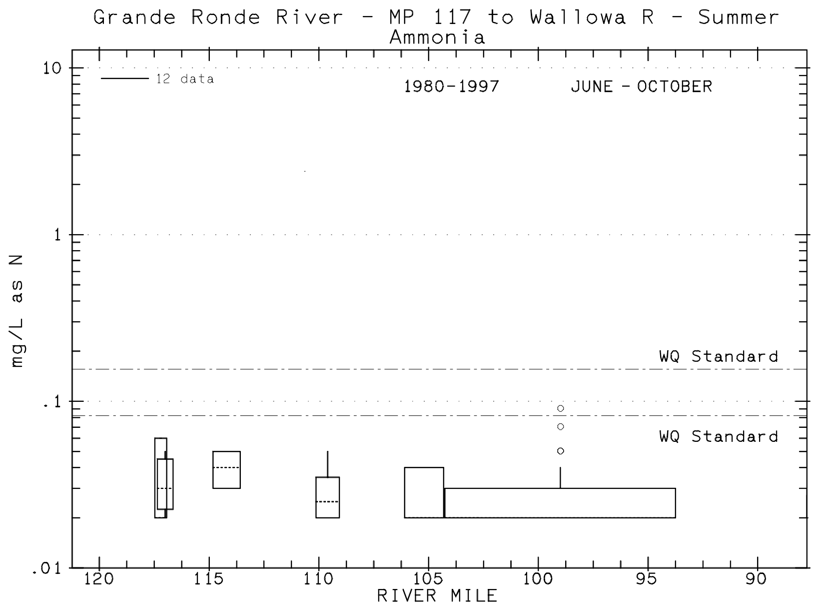
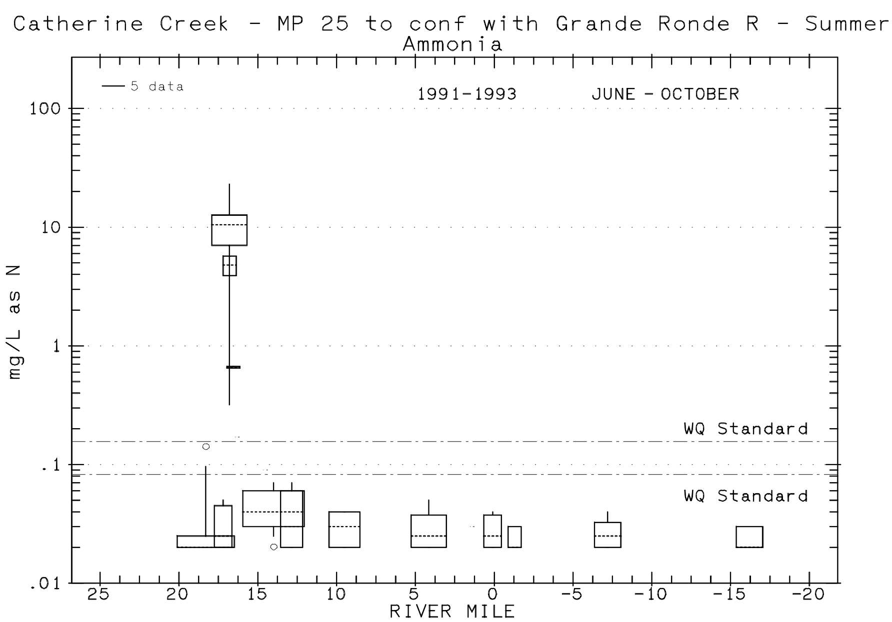


Figure 17. Middle Grande Ronde River observed Ammonia concentrations during the summer.



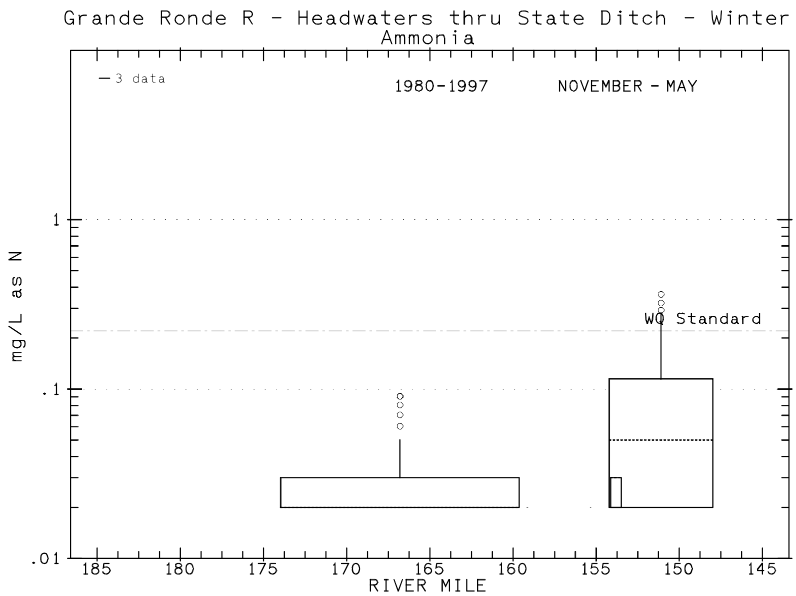
Observed summer ammonia concentrations for Catherine Creek are presented in **Figure 18**. As shown in **Figure 18**, significant ammonia standard exceedances occur near the Union WWTP discharge. However, away from the discharge no violations are observed. The exceedances are caused by high ammonia concentrations in the Union effluent coupled with very poor dilution in the Creek. The poor dilution is due to lack of flow because of irrigation diversions. Not only is the chronic criteria of 0.082 mg/L (as N) exceeded near the discharge, but the acute criteria of 0.6 mg/L (as N) is also frequently exceeded. The recommended "No Discharge" allocation for summer months will eliminate these violations.

Figure 18. Catherine Creek observed Ammonia concentrations during the summer.



Winter conditions are illustrated by **Figure 19**, which compares observed ammonia concentrations in the upper Grande Ronde River to the chronic ammonia standard for a temperature of 15^{o}C and pH of 8.7. As shown, the chronic criteria is potentially exceeded at times during the winter near the La Grande WWTP discharge (MP 153.8). This is of concern because the WWTP will be allowed to discharge during the months of November through May. The permit limits for both the La Grande and Union WWTPs will be designed to insure that ammonia toxicity criteria are met at all times of the year.

Figure 19. Grande Ronde River observed Ammonia concentrations during the winter.



Habitat Modification and Flow Modification

Habitat Modification and Flow Modification were identified on the § 303(d) list for the Upper Grande Ronde sub-basin. **Habitat modification** is not the direct result of a pollutant although it does affect beneficial uses. Because a pollutant is not the cause, the concept of establishing a loading capacity and allocations does not apply. There is the expectation, however, that the improvements to riparian vegetation that will be necessary to meet temperature surrogates will also lead to improvements in habitat. **Flow modification** also is not the direct result of a pollutant load although decreased flow does affect beneficial uses. Although loading capacities and allocations are not established, improved flow is, however, necessary to adequately address water quality standards and habitat below the City of La Grande on the Grande Ronde River and below the City of Union on Catherine Creek. Improving in-stream flow is an identified goal in this TMDL and is identified as a high priority in the Water Quality Management Plan.

Reasonable Assurance of Implementation

There are several programs that are either already in place or will be put in place to help assure that this water quality management plan will be implemented. Some of these are traditional regulatory programs such as discharge permit programs for point source discharges. In these cases, the pollutants of concern in the Upper Grande Ronde sub-basin will be considered and the regulation will be carried out as required by federal, state, and local law. The state Forest Practices Act, implemented by the Oregon Department of Forestry, regulates forest activities. The Agricultural Water Quality Management Area Plans, implemented by the Oregon Department of Agriculture, provide the assurance that agricultural activities are addressed. An interdepartmental review of these programs will provide the assurance that standards will be met. Other programs, while structured, are not strictly regulatory. In these cases local implementing agencies agree to make a good faith effort to implement the program. Structured programs that provide reasonable assurance of implementation include (for more complete information on these programs see Upper Grande Ronde River Sub-basin Water Quality Management Plan, Grande Ronde Water Quality Committee):

1. NPDES and WPCF Permit Programs: DEQ administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. The statute requires that no person shall discharge waste into waters of the state or operate a waste disposal system without obtaining a permit from DEQ.
2. Transportation: Management practices for transportation sources identified in the WQMP will be voluntarily implemented by the responsible agencies. There is incentive to voluntarily implement the practices not only to improve water quality and protect threatened species but also to avoid any additional regulation. In addition to voluntary incentives there are existing authorities and agreements that are adequate to assure implementation.
3. Municipal & Rural Residential: Union County and the City of La Grande have ordinances and policies that are relevant to the implementation of the management practices discussed under Municipal Sources in the Management Measures element of the Water Quality Management Plan. These Ordinances and Policies will be reviewed and revised to insure that they adequately address non-point source pollution control.
4. Forestry: The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on nonfederal forestlands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe best management practices (BMPs) for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness.
5. Agriculture: The Oregon Department of Agriculture (ODA) has primary responsibility for control of pollution from agricultural sources. This is done through the Agricultural Water Quality Management (AWQM) program authorities granted ODA under Senate Bill 1010, adopted by the Oregon State Legislature in 1993.

There are also many voluntary, non-regulatory, watershed improvement programs (activities) that are already in place and are helping to address the water quality concerns in the Upper Grande Ronde River sub-basin. Both technical expertise and partial funding are provided through these programs. Examples of activities promoted and accomplished through these programs include: planting of conifers, hardwoods, shrubs, grasses and forbs along streams; relocating legacy roads that may be detrimental to water quality; replacing problem culverts with adequately sized structures, and improvement/ maintenance of legacy roads known to cause water quality problems; and active channel restoration**.** These activities have been and are being implemented to improve watersheds and enhance water quality. Many of these efforts are helping resolve water quality related legacy issues. The programs addressing these problems include, but are not limited to, the following (for more complete information on these programs see Upper Grande

Ronde River Sub-basin Water Quality Management Plan, Grande Ronde Water Quality Committee):

- The Oregon Plan
- Grande Ronde Model Watershed
- Landowner Assistance Programs

  Forestry Incentive Program (FIP)
  Stewardship Incentive Program (SIP)
  Environmental Quality Incentives Program (EQIP)
  Wildlife Habitat Incentive Program (WHIP).
  Conservation Reserve Program (CRP)
  Conservation Reserve Enhanced Program (CREP)
  Forest Resource Trust (FRT)

- Private Lands Forest Network (PLFN).
- Oregon Department of Fish and Wildlife Programs

Glossary of Terms

General Terminology

Active Bank Erosion: Estimates from observation of the active stream bank erosion as a percentage (%) of the total reach length.

Adaptive Management: An iterative process where policy decisions that are implemented based on scientific experiments that tests the predictions and assumptions specified in a management plan. The results of the experiment are then used to guide policy changes for future management plans.

Anadromous Fish: Species of fish that spawn in fresh water, migrate to the ocean as juveniles, where they live most of their adult lives until returning to spawn in fresh water.

Anthropogenic Sources of Pollution: Pollutant deliver to a water body that is directly related to humans or human activities.

Autotrophs: Organisms that obtain energy from sunlight and their materials from non-living sources. In streams, autotrophs include periphyton, phytoplankton, and macrophytes.

Base Flow: Groundwater fed summertime flows that occur in the long-term absence of precipitation.

Bank Building Event: A hydrologic event (usually high flow condition) that deposits sediments and organic debris in the flood plain and along stream banks.

Beneficial Use: Legislatively approved use of water for the best interest of people, wildlife and aquatic species.

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.

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.

Clearcut Harvest: Timber harvests that remove all trees are removed in a single entry from a designated area.

Debris Flow: A rapidly moving congregate of soil, rock fragments, water and trees, where over half of the material in transport has a particle size greater than that of sand.

Decommission: The removal of a road to improve hillslope drainage and stabilize slope hazards.

Endangered Species: A species that is declared by the Endangered Species Act (ESA) to be in danger of extinction throughout a significant portion of its range.

Fine Sediment: Sand, silt and organic material that have a grain size of 6.4 mm or less.

Fire Regime: The frequency, extent, intensity and severity of naturally occurring seasonal fires in an ecosystem.

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.

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.

Fluvial: Of, found in or produced by a river.

Gradient: Reach gradient estimated by valley gradient reported in percent (%) from 1:24,000 topography.

Groundwater: Subsurface water that completely fills the porous openings is soil and rocks.

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.

Incipient Lethal Limit: Temperature levels that cause breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation.

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.

Instantaneous Lethal Limit: Temperature levels where denaturing of bodily enzymes occurs.

Instream Roughness: Refers to the substrate (both organic and inorganic) that is found in the stream bank.

Intermittent Flow: Stream flow that ceases seasonally, at least once a year.

Langley: A unit of solar radiation equivalent to one gram calorie per square centimeter of irradiated surface.

Large Woody Debris (LWD): Pieces of woody debris located in the stream channel at least 36 inches in diameter and 50 feet in length.

LWD per 100 m: A measure of instream roughness and large woody debris frequency. The number of pieces of woody debris with a minimum diameter of 24 inches and at least 50 inches in length divided by the primary channel length and multiplied by 100 meters.

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.

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.

Macrophytes: Large vascular plants and bryophytes (mosses and liverworts). Some large members of periphyton, such as long filaments of green alga Cladophora, may also be classified as Macrophytes.

Mass Movement: The movement of soil due to gravity, such as: landslides, debris avalanches, rock falls and creep.

Measured Daily Solar Radiation Load: The rate of heat energy transfer originating from the sun as determined by using a Solar Pathfinder©.

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.

Periphyton: Algae and other small autotrophs that are attached to substrate (submerged rocks, vegetation, etc.). Periphyton consist of complex assemblages of diatoms, green algae, and cyanobacteria (blue-green algae) and, to a lessor degree, yellow-brown algae, euglenoids and red algae.

pH: A measure of the hydrogen ion active concentration in aqueous solutions ($pH = -\log_{10}\{H^+\}$). Acidic solutions have a pH less than 7, neutral solutions have a pH of 7, and basic solutions have a pH that is greater than 7.

Peak Flow: The largest flow volume occurring during a storm event.

Perennial Flow: Stream flow that persists throughout all seasons, yearlong.

Phytoplankton: algae and other small autotrophs which are suspended in the water column

Pools: Number of pools reported in the survey reach of a stream.

Pools per 100 m: The frequency of pools observed in the survey reach per 100 meters of stream length. Calculated as the number of observed pools in the reach multiplied by 100 meters and divided by the primary channel length.

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: Channel width of a stream reported in meters.

Rate: A measurable occurrence over a specified time interval.

Reach: Survey reaches in the same stream, numbered for organization.

Redd: An anadromous fish nest made in the gravel substrate of a stream where a fish will dig a depression, lay eggs in the depression and cover it forming a mound of gravel.

Residual Pool Depth: Average pool depth reported in meters.

Riparian Area: A geographic area that contains the aquatic ecosystem and the upland areas that directly affect it. Also defined as 360 feet from a fish bearing stream and 180 feet from a non-fish bearing stream.

Sac Fry: Larval salmonid that has hatched, but has not fully absorbed the yolk sac and has not emerged from the redd.

Sediment: Fragmented material that originates from the weathering of rocks and is transported by, suspended in, or deposited by water or air.

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.

Site Potential: Physical and biological conditions that are at maximum potential, taking into account local natural environmental constraints and conditions.

Smolt: Juvenile salmonid one or two years old that has undergone physiological changes adapted for a marine environment. Generally, the seaward migrant stage of an anadromous fish species.

Soil Compaction: Activities/processes, vibration, loading, pressure, that decrease the porosity of soils by increasing the soil bulk density $\left(\frac{\text{Weight}}{\text{Unit Volume}}\right)$.

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.

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.

Surface Erosion: Detachment, entrainment, and transport of flood plain or upslope soil particles by wind and 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.

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.

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 nonpoint 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 nonpoint 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 nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs” (340-04l-006(21))

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.

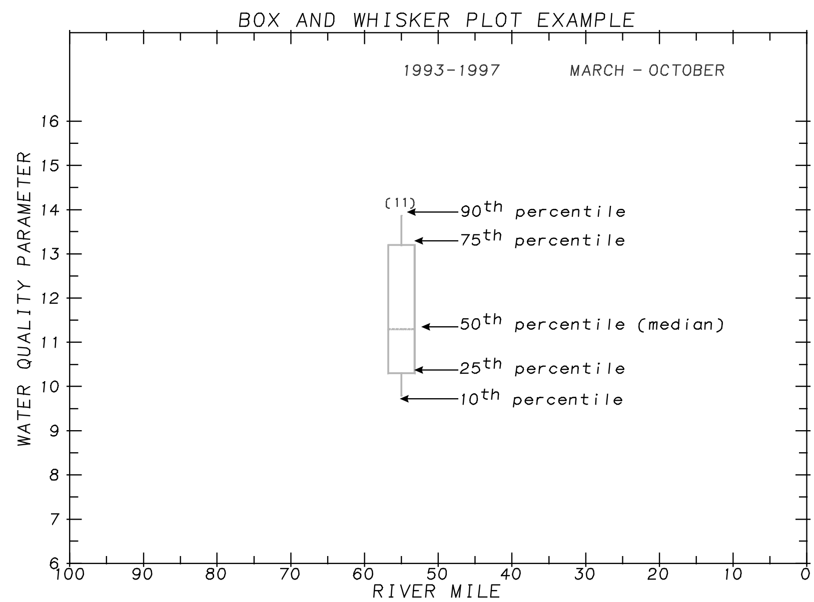
Watershed: A drainage basin that contributes water, organic material, dissolved nutrients, and sediment to streams, rivers, and lakes.

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))

Width:Depth Ratio: The width of channel divided by the average depth in the survey reach of a stream.

Statistical Terminology

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 75^{th} percentile (75 percent of the data are below that concentration), and the lower corner is the 25^{th} percentile (25 percent of the data are below that concentration). The upper and lower tails are the 90^{th} and 10^{th} percentiles, respectively. Points above and below the tails represent data higher and lower than the 90^{th} and 10^{th} percentiles. The dashed line in the box is the median concentration for that site (half of the data fall above and below that concentration).

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.

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

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.

Mean (μ): Refers to the arithmetic mean.

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

Median: A value in the data in which half the values are above and half are below.

Reach Averaged: An average that is based on the occurrence of a property weighted by the occurrence frequency over perennial stream length.

Standard Deviation ( ): The measure of how widely values are dispersed from the mean (μ).

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

Tempertaure Statistic: The maximum seasonal seven (7) day moving average of the daily maximum stream tempertaures.

Page Left Blank Intentionally

References

Ambrose, R.B., T.A. Wool, J.P.Connolly, and R.W. Schanz, 1988. WASP4, A hydrodynamic and water quality model—model theory, user's manual, and programmer's guide (model developed by D.M. DiToro, J.J. Fitzpatrick, and R.V. Thomann of HydroQual, Inc.). Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, Georgia

Allan, J.D. 1995. *Stream ecology, structure and function of running waters.* Chapman & Hall, London.

Baumgartner, B. 1996. Analysis of MZ data using QUAL2EU. ODEQ Memo to File.

Bell, M.C. 1986. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, U.S. Army Corps of Engineers, North Pacific Division. Portland, Oregon, 290 pp.

Beschta, R.L, R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. Pp. 191-232. *In*: E.O. Salo and T.W. Cundy (eds), Streamside Management: Forestry and Fishery Interactions. University of Washington, Institute of Forest Resources, Contribution No. 57. 471 pp.

Beschta, R.L. and J. Weatherred. 1984. A computer model for predicting stream temperatures resulting from the management of streamside vegetation. USDA Forest Service. WSDG-AD-00009.

Beschta, R.L., S.J. O'Leary, R.E. Edwards, and K.D. Knoop. 1981. Sediment and Organic Matter Transport in Oregon Coast Range Streams. Water Resources Research Institute. OSU. WRRI-70.

Bjornn, T.C. 1974. Sediment in streams and its effects on aquatic life. Moscow, Idaho: Water Resources Research Institute, Research Technical Completion Report, Project No. B-025-IDA.

Bohle, T.S. 1994. Stream temperatures, riparian vegetation, and channel morphology in the Upper Grande Ronde River Watershed, Oregon. Department of Forest Engineering, Oregon State University, Corvallis, Oregon.

Bowen, I.S. 1926. The ration of heat loss by convection and evaporation from any water surface. Physical Review. Series 2, Vol. 27:779-787.

Boyd, M.S. 1996. Heat Source: stream temperature prediction. Master's Thesis. Departments of Civil and Bioresource Engineering, Oregon State University, Corvallis, Oregon.

Brett, J.R. 1952. Temperature Tolerance in Young Pacific Salmon, Genus ***Oncorhynchus***. *J. Fish. Res. Bd. Can*., 9(6):265-323.

Brown, G.W. 1983. Chapter III, Water Temperature. Forestry and Water Quality. Oregon State University Bookstore. Pp. 47-57.

Brown, G.W. 1970. Predicting the effects of clearcutting on stream temperature. *Journal of Soil and Water Conservation.* 25:11-13.

Brown, G.W. 1969. Predicting temperatures of small streams. *Water Resour. Res.* 5(1):68-75.

Brown, L.C. and T.O. Barnwell. 1987. *The enhanced stream water quality models qual2e and qual2e-uncas: documentation and user manual*. U.S. Environmental Protection Agency, Athens, Georgia.

Bureau of Land Management (BLM), 1998. WODIP Guidebook: Western Oregon Digital Image Project. Oregon.

Chapra, S.C. 1997. *Surface water-quality modeling.* McGraw-Hill.

Chen, D.Y. 1996. Hydrologic and water quality modeling for aquatic ecosystem protection and restoration in forest watersheds: a case study of stream temperature in the Upper Grande Ronde River, Oregon. Ph.D. Dissertation. University, of Georgia. Athens, Georgia.

Chow, V.T. 1959. *Open Channel Hydraulics*. New York: McGraw-Hill Co.

Clarke, S.E. and S.A. Bryce. 1997. Hierarchical subdivisions of the Columbia Plateau and Blue Mountains Ecoregions, Oregon and Washington. Gen. Tech. Rep. U.S. Department of Agriculture, Forest Service, Portland, OR.

Clasunitzer, R.R. and E.A. Crowe. 1997. Mid-Montane Wetland Plant Associations of the Malheur, Umatilla and Wallowa-Whitman National Forests. United States Department of Agriculture Forest Service, Pacific Northwest Region. Technical Paper R6-NR-ECOL-TP-22-97.

Cole, T.M. and E.M. Buchak, 1994. *CE-QUAL-W2: A two-dimensional lateraly averaged, hydrodynamic and water quality model, version 2.0 – User manual*. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79-31. USDI Fish and Wildlife Service, Washington, DC. 131 pp.

Evans, J.W. 1990. *Powerful Rocky: The Blue Mountains and the Oregon Trail, 1811-1883*. Eastern Oregon State College, La Grande, OR.

Everest F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and D.J. Cederholm. 1987. Fine Sediment and salmonid production a paradox. in *Streamside Management Forestry and Fishery Interactions*. Salo and Cundy Eds. College of Forest Resources. University of Washington, Seattle WA.

Geiger, R. 1965. *The Climate Near the Ground*. Harvard University Press. Cambridge, Massachusetts.

Gildemeister, J., 1999. The Grande Ronde Watershed History Report. Completed for the Dept. of Natural Resources, CTUIR, Mission, OR.

Halliday D. and R. Resnick. 1988. *Fundamentals of Physics*. 3rd Edition. John Wiley and Sons, New York. pp. 472-473.

Harbeck, G.E. and J.S. Meyers. 1970. Present day evaporation measurement techniques. J. Hydraulic Division. A.S.C.E., Prceed. Paper 7388.

Heath A.G. and G.M. Hughes, . 1973. Cardiovascular and respitory changes during heat stress in rainbow trout *(**Salmo gairneri**)*. *J. Exp. Biol*., 59:323-338.

Hines, C.A. 1999. Evaluating the Restoration Potential of Black Cottonwood (Populus trichocarpa) from multiple scales of observation, Grande Ronde River Basin, Oregon, USA. Master's Thesis. Department of Forest Science, Oregon State University. Corvallis Oregon.

Hogan, J.W. 1970. Water temperature as a source of variation in specific activity of brain acetylcholinesterase of bluegills. *Bull. Environment. Contam. Toxicol*., 5:347-353.

Hokanson, K.E.F., C.F. Kleiner and T.W. Thorslund. 1977. Effects of Constant Temperatures and Diel Temperature Fluctuations on Specific Growth and Mortality Rates and Yield of Juvenile Rainbow Trout, ***Salmo gairdneri****. J. Fish. Res. Bd. Can*., 34:639-648.

Holaday, S.A. 1992. Summertime water temperature trends in Steamboat Cr. basin, Umpqua National Forest. Master's Thesis. Department of Forest Engineering, Oregon State University, Corvallis, Oregon.

HydroQual, 1995. South Florida Water Management District Wetlands Model: Model Design. HydroQual, Inc., 1 Lethbridge Plaza, Mahwah, New Jersey

Ibqal, M. 1983. An Introduction to Solar Radiation. Academic Press. New York. 213 pp.

Iwamoto R.N., E.O. Salo, M.A. Madej, R.L. McComas. 1978. Sediment and water quality: A review of the literature including a suggested approach for water quality criteria. EPA 910/9-78-048.

Jobson, H.E. and T.N. Keefer. 1979. Modeling highly transient flow, mass and heat transfer in the Chattahoochee River near Atlanta, Georgia. Geological Survey Professional Paper 1136. U.S. Gov. Printing Office, Washington D.C.

Khan, H.R., 1971. Laboratory Studies of Alluvial river Channel Patterns. Ph.D. Dissertation, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO.

Kovalchik, B.L. 1987. Riparian zone associations of the Deschutes, Ochoco, Fremont and Winema National Forests. R6ECOLTP279/87. Portland, OR:U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 171 pp.

Li, H.W., G.L. Lamberti, T.N. Pearsons, C.K. Tait, J.L. Li and J.C. Buckhouse. 1994. Cumulative effects of riparian disturbance along high desert trout streams of the John Day Basin, Oregon. *Am. Fish Soc.* 123:627-640.

Martin, J. L. and S. C. McCutcheon. 1999. *Hydrodynamics and Transport for Water Quality Modeling*. Lewis Publishers. Washington, D. C.

McIntosh, B.A. 1992. Historical changes in anadromous fish habitat in the Upper Grande Ronde River, Oregon, 1941-1990. Master's Thesis. Oregon State University. Oregon. 87 pp.

McIntosh, B.A. 1995. Historical changes in stream habitats in the Columbia River Basin. PhD. Dissertation. Oregon State University. Oregon.

McIntosh, B. 1999. Grande Ronde River FLIR data acquisition. Personal Communication.

Metcalf and Eddy. 1991. Wastewater Engineering – Treatment Disposal Reuse. 3rd edition. McGraw-Hill, Inc. San Francisco.

Newcombe C.P. and D.D. MacDonold. 1991. Effects of suspended sediment on aquatic ecosystems. North American Journal of Fishery Management. 11:72-82

Oregon Department of Environmental Quality. 1999. *Draft Upper Grande Ronde River Sub-basin temperature total maximum daily load (TMDL).* January, 1999. State of Oregon Department of Environmental Quality, Portland, Oregon.

Oregon Department of Environmental Quality. 1997. Water Quality Management Plan Guidance.

Oregon Department of Environmental Quality. 1995. 1992-1994 Water Quality Standards Review. DO issue paper.

Oregon Department of Environmental Quality. 1995a. River Basin Assessment - Upper/Middle Grande Ronde River and Catherine Creek. June, 1995

Oregon Department of Environmental Quality. 1994. Grande Ronde River, Results of Temperature Monitoring, 1992 and 1993 Field Seasons (undated, 1994 date assumed).

Oregon Coastal Salmon Restoration Initiative (CSRI). 1997. State Agency Measures.

Owens, M., R.W. Edwards and J.W. Gibbs. 1964. Some reaeration studies in streams. *International J. of Air and Water Pollution*, vol.8, no.8/9, pp.469-486, September, 1964.

Park, C. 1993. SHADOW: stream temperature management program. User's Manual v. 2.3. USDA Forest Service. Pacific Northwest Region.

Parker, F.L. and P.A. Krenkel. 1969. Thermal pollution: status of the art. Rep. 3. Department of Environmental and Resource Engineering, Vanderbilt University, Nashville, TN.

Rishel, G.B., Lynch, J.A. and E.S. Corbett.. 1982. Seasonal stream temperature changes following forest harvesting. *J. Environ. Qual.* 11:112-116.

Rosgen, D. 1996. *Applied River Morphology*. Wildland Hydrology. Pagosa Springs, CO.

Satterland, D.R. and P.W. Adams. 1992. *Wildland Watershed Management. 2nd edition*. John Wiley and Sons, Inc., New York.

Schnurbusch, S. 1996a. Ammonia Toxicity - Grande Ronde River. Memorandum to File, Oregon Department of Environmental Quality, January 24, 1996.

Schnurbusch, S. 1996b. Grande Ronde River TMDL Analysis for the La Grande WWTP. Memorandum to File, Oregon Department of Environmental Quality, April 18, 1996.

Sellers, W.D. 1965. Physical Climatology. University of Chicago Press. Chicago, IL. 272 pp.

Sinokrot, B.A. and H.G. Stefan. 1993. Stream temperature dynamics: measurement and modeling. *Water Resour. Res.* 29(7):2299-2312.

Snoeyink, V.L. and D. Jenkins. 1980. *Water Chemistry*. John Wiley & Sons, New York.

Stedinger, J.R., R.M. Vogel, and E. Foufoula-Georgiou. Frequency Analysis of Extreme Events. *Handbook of Hydrology*, 1993, D.R. Maidment, editor in chief. McGraw-Hill, Inc., New York

Stumm, W. and J.J. Morgan. 1981. *Aquatic chemistry, an introduction emphasizing chemical equilibria in natural waters, 2nd. Edition.* John Wiley & Sons, New York.

Tappel, P.D. and T.C. Bjornn. 1993. A new method of relating size of spawning gravel to salmonid embryo survival. *N. Am. Journal Fish Mgmt*. 3:123-135.

Thomann, R.V. and J.A. Mueller. 1987. *Principles of surface water quality modeling and control.* Harpor & Row, New York.

Torgersen, C.E., D.M. Price, H.W. Li, and B.A. McIntosh. 1995. Thermal refugia and chinook salmon habitat in Oregon: Applications of airborne thermal videography. Proceedings of the 15th Biennial Workshop on Color Photography and Videography in Resource Assessment, Terre Haute, Indiana. May, 1995. American Society for Photogrammetry and Remote Sensing.

U.S. Fish Commission. 1894. Bulletin of the United States Fish Commission, Volume XIV. Government Printing Office, Washington, D.C.

U.S. Forest Service (USFS) and Bureau of Land Management (BLM). 1995. "Interim Strategies for Managing Anadromous Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, and portions of California [**PACFISH**]".

U.S. Forest Service. 1994. Upper Grande Ronde Watershed Analysis.

U.S. Environmental Protection Agency. 1985. Rates, constants, and kinetics formulations in surface water quality modeling (2nd ed.). (G.L. Bowie, W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopf, G.L. Rupp, K.M. Johnson, P.W.H. Chan, S.A. Gherini, C.E. Chamberlin, and T.O. Barnwell). EPA/600/3-85/040

U.S. Environmental Protection Agency. 1998. Report of the Federal Advisory Committee on theTotal Maximum Daily Load Program. EPA 100-R-98-006.

U.S. Environmental Protection Agency. 1993. Land Cover Classification for the Upper Grande Ronde. Unpublished.

Webster, James, Personal Communications, 1999. Upper Grande Ronde Sub-basin WQMP edits and additions, Watershed Hydrologist, CTUIR.

Wunderlich, T.E. 1972. Heat and mass transfer between a water surface and the atmosphere. Water Resources Research Laboratory, Tennessee Valley Authority. Report No. 14, Norris Tennessee. Pp. 4.20.

Page Left Blank Intentionally

Page Left Blank Intentionally

Oregon Department of Environmental Quality
Water Quality Division
811 Southwest 6th Avenue
Portland, Oregon 97204

This document can be accessed on the Internet

http://waterquality.deq.state.or.us/wq/