APPLEGATE SUBBASIN
TOTAL MAXIMUM DAILY LOAD (TMDL)
HUC # 17100309

Applegate River   Mile 8

Applegate River   Mile 39

Little Applegate River   Near Mouth

Beaver Creek   Mile 3

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Prepared by
Oregon Department of Environmental Quality

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Statement of Purpose
This Total Daily Maximum Load (TMDL) document has been prepared to meet the requirements of Section 303(d) of the 1972 Federal Clean Water Act.

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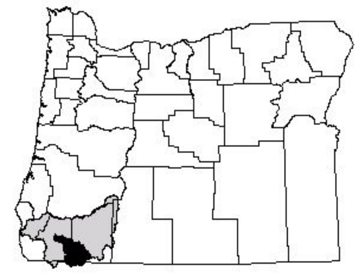
EXECUTIVE SUMMARY

Rogue Basin and Applegate Subbasin



WATER QUALITY SUMMARY

Introduction

The following document contains the required components for a Total Maximum Daily Load (TMDL) as described by the US Environmental Protection Agency (EPA) for compliance with the Federal Clean Water Act. The document and its appendices provide a thorough analysis of pollutant sources and accumulation processes in the Applegate Subbasin.

Scope

The Applegate Subbasin encompasses an area of approximately 770 square miles located in southern Oregon and northern California. There are approximately 90 square miles in the headwaters section of the subbasin located within the State of California. Of these California lands, 79 square miles are managed by the Medford office of the USFS and 11 square miles are privately owned. This TMDL provides an analysis for all lands in the subbasin; however, Oregon Administrative Rules (OARs) that set water quality criteria apply only to those lands within the State of Oregon. Within the California lands there are currently no 303(d) listed streams (CA State Water Resources Control Board: http://www.swrcb.ca.gov/tmdl/303d_lists.html.).

Legal Requirements

Under Section 303(d) of the Clean Water Act, the EPA or its state delegates are required to develop a list of the surface waters in each state that do not meet water quality criteria. These criteria are developed by each of the states to protect "beneficial uses" and must be approved by EPA. The resulting "303(d) list" is based on the best available data and, in most cases, must be revised every two years. Water bodies that are listed as impaired must have TMDLs developed for each pollutant.

Listed Parameters

This TMDL document addresses all listings on the 1998 303(d) list and all temperature listings on the 2002 303(d) list for the Applegate Subbasin (18 TMDL segment listings). At the time of the writing of this document it was impractical to address the additional 2002 listings (9 dissolved oxygen listings were added to the 2002 list). The additional parameters in the 2002 list will be addressed by DEQ as part of the five-year review of this plan and are not a part of this document.

Parameters addressed in this TMDL includes temperature, biological criteria, and sedimentation. Of the 700 miles of streams and creeks in the Applegate Subbasin, approximately 126 miles of streams are known to exceed the 64°F summer rearing temperature criterion, 2 miles of streams exceed the 55°F spawning temperature criterion, 9 miles exceed the biological criterion, 9 miles exceed the sedimentation criterion.

TMDL SUMMARIES

TMDL Load Capacity and Allocations:

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)). A loading capacity provides the reference for calculating the amount of pollutant reduction needed to bring waters into compliance with standards. The loading capacity can be divided into the sum of pollution coming from point sources plus the sum of pollution from nonpoint sources [40 CFR 130.2(i)]. Point sources in the Applegate Subbasin include National Pollutant Discharge Elimination System (NPDES) permitted facilities and recreational suction dredging. Nonpoint sources include forestry activities, agriculture activities, roads, highways, bridges and rural residential and urban development. Applegate Dam also receives a portion of the loading capacity.

Temperature TMDL:

The numeric temperature criteria for cold water salmonids in the Applegate Subbasin is a seven (7) day moving average of daily maximum temperature not to exceed 64°F (17.8°C) during times when salmonid rearing is a beneficial use (August-September) and 55°F (12.8°C) during times and in waters that support salmon spawning, egg incubation and fry emergence from the egg and in gravels (October-July).

This TMDL analysis focused on the August-September period of maximum solar load and maximum stream temperatures. Under current conditions models predict that approximately 90% of the Applegate River and 10% of the Little Applegate River exceed the 64°F criteria during the hottest time of year (usually occurring in early August).

The water temperature criteria indicates that an exceedance of the 64°F numeric trigger invokes a condition that requires "no measurable surface water temperature increases resulting from anthropogenic activities." To meet the condition of no anthropogenic inputs, point source temperature inputs are set to "no measurable increase" and nonpoint source impacts are set to a natural conditions scenario known as system potential.

System potential is defined as an estimate of a condition without anthropogenic activities that disturb or remove near stream vegetation. This condition is defined by riparian vegetation that is mature and undisturbed; vegetation height and density at or near the potential expected for the given plant community, vegetation buffer is sufficiently wide to maximize solar attenuation (Note: Buffer widths required to meet the system potential target will vary given potential vegetation, topography, stream width, and aspect.), vegetation width accommodates channel migrations.

A TMDL allows for the use of "*other appropriate measures*" or surrogate measures as provided under EPA regulations [40 CFR 130.2(i)]. In addition to system potential, percent-effective shade serves as the other appropriate or surrogate measure for meeting the temperature TMDL.

Stream temperature modeling, using the HEATSOURCE 6.0 model (Boyd 1996) demonstrates that significant reductions in temperature can be attained by increasing riparian vegetation and shade to that of system potential. At system potential, however, the Applegate River is not expected to achieve the water quality criteria of 64°F during the hottest time of the year. The Heat Source model predicts that during the hottest time of year 90% of the steam will reach a maximum temperature greater than 64°F and 69% will be greater than 68°F. At system potential 89% will reach a maximum temperature greater than 64°F and 49% will be greater than 68°F. This is the result of percent-effective shade increasing from an average of 4% on the Applegate under current conditions to an average of 13% at system potential. The Little Applegate River tributary is expected to achieve the 64°F criterion at system potential for the day modeled as percent-effective shade increases from 75% currently to 93% at system potential.

One hundred percent of the temperature load allocation for this subbasin is assigned to natural background sources. Any activity that results in anthropogenic caused heating of the stream is considered unacceptable (Table 1). To determine compliance with the temperature TMDL, surrogate percent-effective shade targets have been set for all perennial streams in the watershed. Percent-effective shade is used as a surrogate target for system potential loading because it provides a field measurable parameter to monitor and can be directly translated into site specific restoration targets.

Table 1: Applegate Subbasin Temperature TMDL Load Allocation

Nonpoint Sources: Load Allocations by Land Use	
Source	***Load Allocation*** ***Distribution of Solar Radiation Loading Capacity***
Natural	100%
Agriculture	0%
Forestry	0%
Urban	0%
Transportation	0%
Future Sources	0%
Point Sources: Waste Load Allocations by Source	
Source	***Waste Load Allocation*** ***Distribution of Point Source Loading Capacity***
Current and Future NPDES Permit holders	No Measurable Increase[1] over System potential Surface Water Temperatures
NPDES Permitted Activities: Recreational Mining	No Measurable Increase[1] in Surface Water Temperatures
Dams: Load Allocation	
Source	***Waste Load Allocation*** ***Distribution of Point Source Loading Capacity***
Applegate Dam	No Measurable Increase in Surface Water Temperatures[1] above that which would occur under natural conditions

[1]No measurable increase is defined as no more than 0.25°F

The rule applicable to the Applegate Dam is "unless specifically allowed under a DEQ-approved surface water temperature management plan as required under OAR 340-041-0026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:" For the Applegate Dam, no measurable increase is considered to be no more than a 0.25°F increase over that which would occur if the dam were not present. Actual heat loads for the dam are estimated from 6.2×10^7 to 2.0×10^8 kcal/day depending on flow at the dam outfall (Table 19).

ODFW data indicates that the 0.25°F increase is exceeded October through February. The US Army Corps of Engineers (USACE) has worked with Oregon Department of Fish and Wildlife (ODFW) to develop a release schedule that maximizes benefits to chinook salmon and winter steelhead (Fustich et.al. 1988, Fustich et.al. 1995). These target temperatures and flow recommendations form the foundation of a temperature management plan (TMP); however, DEQ requests that the USACE work with the Department to submit a formal TMP.

Sedimentation:

Beaver Creek from its mouth to the headwaters (8.7 miles) is included on the 1998 303(d) list for sedimentation. This listing was determined after an analysis of macroinvertebrate populations indicated an impairment due to excessive fine sediments (Schroeder, P.C., 2002, USFS, 1994). Beaver Creek is also on the 1998 303(d) list for temperature, biological criteria, habitat modification, and flow modification (Note: habitat modification and flow modification have been delisted on the 2002 303(d) list).

The State of Oregon does not currently have a criteria that specifies a concentration of sediment or a proportion of bottom sediments that will protect beneficial uses such as macroinvertebrates or salmonid spawning. In this TMDL, the sediment loading capacity for all streams in the Beaver Creek Analytical Watershed is the amount of sediment resulting in no more than 33% cobble embeddedness. The achievement of the load capacity will result in the restoration of macroinvertebrate populations.

To meet the sediment load capacity, the sedimentation TMDL uses an "other appropriate measures" approach identifying the following three surrogate measures: 1) restore system potential riparian vegetation within the Beaver Creek Analytical Watershed, 2) achieve road density targets set for each drainage, 3) achieve road crossing targets set for each drainage. Long-term monitoring of V* (fraction of pool volume filled with fine sediment) and macroinvertebrate populations and the adaptive management nature of this TMDL will be used to evaluate the effectiveness of these surrogate measures over time.

Biological Criteria:

Beaver Creek from its mouth to the headwaters (8.7 miles) is on the 1998 303(d) list for biological criteria due to an impairment of macroinvertebrate populations. In Beaver Creek the macroinvertebrate community impairments are the result of habitat limitations created by an excess of fine sediments and excessive summer temperatures (Schroeder P.C. 2002, USFS 1994). Beaver Creek is also on the 1998 303(d) list for temperature, sedimentation, habitat modification, and flow modification (Note: habitat modification and flow modification have been delisted on the 2002 303(d) list).

The Applegate Subbasin TMDL allocations set to meet both the sedimentation and temperature TMDLs (riparian shade, streambank and channel restoration, stabilization of sediment sources) will restore the macroinvertebrate communities in Beaver Creek. Long-term monitoring of the macroinvertebrate populations and the adaptive management nature of this TMDL will be used to evaluate this approach over time.

Flow Modification:

Flow 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. Note: flow modification has been delisted on the 2002 303(d) list.

Habitat Modification:

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. Note: habitat modification has been delisted on the 2002 303(d) list).

WATER QUALITY MANAGEMENT PLAN

A Water Quality Management Plan (WQMP) is included as a companion document to this TMDL. This document explains the roles of various land management agencies, federal, state, and local governments, as well as private landowners in implementing the actions necessary to meet the allocations set forth in the TMDLs and is intended to fulfill the requirements for implementing a TMDL as described in OAR 340-042-0080. The WQMP for the Applegate Subbasin focuses specifically on the following plans and the Designated Management Agencies (DMAs) to which they apply:

- State Forest Lands (Forest Practices Act);
- Federal Forest Lands (Northwest Forest Plan);
- Private Agricultural Lands (Inland Rogue Agricultural Water Quality Management Area Plan – SB1010);
- Jackson and Josephine County Ordinances;
- The Applegate and the Williams Creek Watershed Council Action Plans
- The Little Applegate River Watershed Management Plan – Integrating the Endangered Species Act and the Clean Water Act.
- The Little Applegate Owner's Manual: A landowners guide to good stewardship in the Little Applegate River Watershed.
- Oregon Department of Transportation: routine road maintenance to protect water quality and fish habitat.

SECTION 1. APPLEGATE SUBBASIN TMDL BACKGROUND AND INTRODUCTION

This document seeks to clearly address the elements required by EPA for a Total Maximum Daily Load (TMDL). The TMDL and its associated Water Quality Management Plan (WQMP) were prepared by the Oregon Department of Environmental Quality (DEQ) with assistance from local partners.

OREGON'S TMDL PROGRAM (GENERALLY DEFINED)

The quality of Oregon's streams, lakes, estuaries, and groundwater is monitored by DEQ and a variety of partners. This information is used to determine whether water quality criteria are being violated and whether the beneficial uses of the waters are being threatened. Specific State and Federal plans and regulations are used to determine if violations have occurred: these regulations include the Federal Clean Water Act of 1972 and its amendments (40 Codified Federal Regulations 131), Oregon's Administrative Rules (OAR Chapter 340**)** and Oregon's Revised Statutes (ORS Chapter 468). Since the Applegate Subbasin crosses state lines, this TMDL covers only those lands within the State of Oregon as per OAR Chapter 340, (4)(c) "For interstate waterbodies, the State shall be responsible for completing the requirements of section (3) of this rule for that portion of the waterbody within the boundary of the state."

The term *water quality limited* is applied to streams and lakes where required treatment processes are being used, but violations of state water quality criteria still occur. With a few exceptions, such as in cases where violations are due to natural causes, the State must establish a TMDL for any waterbody designated as water quality limited. A TMDL is the maximum amount of a pollutant (from all sources) that can enter a specific waterbody without causing a violation of water quality criteria.

The total permissible pollutant load is allocated to point, nonpoint, background, future sources of pollution and a margin of safety. Wasteload Allocations are portions of the total pollutant load that are allotted to point sources of pollution, such as sewage treatment plants or industries and are used to establish effluent limits in discharge permits. Load Allocations are portions of the TMDL that are attributed to either natural background sources, such as natural runoff or background solar loading, or from nonpoint sources, such as roads, agriculture or forestry activities. Allocations can also be set aside in reserve for future uses.

The Clean Water Act requires that each TMDL be established with a margin of safety. This requirement is intended to account for uncertainties in the available data or in the effectiveness of control actions. The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, wasteload allocations, and loading allocations. The margin of safety may also be explicitly stated as an added separate allocation in the TMDL calculation. The margin of safety is not meant to compensate for a failure to consider known sources. Implicit margins of safety were developed for temperature and sediment in this TMDL and will be discussed further.

DOCUMENT ORGANIZATION

As defined in OAR 340-042-0040 a Total Maximum Daily Load will contain the following elements:

- Name and Location
- Pollutant Identification
- Water Quality Standards and Beneficial Uses
- Loading Capacity
- Excess Load
- Sources and Source Catagories
- Wasteload Allocations
- Load Allocations
- Margin of Safety

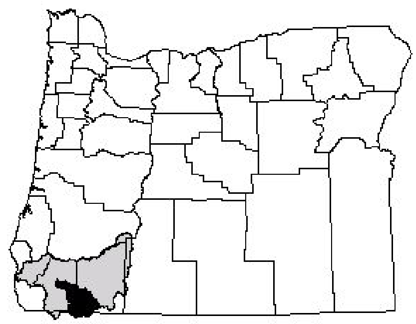
- Seasonal Variation
- Reserve Capacity
- Water Quality Management Plan

WATERSHED CHARACTERIZATION

Geographic Setting

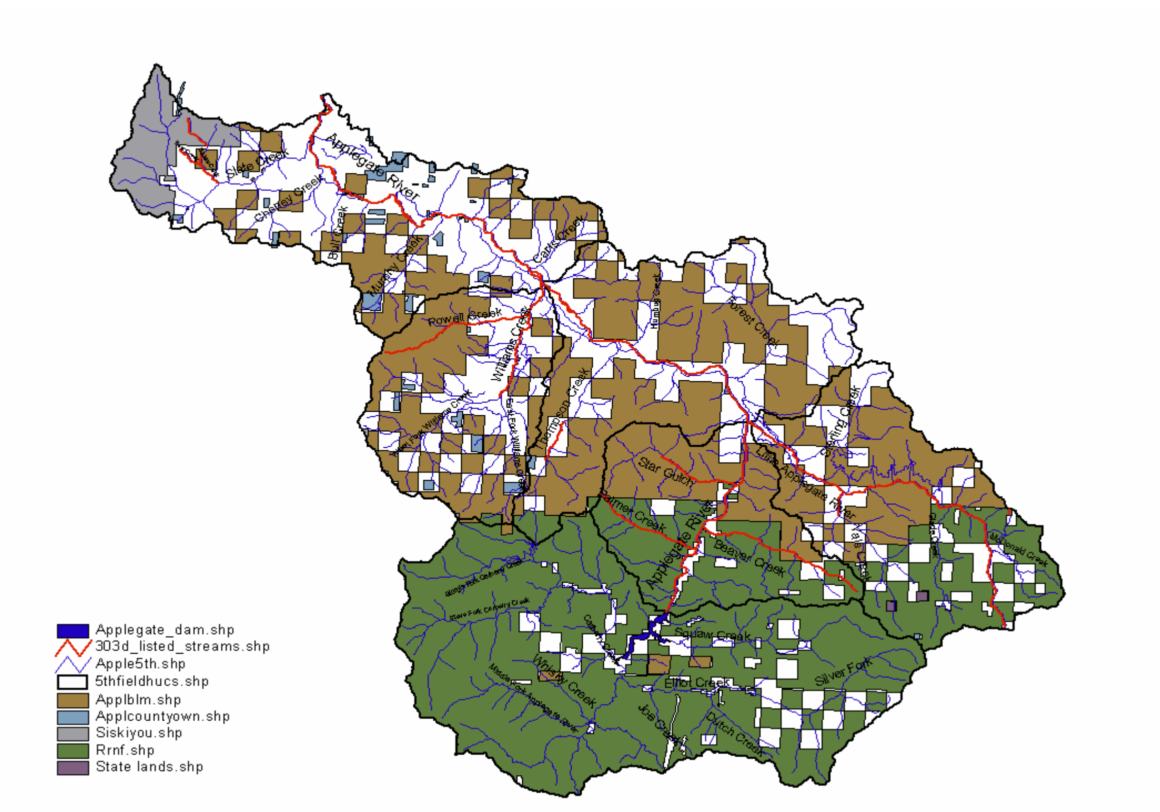
The Applegate Subbasin is an important part of the diverse 3,300,000 acre (5,156 square miles) Rogue River Basin. Map 1 shows the location of the Applegate Subbasin within the Rogue Basin. The 493,000 acre (770 square mile) Applegate Subbasin includes lands in Jackson County, Oregon (approximately 410 square miles), Josephine County, Oregon (approximately 270 square miles) and in Siskiyou County, California (approximately 90 square miles). The subbasin is located on the northeastern flank of the Siskiyou Mountains in southwestern Oregon. This is one of the most biologically, botanically, and geologically diverse areas in the country. It is steep and rugged, ranging in elevation from 850 feet to 7,418 feet above sea level.

Map 1. Rogue Basin and Applegate Subbasin



Numerous small tributaries flow into the Applegate River which joins the Rogue River near the City of Grants Pass in Josephine County. Map 2 shows the rural communities, primary tributaries, and peaks in the Applegate Subbasin. There are no incorporated towns within the subbasin. Major communities include Wilderville, Wonder, Murphy, Williams, Applegate, Ruch and McKee Bridge. The subbasin contains approximately 700 miles of streams.

Map 2. Applegate Subbasin Ownership



Ownership

Over 68 percent of the lands within the Applegate Subbasin are federally owned

The 493,000 (770 square miles) Applegate Subbasin includes lands in Jackson County (approximately 410 square miles) and Josephine County (approximately 270 square miles) in Oregon and in Siskiyou County, California (approximately 90 square miles). There are no incorporated towns within the subbasin. Major communities include Wilderville, Wonder, Murphy, Provolt, Williams, Applegate, Ruch and McKee Bridge. The population in the subbasin has increased from 3025 in 1970, to 9000 in 1980, to 12250 in 1990.

Primary land owners within the subbasin include the US Forest Service, Bureau of Land Management, as well as privately owned residential, agricultural, and timber lands (Map 2) (Table 2).

Table 2. Ownership within the Applegate Subbasin

Ownership[1]	Acres
USFS	197,698 (40%)
BLM	138,034 (28%)
Private	155,318 (32%)
Miscellaneous[2]	1,442 (0.3%)
Tribal Lands	0(0%)
Totals	**492,492 (100%)**

[1] 90 square miles of the subbasin are within the state of California and are outside the jurisdiction of this TMDL. Of these 90 square miles, 79 are part of the Rogue River National Forest and managed as per the rest of the forest. The remainder of the California lands are under private ownership.
[2]Miscellaneous includes state, county, and US Army Corps of Engineers (USACE) ownership.

Geology

The Applegate Subbasin contains some of the oldest (150-250 million years) and most complex geologic assemblages along the U.S. West Coast (Applegate Watershed Assessment, 1994). Bedrock in the subbasin is composed of intrusive and metamorphic rock types which have been faulted, folded and broadly uplifted. Major rock types in the headwaters include granite, graphite/mica schist, serpentine, and medium-grade metamorphosed sedimentary formations. The vast majority of bedrock found in the middle and lowland portions of the basin is composed of weakly metamorphosed volcanic and sedimentary rocks. Notable exceptions are the large granitic intrusion near the confluence with the Rogue River and the large granitic pluton underlying the Williams Valley.

The sediment produced from granitic terrain contains mostly coarse sandy material with little gravel, cobbles or boulders. Deposited granitic sands are usually tightly packed and lack void space needed by many aquatic life forms. Granitic soils are very susceptible to surface erosion and debris slides.

Narrow bands of serpentine bedrock have very cobbley, clay-like soils with a distinct plant community. When vegetation is removed it is often difficult to reestablish because of a nutrient imbalance. The low shear strength of fresh serpentine and the clay-like nature of weathered serpentine make these areas very susceptible to landslides. The more widespread metavolcanic and metasedimentary rocks are generally more stable; however, some soil types developed on these rock formations are susceptible to high erosion rates.

Most of the Applegate Subbasin today is characterized by highly dissected mountain slopes with long, steep, narrow canyons that have been carved into the rugged terrain by high gradient drainage. Steeper slopes in the upper and middle elevations are noted for their relatively high rates of mass wasting and erosion. In general, high erosion rates on the steep slopes cause soil profiles to be relatively thin and rocky. Major valleys have broad, gently sloping landscapes with river valley bottoms characterized by extensive accumulation of river deposits.

Climate and Weather

As a part of interior southwestern Oregon, the Applegate Subbasin has the lowest annual precipitation and highest annual summer temperatures for the west side of the Cascade Mountains between Northern California and the Canadian border. Rainfall ranges from 20 to 100 inches per year with the high elevation glaciated basins receiving over ten feet of snow annually. The rain shadow effect, created by the Siskiyou Mountains, accounts for the relatively light rainfall. Annual rainfall amounts vary widely across the subbasin as the rugged terrain exerts a strong rain shadow and rain-producing effect.

Precipitation usually occurs in the form of rainfall over most of the subbasin with snow falling in the winter at elevations above 5,000 feet. Between 3,500 and 5,000 feet, rain and snow occur with equal frequency; this elevation band is called the transient snow zone. Rain on snow events in this range can cause very high peak flows resulting in severe erosion and flooding.

Hydrology

Stream flow in the Applegate River mirrors the precipitation pattern. Approximately 80 to 90 percent of the annual water yield occurs between December and May. Run-off usually peaks in February and March. Historically, extreme flood events have come in December and January as a result of rain-on-snow events.

Naturally low summer stream flows are directly affected by withdrawals for agriculture and domestic use. The result is seriously depleted stream flows which affect instream fish habitat. The Applegate Dam, completed in 1980, has moderated both high and low flows in the mainstem. An increase in rural population density has been accompanied by an increase in surface and ground water diversion.

Applegate Dam

The Applegate project was authorized by the flood control act of 1962 and constructed by the US Army Corps of Engineers (USACE). Construction of the dam and related structures was completed in fall of 1980 to provide flood control, irrigation, fish and wildlife enhancement, recreation and water quality control benefits. The dam and related structures are currently owned and operated by USACE. Releases from the dam are made in accordance with the USACE standard operating procedures. Water releases and target temperatures are developed in conjunction with Oregon Department of Fish and Wildlife (ODFW) on a yearly basis. The dam is equipped with a multiple level intake tower which allows for the selection of release water temperatures. Flows into the reservoir come from Applegate River and minor tributaries (Elliot and Squaw Creeks). These inflows have ranged from 100,000 acre-feet (AF) to over 750,000 AF annually. The overall average watershed yield (1960-2000) is 317,000 AF per year. The dam is located at mile 45.7 on the Applegate River. It is 4 miles long with about 18 miles of shoreline with a usable storage capacity of 75,200 acre-feet (USACE, 2002).

There is a proposal to use the Applegate Dam for power generation (FERC#11910). First stage consultation on this project was initiated by Symbiotics LLC on September 18, 2002. The proposed project will utilize the existing dam and structures to result in an installed capacity of 12 mega-watts (Mw) generated from a 3Mw and 9Mw unit. The permittee intends to file a license application for the development of the proposed Applegate Dam Hydroelectric Project with the Federal Energy Regulatory Commission (FERC). As this permitting process continues Symbiotics LLC will need to obtain a water quality standards compliance certification statement for the Project from the DEQ, pursuant to requirements of §401 in the Federal Clean Water Act and Oregon Administrative Rules Chapter 340, Division 48. Section 401 of the Federal Clean Water Act establishes requirements for state certification of proposed projects or activities that may result in any discharge of pollutants to navigable waters. This certification will require additional analysis on the effect of the dam and its operations on water quality and requires that the facility be operated in accordance with established load allocations adopted pursuant to a TMDL.

Fisheries

The Applegate River has significant populations of coho, fall chinook, winter and summer steelhead, and resident trout (rainbow and cutthroat). Winter steelhead and fall chinook are the primary anadromous species using the Applegate River system. In addition Pacific lamprey, western brook lamprey, reticulate sculpin, and Klamath smallscale sculpin are present. Nonnative species also exist in the basin: redside shiner, speckeled dace, and Umpqua pikeminnow are also common in the subbasin (USFS, 1994).

Coho salmon in the Rogue and Applegate River Basins belong to the Southern Oregon-Northern California Coast Evolutionary Significant Unit (ESU) which occurs between Cape Blanco, Oregon and Punta Gorda, California. This ESU is listed under the Federal Register (2002) as threatened by NOAA Fisheries. Steelhead in the Rogue and Applegate basins belong to the Klamath Mountain Province ESU, which is inclusive of the Klamath River in California north to the Elk River in Oregon. A recent status review concluded that the listing of Steelhead in this ESU was not warranted (Federal Register, 2001).

All salmonids require a cold freshwater environment for spawning. Each species, however, differs in the extent to which they rear in fresh water. All salmonid species dig a nest (redd) in the gravel bottom of streams where the eggs are deposited by the female and fertilized by the male. Incubation of the egg depends upon the species and is water temperature dependent. After incubation, an alevin (a small fry with an attached egg yolk sac) emerges from the egg into the gravel. Once the egg sac has been completely absorbed, the alevins emerge from the gravel as developed fry.

The salmonid life cycle involves a complex web of instream habitats, ocean conditions and harvest pressure that all combine to impact salmonid populations. Listed below is a brief description of specific habitat needs by species as found in the Applegate Subbasin. A map of known anadromous salmonid containing areas is shown in Map 3.

Coho Salmon (Oncorhynchus kisutch)

Coho are most linked to the complex riverine habitats that were once prevalent in the Applegate River. Spawning of wild coho in the Applegate was historically limited to the upper third of the mainstem Applegate. Coho prefer pools, glides, or slow velocity areas with overhead cover for rearing. Juveniles are territorial and prefer plunge pools, lateral scour pools, and glides during the summer months. They spend the winter months in low gradient braided channel areas where side channels, sloughs, and beaver ponds, are present before migrating to the ocean. They depend on smaller streams that have wide riparian areas with marshes and side channels and pools in off-channel areas, alcoves along the edges of streams and rivers and beaver dams for summer and winter freshwater habitat.

Chinook Salmon (Oncorhynchus tshawytscha)

Most spawning and rearing occurs in the lower segments of larger tributaries and the mainstem of the Applegate River. Prior to the construction of the Applegate dam, the river frequently flowed intermittently during the fall spawning period limiting chinook salmon to the lower 12 miles of the river. Flow releases from the dam increased adult access up to the dam, adding an additional 38 miles of mainstem habitat. Mainstem river edge habitat is used for refuge by fry in the early spring prior to their migration downstream to the estuary. Drought has impacted fall chinook because of reduced water levels.

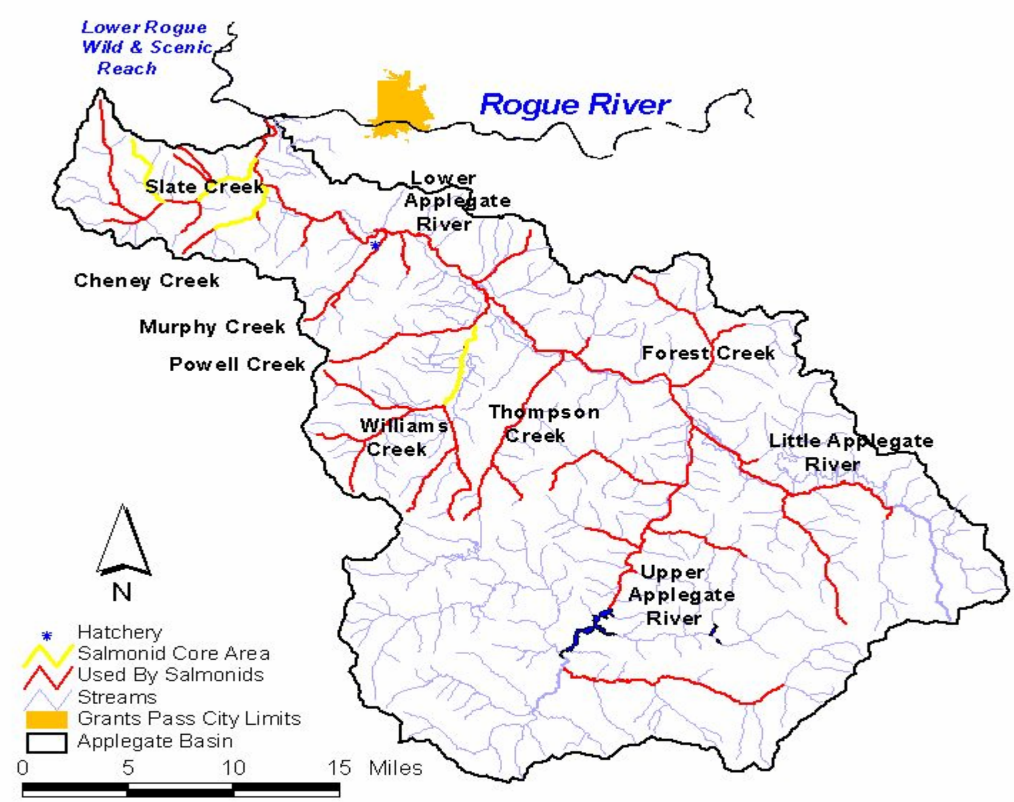
Steehhead (Oncorhynchus mykiss)

Steelhead are rainbow trout which migrate to the ocean. Of the three anadromous species present in the Applegate, steelhead are the most adaptive. The Applegate River is home to two distinct runs of steelhead: summer run and winter run. Steelhead spawn and rear throughout the subbasin, but seem to prefer headwater streams or upper segments of streams. Juvenile steelhead reside in small streams and in the mainstem of the Applegate if temperatures are cool. Unlike the salmon which prefer pools and glides, steelhead are able to rear in fast-moving water. This trait and their variable stay in fresh water from one to four years make them very adaptive to changing habitat conditions, but also most susceptible to high water temperatures. They can compensate somewhat for elevated stream temperatures by seeking turbulent water with more oxygen. Many of the streams preferred by steelhead for spawning dry up in the summer. Drought, exacerbated by water withdrawals, has impacted both adult and juvenile steelhead. Low flows limit adult access to spawning tributaries, forcing steelhead to spawn in the mainstem Applegate, resulting in lower juvenile survival rates.

Applegate Lake has cut off much of the historic winter steelhead habitat in the upper basin such as Carberry Creek, Middle Fork Applegate River, and Elliott Creek. There is a collection facility at the base of Applegate Dam where approximately 400 steelhead adults are collected and transported to Cole Rivers Hatchery where sufficient offspring are raised to produce 120,000 smolts each year for release in April and May at the base of Applegate Dam to replace the estimated 2,000 adults that historically spawned and reared above the dam site.

Resident Trout (Oncorhynchus species)

The Applegate and Rogue Rivers' resident rainbow population is somewhat unusual for coastal basins. Cutthroat trout (Oncorhynchus clarki clarki) are ubiquitous in upper tributaries and headwater streams.



Map 3. Primary Salmonid Waterways in the Applegate Subbasin

WATER QUALITY IMPAIRMENTS

Monitoring has shown that water quality in the Applegate Subbasin does not meet state water quality criteria at all times of the year. This TMDL will address all parameters on the 1998 303(d) list and only temperature on the 2002 303(d) list. Additional listings on the 2002 list will be addressed in 5 years when this TMDL is reviewed. A total of eighteen 303(d) listings are addressed in this TMDL: temperature (16 listings), Sedimentation (1 listing), and Biological criteria (1 listing), NOTE: Habitat (2 listings), Flow (3 listings) on the 1998 303(d) list have been delisted on the 2002 list.
Table 3 below shows the stream reaches addressed in this TMDL together with the water quality criterion that is exceeded, and number of stream miles on the 303(d) list.

Table 3. 303(d) Listings Addressed in the Applegate Subbasin TMDL

303(d) List[1]	Stream Segment	Listed Parameter	Applicable Rule	Miles Affected
1998	Applegate River, mouth to Applegate Reservoir	Summer Temperature	OAR 340-041-0365(2)(b)(A)	50
1998	Applegate River, mouth to Applegate Reservoir	Flow Modification	OAR 340-041-0362 OAR 340-041-0365(2)(I)	50
1998	Beaver Creek, mouth to headwaters	Biological Criteria	OAR 340-041-027 OAR 340-041-0362	8.7
1998	Beaver Creek, mouth to headwaters	Habitat Modification	OAR 340-041-0362 OAR 340-041-0365(2)(I)	8.7
1998	Beaver Creek, mouth to headwaters	Flow Modification	OAR 340-041-0362 OAR 340-041-0365(2)(I)	8.7
1998	Beaver Creek, mouth to headwaters	Sedimentation	OAR 340-041-0362 OAR 340-041-0365(2)(j)	8.7

303(d) List[1]	Stream Segment	Listed Parameter	Applicable Rule	Miles Affected
1998	Applegate River, mouth to Applegate Reservoir	Summer Temperature	OAR 340-041-0365(2)(b)(A)	50
1998	Beaver Creek, RM 3.5 to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	5.3
2002	Beaver Creek, RM 0 to 3.5	Summer Temperature	OAR 340-041-0365(2)(b)(A)	3.5
2002	Humbug Creek, RM 0 to 5	Summer Temperature	OAR 340-041-0365(2)(b)(A)	5.0
1998	Little Applegate River, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	21.0
1998	Palmer Creek, mouth to headwaters	Flow Modification	OAR 340-041-0362 OAR 340-041-0365(2)(I)	5.7
1998	Palmer Creek, mouth to headwaters	Habitat Modification	OAR 340-041-0362 OAR 340-041-0365(2)(I)	5.7
1998	Palmer Creek, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	6.0
1998	Powell Creek, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	8.0
2002	Powell Creek, mouth to RM 2.0	Spawning Temperature Oct 1 – May 31	OAR 340-041-0365(2)(b)(A)	2.0
2002	Slate Creek, RM 0 to 5.3	Summer Temperature	OAR 340-041-0365(2)(b)(A)	5.3
1998	Star Gulch, mouth to 1918 Gulch	Summer Temperature	OAR 340-041-0365(2)(b)(A)	4.0
1998	Thompson Creek, Mee Cove to Ninemile Creek	Summer Temperature	OAR 340-041-0365(2)(b)(A)	2.3
2002	Sterling Creek, mouth to RM 2.5	Summer Temperature	OAR 340-041-0365(2)(b)(A)	2.5
1998	Waters Creek, mouth to RM 2	Summer Temperature	OAR 340-041-0365(2)(b)(A)	2.0
1998	Waters Creek, West Fork, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	1.9
1998	Williams Creek, mouth to East/West Fork confluence	Summer Temperature	OAR 340-041-0365(2)(b)(A)	7.0
1998	Yale Creek, mouth to Waters Gulch	Summer Temperature	OAR 340-041-0365(2)(b)(A)	1.3
Total Stream Miles listed for Summer Temperature Criteria (June 1 to Sept 30)				**126.3**
Total Stream Miles listed for Spawning Temperature Criteria Exceedances (October 1 to May 31)				**2.0**
Total Stream Miles listed for Sedimentation				**8.7**
Total Stream Miles listed for Biological Criteria				**8.7**
Total Stream Miles listed for Habitat Modification Note: habitat modification is delisted on the 2002 303(d) list.				**14.4**
Total Stream Miles listed for Flow Modification Note: flow modification is delisted on the 2002 303(d) list				**64.4**

[1] This TMDL document addresses all listings on the 1998 303(d) list and only the temperature listings on the 2002 303(d) list for the Applegate Subbasin. The entire 2002 303(d) list will be addressed by DEQ as part of the 5-year review of this plan.

WATER QUALITY IMPAIRMENTS – CALIFORNIA LANDS

There are approximately 90 square miles in the headwaters section of the Applegate Subbasin located within the State of California. Of those lands over 87% (79 square miles) are part of the Rogue/Siskiyou National Forest. The two main streams originating in California and draining into the Applegate Subbasin are the Applegate to the west and Elliot Creek to the east. Both tributaries drain into Applegate Lake at the Oregon state line. There is very little water quality data available for this area. Limited data available from the USFS indicates that State of Oregon temperature criteria for rearing (64°F) is being met on Butte Fork of the Applegate River and Upper Elliot Creek although it is not being met on the lower section of Elliot Creek (Table 4). At the time of this writing there are no streams in this area on either the California or Oregon 303(d) lists.

Table 4. Water Quality Data – California Lands

Site Description	Location	Data Source	Data Description	Listing Status
Butte Fork of Applegate River	T48N, R12W,S36	USFS	1993, 1994 with 0 days exceeding temperature criteria of 64F. Stream in California	Did not meet listing criteria
Elliot Creek (ELL1)	T48N, R10W, S26	USFS	Maximum 7 day Average: 1994 67.3F, 1995 58.8, 1997, 62.0; 1998, 61.8. Stream in California	Does not appear to meet listing criteria
Elliot Creek (ELL2)	T48N, R11W, S17	USFS	Maximum 7 day Average: 1995, 63.0F; 1997, 66.4; 1998, 66.4; 1999, 62.9; 2001, 68.2. Stream in California	Appears to meet listing criteria

APPLICABLE WATER QUALITY STANDARDS

Beneficial Uses:

The Oregon Environmental Quality Commission (OEQC) has adopted numeric and narrative water quality standards to protect designated *beneficial use*s. In practice, water quality standards have been set at a level to protect the most sensitive beneficial uses and seasonal standards may be applied for uses that do not occur year-round. Cold-water aquatic life such as salmon and trout are the most sensitive *beneficial uses* occurring in the Applegate Subbasin (DEQ, 1995). The specific beneficial uses for the Applegate Subbasin are presented in Table 5 (Oregon Administrative Rules OAR 340–041–0362).

Table 5. Beneficial Uses in the Applegate Subbasin

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 & Transportation		Hydro Power	✓

Temperature Standard: OAR 340-041-0365(2)(b)(A)

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

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

It is important to understand the State of Oregon's temperature criteria is more than just a 64°F 7-day statistic. The specifics for the Applegate Subbasin temperature criteria can be found in the Rogue Basin Temperature Standard OAR below (Table 6).

Table 6. Applicable Water Temperature Standards for the Applegate Subbasin

Rogue Basin Temperature Standard: OAR 340-041-0365(2)(b)(A)(i-vii)

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 DEQ to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C);
(iii) In waters determined by DEQ to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);
(iv) In waters determined by DEQ 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.

Sedimentation Standard: OAR 340-041-0365(2)(j), (OAR 340-41-027), OAR 340-41-0365(2)(c)

There is currently one stream (Beaver Creek) in the Applegate Subbasin listed on the 1998 303(d) list for sedimentation. Oregon water quality standards related to sedimentation as applicable to Beaver Creek are:

> *Sedimentation* OAR 340-041-0365(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."
>
> *Turbidity* OAR 340-41-0365(2)(c) - "No more than a ten percent cumulative increase in natural stream turbidities shall be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity."

The sedimentation listing is based on findings of large amounts of fine sediment in portions of Beaver Creek. The listing originated with a benthic macroinvertebrate study that found macroinvertebrates to be moderately to severely impaired due to habitat limitations caused by fine sediments (USFS 1994).

Biological Criterion: OAR 340-41-027

There is currently one stream (Beaver Creek) in the Applegate Subbasin listed on the 1998 303(d) list for biological criteria exceedances. The listing originated with a benthic macroinvertebrate study that found populations to be moderately to severely impaired due to habitat limitations caused by fine sediments (USFS 1994). Standards related to biological criteria are:

- *"Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the residential biological communities."*
- *"Aquatic species" means any plants or animals which live at least part of their life cycle in waters of the State.*
- *"Biological Criteria" means numerical values or narrative expressions that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use.*
- *"Resident Biological Community" means aquatic life expected to exist in a particular habitat where water quality standards for a specific ecoregion, basin, or water are met. This shall be established by accepted biomonitoring techniques.*
- *"Without Detrimental Changes in the Resident Biological Community" means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.*
- *"Ecological Integrity" means the summation of chemical, physical and biological integrity capable of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.*
- *"Appropriate Reference Site or Region" means a site on the same water body or within the same basin or ecoregion that has similar habitat conditions, and represents the water quality and biological community attainable within the area of concern.*

Flow Modification Standard: OAR 340-041-0365 (2)(I), OAR 340-41-362

The beneficial uses affected by flow modification include resident fish and aquatic life and salmonid Fish Rearing. A stream is listed as Water Quality Limited (WQL) if flow conditions are documented that are a significant limitation to fish or other aquatic life. The standard that applies is: *The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life, or affect the potability of drinking water, or the palatability of fish or shellfish shall not be allowed; or: Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.*

Flow 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 load allocations through the development of a TMDL does not apply. Note: flow modification is delisted on the 2002 303(d) list

Habitat Modification Standard: OAR 340-041-0365 (2)(I), OAR 340-41-362

The beneficial uses affected by habitat modification include Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing. The standard that applies is: *The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life, or affect the potability of drinking water, or the palatability of fish or shellfish shall not be allowed; or: Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.*

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 through the development of a TMDL does not apply. Note: habitat modification is delisted on the 2002 303(d) list

SECTION 2. TEMPERATURE TMDL

Summary of Temperature TMDL Development and Approach

Temperature Issues in the Applegate Subbasin

Salmonids, often referred to as cold water fish, and some amphibians are highly sensitive to temperature. In particular, Chinook salmon (Oncorhynchus tshawytscha) and coho salmon (Oncorhynchus kisutch) are among the most temperature sensitive of the cold water fish species in the Applegate subbasin. Excessive summer water temperatures have been recorded in a number of tributaries and the mainstem Applegate River. These high summer temperatures are reducing the quality of rearing and spawning habitat for chinook and coho salmon, steelhead and resident rainbow trout. The potential causes of the high water temperatures include past forest management within riparian areas, upslope timber harvest practices, agricultural land use within the riparian area, road construction and maintenance, and rural residential development near streams and rivers.

Scope

All lands within the State of Oregon (680 square miles) with streams that drain to the Applegate River within HUC 17100309 are included in this temperature TMDL. All land uses and ownerships are included: lands managed by the State of Oregon, US Army Corps of Engineers (USACE), the U.S. Forest Service (USFS) and Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, transportation uses and urbanized areas. Note: There are approximately 90 square miles of the Applegate Subbasin located within the State of California. These lands fall under the regulatory jurisdiction of the State of California and are not addressed directly in this TMDL and WQMP.

Applying Oregon's Temperature Standard

Oregon's water temperature standard employs a logic that relies on using the indicator species, salmonids. If temperatures are protective of these indicator species, other species will share in this protection. As a result of water quality criteria exceedances for temperature, 16 stream reaches(approximately 128 stream miles) in the Applegate Subbasin are on Oregon's 1998 and 2002 303(d) list. The reduction in thermal loading needed to meet the water quality criteria for temperature is evaluated in this TMDL. Attainment of the temperature criteria relies on simulating the thermal effects of "system potential" riparian vegetation for nonpoint sources and a "no measurable effects on surface water temperature" condition for point sources. In areas where the numeric criteria are being exceeded, the DEQ considers attainment of system potential conditions to serve as compliance with the temperature standard.

Temperature TMDL Overview

Potential stream temperature pollutants are identified as human-caused increases in solar radiation and warm water discharges. The resultant TMDL loading capacities are expressed as pollutant loading limits for both point and nonpoint sources of pollution. Allocations of the pollutant load are provided to all sources of thermal pollution in the Applegate Subbasin. Percent- effective shade targets are established for all waterways in the subbasin. .

Table 7. Temperature TMDL Component Summary	
State/Tribe: Oregon Waterbody: All perennial streams in Oregon within the Applegate Subbasin (HUC 17100309) Point Source TMDL: YES Nonpoint Source TMDL: YES Date: December 2003	
Pollutant Identification	**Pollutant***:* Solar Flux (Heat Energy), expressed as British Thermal Units per square foot of stream surface per day (BTU/ft^2/day). **Anthropogenic Contribution***:* Excessive solar energy input from changes in riparian vegetation.
Target Identification **CWA §303(d)(1)** **40 CFR 130.2(f)**	*Applicable Water Quality Standards* **Temperature: OAR 340-041-0285(2)(b)(A)** The seven-day moving average of the daily maximum shall not exceed the following values unless specifically allowed under a Department-approved basin surface water temperature management plan: 64°F (17.8°C) Applies to the Applegate Subbasin because salmonid fish rearing is a designated beneficial use August-September. 55°F (12.8°C) Applies during times and in waters that support salmon spawning, egg incubation and fry emergence from the egg and from the gravel October-July.
Existing Sources **CWA §303(d)(1***)*	*Anthropogenic sources of thermal gain from riparian vegetation removal:* • Forest and road management within riparian areas; agricultural land management; rural residential development, roads, mining. *Anthropogenic sources of thermal gain from channel modifications:* • Timber harvest, roads, agricultural activities, flood control.
Seasonal Variation **CWA §303(d)(1)**	*Stream Temperature period of primary interest*: • June 1 through September 30 defined as the Critical Period when numeric criteria are exceeded. Solar energy inputs are at a maximum and stream flows are at a minimum.
TMDL/Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Loading Capacity:* • System potential conditions expressed as a percent-effective shade and BTU/ft^2/day target for all perennial streams within the subbasin. These target values are given as an average measured value over perennial stream length (See Table 21). *Wasteload Allocations*: • Permitted point sources in the Applegate Subbasin are permitted no measurable increase in surface water temperatures. *Load Allocations:* • 100% of available load is allocated to natural sources. .
Margin of Safety *CWA §303(d)(1)*	*Implicit margin of safety:* Conservative assumptions in modeling; assumptions of no tributary cooling
WQS Attainment Analysis *CWA §303(d)(1)*	• Statistical demonstration of relationship between temperature and current shade conditions. • Analytical assessment of simulated temperature change for the Applegate and Little Applegate under system potential conditions.
Public Participation (40 CFR 25)	See Appendix B for public hearing information. See also response to comment documentation.

INTRODUCTION:

This TMDL Summary seeks to clearly address the elements required by EPA to meet the requirements for Total Maximum Daily Load (TMDL) development for temperature within the Applegate Subbasin. These elements are addressed in this TMDL with references to the accompanying Water Quality Management Plan (WQMP). The TMDL and WQMP were prepared by the Oregon Department of Environmental Quality (DEQ) with assistance from state, federal and local partners.

SUBWATERSHED DESCRIPTION AND OWNERSHIP

The temperature TMDL applies to the entire Applegate Subbasin. The subbasin is an important part of the diverse 3,300,000 acre (5,156 square miles) Rogue River Basin. The subbasin is located on the northeastern flank of the Siskiyou Mountains in southwestern Oregon. This is one of the most biologically, botanically, and geologically diverse areas in the country. It is steep and rugged, ranging in elevation from 850 feet to 7,418 feet above sea level. The 493,000 acre (770 square mile) Applegate Subbasin includes lands in Jackson County, Oregon (approximately 410 square miles), Josephine County, Oregon (approximately 270 square miles) and in Siskiyou County, California (approximately 90 square miles). This TMDL applies only to those lands in the Applegate Subbasin within the State of Oregon.

BENEFICIAL USES SENSITIVE TO TEMPERATURE.

The beneficial uses affected by excessive temperatures include Resident Fish and Aquatic Life, Salmonid Fish Spawning, and Rearing (DEQ, 1995, DEQ, 2003) (Table 8).

Table 8. Temperature Sensitive Beneficial Uses

(OAR 340–41–362) *Temperature sensitive beneficial uses are marked in gray*			
Beneficial Use	***Occurring***	***Beneficial Use***	***Occurring***
Public Domestic Water Supply	✓	Anadromous Fish Passage	✓
Private Domestic Water Supply	✓	Salmonid Fish Spawning	✓
Industrial Water Supply	✓	Salmonid Fish Rearing	✓
Irrigation	✓	Resident Fish and Aquatic Life	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Commercial Navigation & Trans.		Hydro Power	

DEVIATION FROM WATER QUALITY STANDARDS; 303(d) LISTINGS

Monitoring has indicated that water temperatures in the Applegate Subbasin exceed the State of Oregon temperature criteria. Accordingly, 15 stream segments within the Applegate Subbasin are on the 2002 303(d) list for exceeding the 64°F 7-day statistic for rearing salmonids and 1 stream segment is on the 2002 303(d) list for exceeding the 55°F 7-day statistic for spawning salmonids. (Table 9 and Map 4). Limited data available for waters above Applegate Lake in the State of California indicate that water temperatures may exceed the 64°F criteria in some areas (USFS data) although these areas are not currently on the California or Oregon 303(d) list (Table 4).

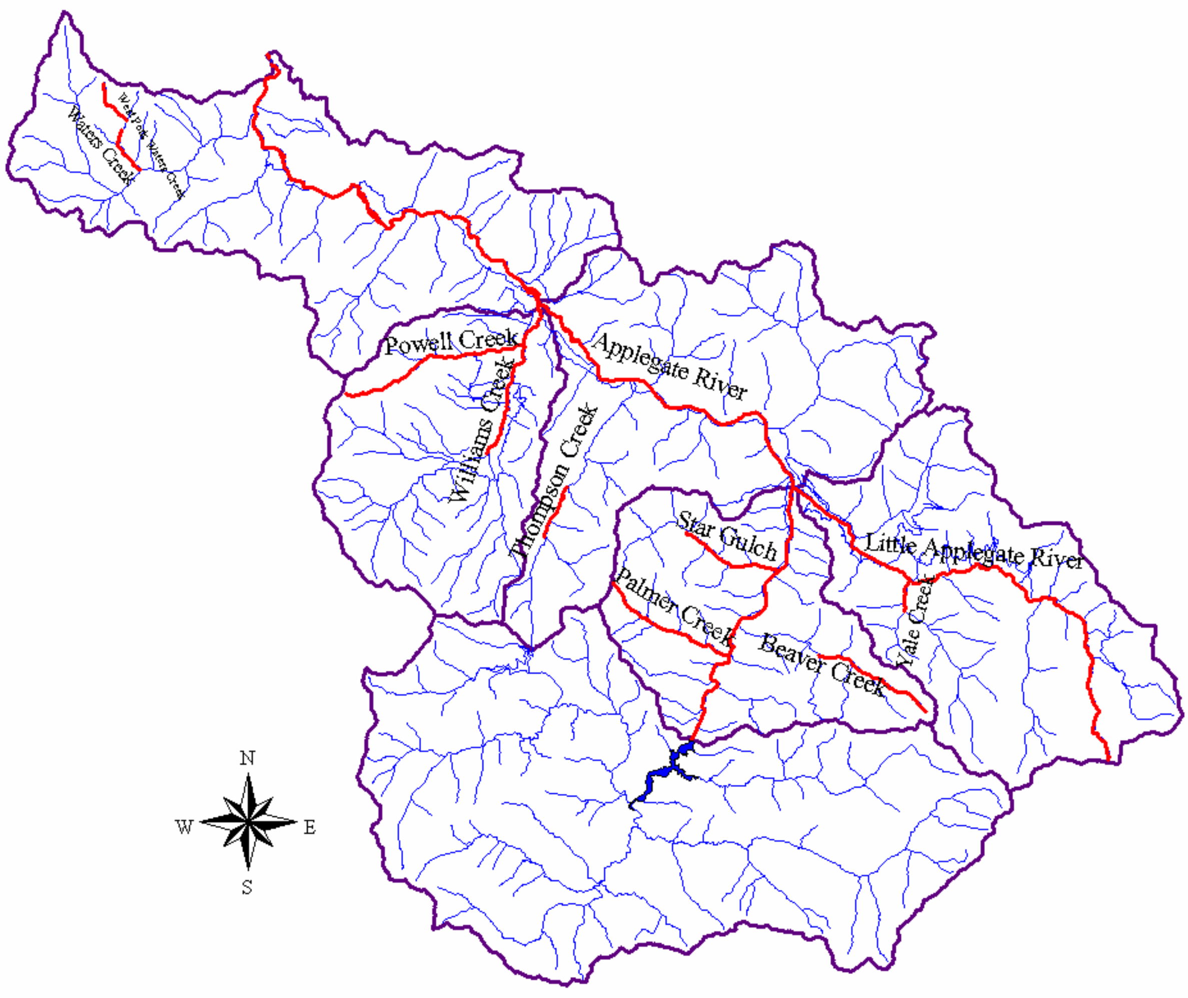
Table 9. 303(d) Temperature Listings Addressed in the Applegate Subbasin TMDL

303(d) List[1]	Stream Segment	Listed Parameter	Applicable Rule	Miles Affected
1998	Applegate River, mouth to Applegate Reservoir	Summer Temperature	OAR 340-041-0365(2)(b)(A)	50
1998	Beaver Creek, RM 3.5 to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	5.3
2002	Beaver Creek, RM 0 to 3.5	Summer Temperature	OAR 340-041-0365(2)(b)(A)	3.5
2002	Humbug Creek, RM 0 to 5	Summer Temperature	OAR 340-041-0365(2)(b)(A)	5.0
1998	Little Applegate River, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	21.0
1998	Palmer Creek, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	6.0
1998	Powell Creek, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	8.0
2002	Powell Creek, mouth to RM 2.0	Spawning Temperature Oct 1 – May 31	OAR 340-041-0365(2)(b)(A)	2.0
2002	Slate Creek, RM 0 to 5.3	Summer Temperature	OAR 340-041-0365(2)(b)(A)	5.3
1998	Star Gulch, mouth to 1918 Gulch	Summer Temperature	OAR 340-041-0365(2)(b)(A)	4.0
1998	Thompson Creek, Mee Cove to Ninemile Creek	Summer Temperature	OAR 340-041-0365(2)(b)(A)	2.3
2002	Sterling Creek, mouth to RM 2.5	Summer Temperature	OAR 340-041-0365(2)(b)(A)	2.5
1998	Waters Creek, mouth to RM 2	Summer Temperature	OAR 340-041-0365(2)(b)(A)	2.0
1998	Waters Creek, West Fork, mouth to headwaters	Summer Temperature	OAR 340-041-0365(2)(b)(A)	1.9
1998	Williams Creek, mouth to East/West Fork confluence	Summer Temperature	OAR 340-041-0365(2)(b)(A)	7.0
1998	Yale Creek, mouth to Waters Gulch	Summer Temperature	OAR 340-041-0365(2)(b)(A)	1.3
Total Stream Miles listed for Summer Temperature Criteria (June 1 to Sept 30)				**126.3**
Total Stream Miles listed for Spawning Temperature Criteria Exceedances (October 1 to May 31)				**2.0**
Total Stream Miles listed for Temperature Criteria Exceedance				**128.3**

1 This TMDL document addresses all listings on the 1998 303(d) list and only the temperature listings on the 2002 303(d) list for the Applegate Subbasin. The entire 2002 303(d) list will be addressed by DEQ as part of the 5-year review of this plan.

Map 4: Temperature Listed Stream Reaches in the Applegate Subbasin

(Stream Reaches Listed for Temperature are Shown in Red)



SALMONID STREAM TEMPERATURE REQUIREMENTS

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

Salmonids, often referred to as cold water fish, and some amphibians are highly sensitive to temperature. In particular, chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) are among the most temperature sensitive of the cold water fish species in the Applegate Subbasin (DEQ, 1995). Oregon's water temperature standard employs a logic that relies on using these sensitive species as *indicator species*. If temperatures are protective of these indicator species, other species will share in protection as well.

If stream temperatures become too hot, fish die almost instantaneously due to denaturing of critical enzyme systems in their bodies (Hogan, 1970). The ultimate *instantaneous lethal limit* occurs in high temperature ranges above 90°F (> 32°C). Such warm temperature extremes may never occur in the Applegate Subbasin. More common and widespread, however, is the occurrence of temperatures in the range of 70°F - 77°F (21°C - 25°). These temperatures cause death of cold water fish species during exposure times lasting a few hours to one day. The exact temperature at which a cold water fish succumbs to such a thermal stress depends on the temperature that the fish is acclimated to, and on life-stage. This cause of mortality, termed the *incipient lethal limit*, results from breakdown of physiological regulation of vital processes such as respiration and circulation (Heath and Hughes, 1973).

The most common and widespread cause of thermally induced fish mortality is attributed to interactive effects of decreased or lack of metabolic energy for feeding, growth or reproductive behavior, increased exposure to pathogens (viruses, bacteria and fungus), decreased food supply (impaired macroinvertebrate populations) and increased competition from warm water tolerant species. This mode of thermally induced mortality, termed indirect or *sub-lethal*, is more delayed, and occurs weeks to months after the onset of elevated temperatures of 64^{o}F - 74^{o}F (20^{o}C - 23^{o}C) (Table 10).

Table 10. Modes of Thermally Induced Cold Water Fish Mortality

Modes of Thermally Induced Fish Mortality[1]	Temperature Range	Time to Death
Instantaneous Lethal Limit – Denaturing of bodily enzyme systems	> 90^{o}F (> 32^{o}C)	Instantaneous
Incipient Lethal Limit – Breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation	70^{o}F - 77^{o}F (21^{o}C - 25$^{o)}$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^{o}F - 74^{o}F (20^{o}C - 23^{o}C)	Weeks to Months

1. Brett, 1952, Hokanson et al, 1977, Bell, 1986.

TEMPERATURE TARGET IDENTIFICATION: CWA 303(D) (1)

The stream temperature TMDL targets the protection of the most sensitive beneficial use: cold-water salmonids. Oregon's stream temperature standard, which is based on the temperature requirements of salmonids, is designed for protection during all salmonid life stages. Several numeric criteria and other triggers for the temperature standard establish factors for designating surface waters as water quality limited (See Table 5). The temperature standard specifies that anthropogenic (i.e. human caused) impacts that cause stream heating should be removed. The TMDL targets this no anthropogenic warming condition. A stream condition that has no anthropogenic induced warming is considered to be in a condition termed system potential.

In applying the temperature standard, it is important to know when specific salmonids are present within the subbasin. Table 11 details the various lifestages present in the subbasin at certain times of the year (migration, spawning, egg incubation, smolt out-migration, and rearing) for five important salmonids (three of them anadromous) present in the Applegate Subbasin. Based on current fisheries data on the Applegate Subbasin the 64^{o}F criterion only applies during the months of August and September when no salmonid spawning or egg incubation is occurring. From October 1-July 31 the 55^{o}F criterion applies (Table 12).

- Chinook Salmon (Fall) – *Oncorhynchus tshawytscha*
- Coho Salmon (Silver Salmon) - *Oncorhynchus kisutch*
- Steelhead (Winter and Summer) - *Oncorhynchus mykiss*
- Rainbow Trout (resident) - *Oncorhynchus mykiss*
- Cutthroat trout (resident) - *Oncorhynchus clarki clarki*

Table 11. Applegate Subbasin Salmonid Use by Month[1].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration/Holding												
Coho	Range									Range	Range	Peak
Fall Chinook	Range								Range	Range	Peak	Range
Winter Steelhead	Range	Peak	Peak	Peak	Range	Range						
Summer Steelhead	Peak									Range	Range	Peak
Resident Rainbow/cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Spawning												
Coho	Peak	Range									Range	Peak
Fall Chinook	Range									Range	Peak	Peak
Winter Steelhead		Range	Peak	Peak	Range	Range						
Summer Steelhead	Peak	Peak	Range									Range
Resident Rainbow/ cutthroat	Range	Range	Peak	Peak	Peak							
Incubation												
Coho	Peak	Peak	Peak	Range							Range	Peak
Fall Chinook	Peak	Peak	Range	Range						Range	Range	Range
Winter Steelhead		Range	Range	Range	Peak	Peak	Range					
Summer Steelhead	Range	Peak	Peak	Range								Range
Resident Rainbow/cutthroat		Range	Peak	Peak	Peak	Range						
Rearing												
Coho	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Fall Chinook		Range	Range	Range	Range	Range	Range					
Winter Steelhead	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Summer Steelhead	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Resident Rainbow/cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Peak Smolt Outmigration												
Coho			Range	Peak	Peak	Range						
Fall Chinook			Range	Range	Peak	Peak	Range					
Summer Steelhead**			Range	Range	Peak	Range						
Winter Steelhead**			Range	Range	Peak	Range						
Resident Rainbow	Grow to Adulthood and Remain in River											

****Can not differentiate summer and winter steelhead at this stage.**

Peak: Peak Use Period
Range: Range of Use

1. ODFW, 2001, Alan Ritchey, ODFW, 2003, Jay Diono

Table 12. Water Temperature Criteria for the Applegate Subbasin. ***OAR 340-041-0285(2)(b)(A)***

Criterion	7-Day Statistic (Numeric Criteria)	When Criteria Applies in Applegate Subbasin
Basic Absolute Criterion: Applies year long in all streams in the subbasin, with the exception of those that qualify for the salmonid spawning, egg incubation and fry emergence criterion.	**≤64°F (17.8°C)**	**August 1-September 30**
Salmonid Spawning, Egg Incubation and Fry Emergence Criterion: Applies to all streams in the subbasin during the specific times of the year when salmonid spawning, egg incubation and fry emergence occur.	**≤55°F (12.8°C)**	**October 1-July 31**

CRITICAL PERIOD - SEASONAL VARIATION – CWA §303(D)(1)

The critical temperature period occurs when stream temperatures are above the numeric criterion.
The critical period in the Applegate Subbasin is from June 1 through October 31.

Section 303(d)(1) requires a TMDL to be "established at a level necessary to implement the applicable water quality standard with seasonal variations." The critical period in the Applegate Subbasin is from June 1 through October 31 – this is the period when stream temperatures exceed the numeric criterion. Stream temperatures in the Applegate River exceed the 64°F numeric criteria in August and September and the 55°F criteria in June, July and October. This TMDL focuses its modeling and attainment analysis on the August – September period with the assumption that actions required to reduce temperatures during this period will benefit surface water temperatures year-round.

The modeling and analysis presented in this TMDL focus on the critical period when controlling factors for stream temperature are most critical. The modeling dates selected: Applegate, July 19, 1999; Little Applegate, July 21, 1999, represent the period when maximum water temperatures can be expected. This modeling effort reflects extreme temperature regimes in this system and clearly depicts the seasonal worst case temperature condition (climax solar loading).

EXISTING POLLUTION SOURCES – CWA §303(D)(1)

Point Sources:

In the State of Oregon, DEQ administers two different types of wastewater permits to protect surface waters from point source discharges (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. Discharge pertains to releasing waste to surface waters and disposal pertains to getting rid of the waste by other means, such as evaporation, seepage, or land application. Waste discharges fall under the DEQ-administered National Pollutant Discharge Elimination System (NPDES) permit. This is a federal permit issued by DEQ. Disposal activities require a Water Pollution Control Facilities (WPCF) permit issued by DEQ. WPCF permitted operations do not allow for any discharge to surface waters. Therefore they are not addressed in this TMDL. NPDES permits may be revised when renewed to insure that all permittees are operating in accordance with this TMDL.

Applegate NPDES permittees are allowed "no measurable increases in surface water temperature[1]"during the critical period (June 1 though October 31).

[1]No measurable increase is defined as no more than 0.25°F

In the Applegate Subbasin there are no NPDES permitted point source discharges which are allowed a measurable increase in surface water temperatures during the critical period (Table 13). There is a single NPDES permitted facility near Murphy (Hidden Valley High School) which is permitted to discharge into the Applegate River near river mile 13; however, no discharge into the river from this point source is permitted between the June 1st - October 31st critical period.

The other NPDES permitted activity occurring in the subbasin is recreational mining. All recreational suction dredging operations are required to obtain a NPDES 700J permit from DEQ. Dredging operations are confined to four designated sites within Applegate Subbasin. Permits define how operations are to be conducted to ensure "no measurable increases in surface water temperature" occurs as a result of this activity.

Table 13: NPDES Permits in the Applegate Subbasin

Facility Name or Permitted Activity	Receiving Water	Effluent Temperature	Permit Type and Restrictions
Hidden Valley High School	Applegate River	No Data	NPDES general permit No surface water discharge June 1 through October 31
Recreational Suction Dredging	Specific designated sites within the Applegate Subbasin	No Data	NPDES 700J permit Permit conditions: "no measurable increases in surface water temperature"

[1]No measurable increase is defined as no more than 0.25°F

Nonpoint source causes of elevated summertime stream temperatures result from riparian vegetation disturbance, channel modification, hydromodification and natural disturbances that affect the riparian area.

Nonpoint Sources:

Riparian vegetation, stream morphology, hydrology, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology and hydrology are affected by human land use. Human activities that contribute to degraded thermal water quality conditions in the Applegate Subbasin are associated with agriculture, forestry, roads, urban development, and rural residential-related riparian disturbance. For the Applegate Subbasin temperature TMDL there are 4 nonpoint source categories which may result in increased thermal loads:

1. ***Near stream vegetation disturbance/removal***
2. ***Channel modifications and widening***
3. ***Hydromodification - Water Withdrawals***
4. ***Natural Sources***

1. Near-stream vegetation disturbance/removal

Near-stream vegetation disturbance/removal reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is commonly measured as percent-effective shade or open sky percentage[1]). Riparian vegetation also plays an important role in shaping channel morphology, resisting erosive high flows, and maintaining floodplain roughness.

In the Applegate Subbasin, as the valley and streamside areas have been converted to agricultural fields and home sites, much of the original vegetation has been removed. Mining activities, particularly along Sterling Creek and the mainstem Little Applegate, removed vegetation and soil, and in some cases rerouted the entire stream channel along the edge of the valley. As a result of these activities, riparian areas in the subbasin today cover less area and contain fewer species than in the past. Trees tend to be younger in age and dominated by hardwoods. Large fir, pine, and cedar that existed along streams historically are often absent. Woodland stands are fragmented, creating a patchy, poorly connected landscape of simpler and less biologically productive habitat. These changes have resulted in less shade on the stream's surface and an increase in stream water temperatures (ARWC, 2003). Figure 1 shows the potential for improvement in shade for the Applegate and Little Applegate. Percent increases in shade are shown the difference between current riparian vegetation (determined from aerial photos) and the shade predicted when the vegetation reaches a system potential condition. The system potential condition as defined in this TMDL is the near-stream vegetation community that can grow on a site at a given elevation, and aspect in the absence of human disturbance.

[1]Percent-effective shade is defined as ((total solar radiation – total solar radiation reaching the stream)/total radiation) x 100

System potential is an estimate of a condition without anthropogenic activities that disturb or remove near stream vegetation.

- Vegetation is mature and undisturbed;
- Vegetation height and density is at or near the potential expected for the given plant community;
- Vegetation buffer is sufficiently wide to maximize solar attenuation (Note: Buffer widths required to meet the system potential target will vary given potential vegetation, topography, stream width, and aspect.),
- Vegetation width accommodates channel migrations.

System potential is not an estimate of pre-settlement conditions. In many areas changes in stream location and hydrology (channel armoring and wetland draining) have occurred and reversing these changes is not a part of the system potential scenario. In addition, system potential does not account for potential major disturbances resulting from floods, drought, fires, insect damage, disease or other factors that could impact riparian areas.

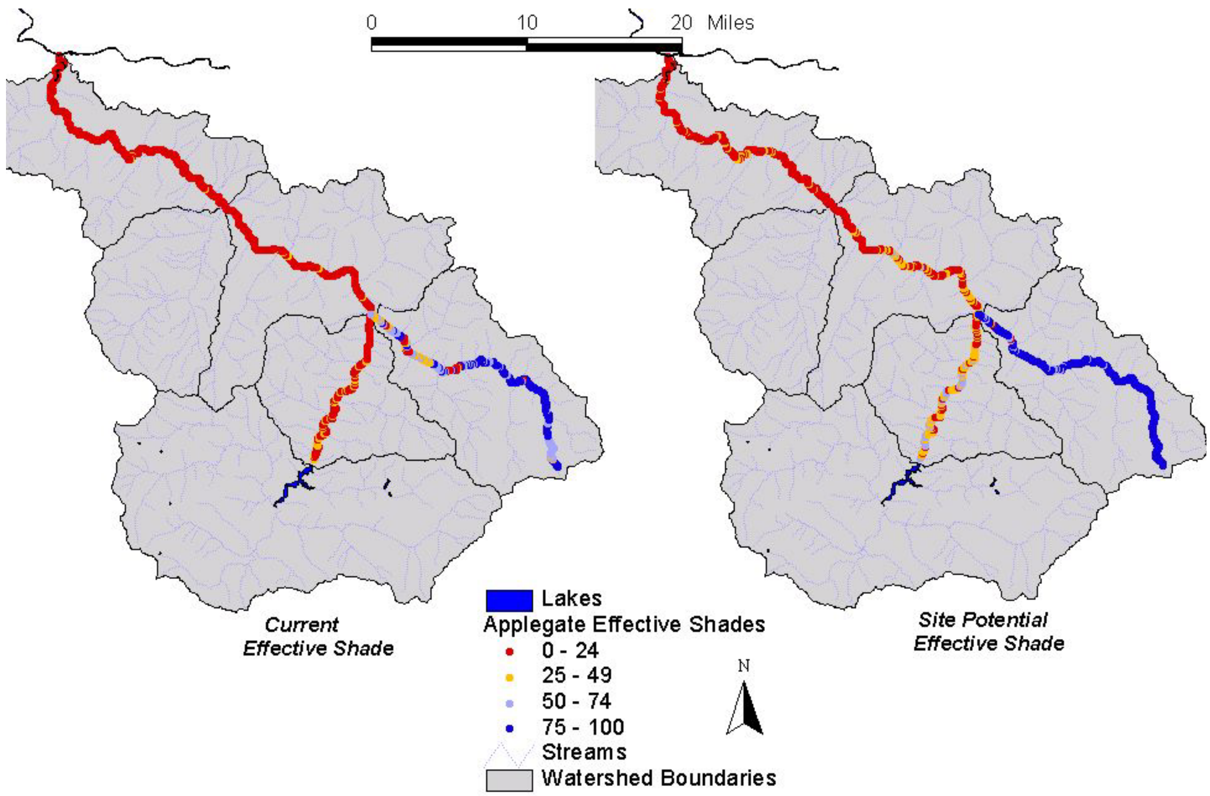


Figure 1. Current Shade and System Potential Percent-Effective Shade on Applegate and Little Applegate Rivers

System potential targets for the Applegate Subbasin were developed using growth curves for the various tree species within southwest Oregon. These growth curves were developed by DEQ in consultation with BLM, ODF and NRCS professionals to project growth rates and maximum height for the dominant riparian tree species. Riparian corridors are assumed to be managed to reach their full system potential condition. Shade densities for system potential conditions were set at 70% for a conifer dominant, mixed old growth stand and 80% for a mature hardwood dominant stand. Table 14 shows the anticipated heights and densities of the vegetation found in the Applegate Subbasin at system potential. Vegetation overhang provides shade to a stream when the sun is directly overhead, it is likely to increase in most cases as riparian stands grow and mature. However, the extent of this increase is difficult to project, so overhang values at system potential were left at current conditions level. Buffer widths, defined as the width of riparian vegetation measured out from the top of stream bank, were set at a value to achieve maximum shade. Buffer widths required to meet the system potential target will vary given potential vegetation, topography, stream width, and aspect.

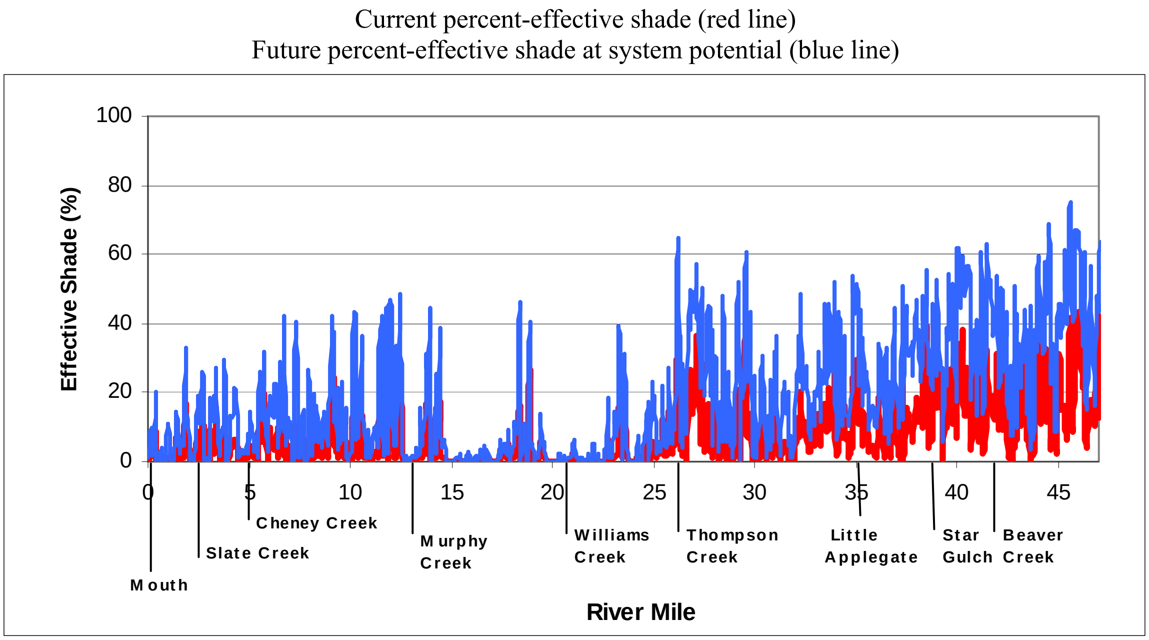
Table 14. Height and Density of Vegetation at System Potential: Applegate Subbasin.

Code	Description	Height at System potential (m)	Density at System potential (%)
302	Pastures/Cultivated Field/Lawn	0.5	75%
500	Large Mixed Con/Hard	42.0	70%
501	Small Mixed Con/Hard	42.0	70%
550	Large Mixed Con/Hard	42.0	70%
551	Small Mixed Con/Hard	42.0	70%
555	Large Mixed Con/Hard	42.0	70%
556	Small Mixed Con/Hard	42.0	70%
600	Large Hardwood	29.3	85%
601	Small Hardwood	26.8	85%
602	Hardwood Mix	28.1	85%
650	Large Hardwood	29.3	85%
651	Small Hardwood	26.8	85%
655	Large Hardwood	29.3	85%
656	Small Hardwood	26.8	85%
700	Large Conifer	43.0	80%
701	Small Conifer	43.0	80%
750	Large Conifer	43.0	80%
751	Small Conifer	43.0	80%
752	Large Conifer	43.0	80%
753	Small Conifer	43.0	80%
802	Shrubs (>50% den)	3.0	75%
803	Shrubs (<50% den)	3.0	25%
902	Grasses	0.5	75%
3011	Active Channel Bottom	0.0	0%
3248	Development - Residential	6.1	100%
3249	Development - Industrial	9.1	100%
3252	Dam/Weir	0.0	0%
3255	Canal	0.0	0%
4001	Riparian Willows	4.5	90%

System Potential Vegetation

The increase in shade calculated as vegetation approaches a system potential condition will vary considerably from site to site along a stream. The figures below illustrate current percent-effective shade (red line) and future percent-effective shade at system potential (blue line) for the Applegate (Figure 2) and Little Applegate (Figure 3). The current average percent-effective shade on the Applegate (mouth to Applegate Dam) is 4%, expected to increase to an average of 13% when vegetation reaches system potential. Current average percent- effective shade on the Little Applegate is 75%, expected to increase to 93% at system potential[2]. See Appendix A, Applegate Subbasin Temperature Assessment, for a more detailed discussion of this analysis and the basis for the system potential scenario.

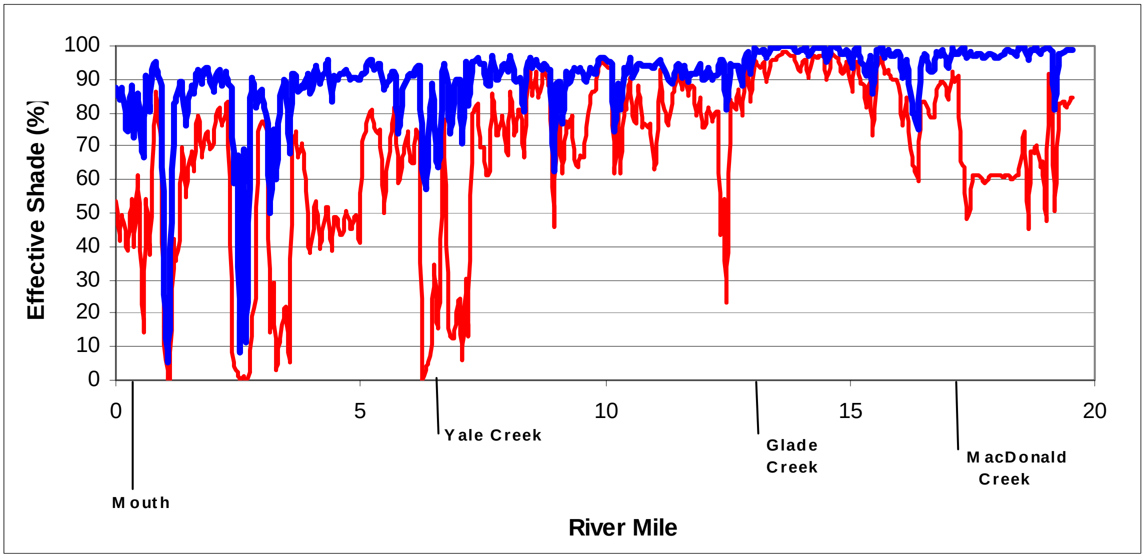
Figure 2. Current and Future Percent-Effective Shade along the Applegate River



[2] Any increase in shade over 80% effective shade is considered a margin of safety. At 80% further reduction in stream temperature as a function of vegetation may not be measurable for all stream flows (Boyd, 1996). At values of >80% effective shade stream is considered recovered and the stream should not be a candidate for active restoration. Additional shade should come from passive management of the riparian area.

Figure 3. Current and Future Percent-Effective Shade along the Little Applegate River

Current percent-effective shade (red line)
Future percent-effective shade at system potential (blue line)



2. Channel modifications and widening

Changes in channel morphology, namely channel widening, can greatly impact stream temperatures. As a stream widens, the surface area exposed to radiant sources and ambient air temperature increases, resulting in increased energy exchange between the stream and its environment (Boyd, 1996). Wide channels are likely to have decreased levels of shade due to simple geometric relationships between shade-producing vegetation and the angle of the sun. Conversely, narrow channels are more likely to experience higher levels of shade. An additional benefit inherent to narrower/deeper channel morphology is a higher frequency of pools that contribute to aquatic habitat or cold water refugia.

Current active channel widths on the Applegate River mainstem vary from 150 to over 580 feet. An in-depth analysis of available aerial photos for four reaches, (two sites each reach) indicates the level of variability in channel width that the Applegate River has experienced since 1939 (Table 15 – ARWC, 2002, Mike Mathews unpublished data). Within these data there is a trend towards a widening of the channel for the period of 1939 though 1974 with major flows occurring in 1955, 1964, 1974 (USGS Station #14361500 Rogue River, Grants Pass). With the absence of major high flow events between 1974 and 1997 the stream channel recovered to the relatively narrow widths seen in 1996. In 1997 a high flow event again widened the active channel to the widths seen in the 1960's. It is expected that as system potential vegetation is established and allowed to mature, stream banks on the Applegate will be more resistant to high flow events and stream channels will narrow. However, given the highly variable nature of stream widths in this system, it was decided that the system potential future conditions scenario will use current stream widths. Since some narrowing of the active channel is expected, this assumption serves as a conservative margin of safety.

Table 15. Applegate Mainstem Channel Widths Taken from Aerial Photos

Reach A	Near Ferris Gulch Applegate River Mile 23.5						
Site	***1939***	***1950***	***1957***	***1965***	***1974***	***1996***	***1997***
#1-Active Width in ft[1]	102	184	336	663	702	92	587
#2 Active Width in ft[1]	189	575	489	624	624	80	188
Reach B	***Near Caris Creek Applegate River Mile 19***						
Site	***1939***	***1950***	***1957***	***1965***	***1974***	***1991***	***1998***
#1-Active Width in ft[1]	82.5	294	418	532	798	92	380
#2 Active Width in ft[1]	82	73	155	1900	1490	38	
Reach C	***Near Murphy Applegate River Mile 13***						
Site	***1939***	***1950***	***1957***	***1965***	***1974***	***1991***	***1997***
#1-Active Width in ft[1]	70	92		207	312	132	157
#2 Active Width in ft[1]	70	69	445	574	585	88	180
Reach D	***Near Cheney Creek Applegate River Mile 4.5***						
Site	***1939***		***1959***	***1965***		***1991***	***1997***
#1-Active Width in ft[1]	126		225	192		110	207
#2 Active Width in ft[1]	80		175	168		105	220

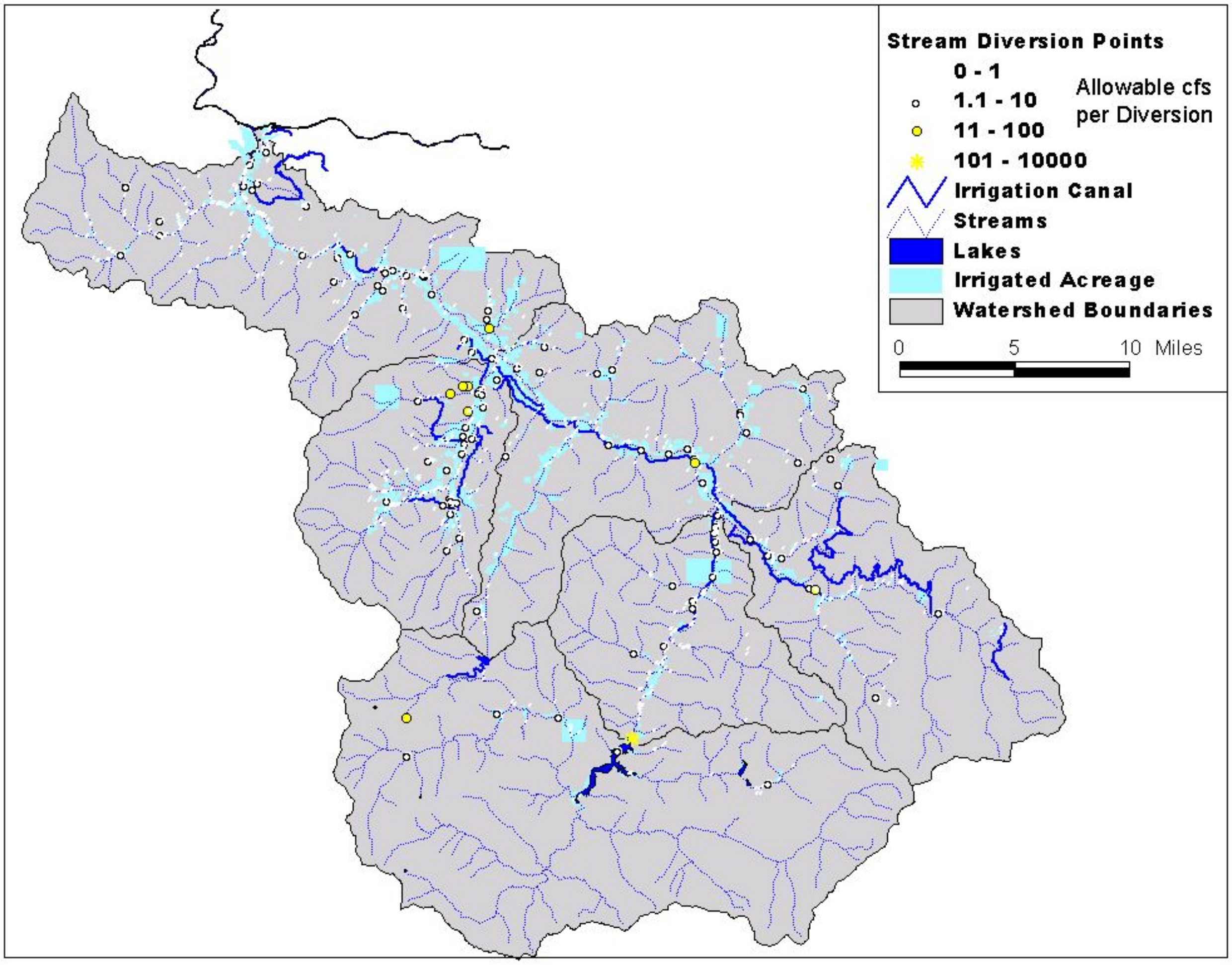
1. Refers to active channel widths defined as the width of a river or stream channel between the highest banks on either side of a stream. Also called bankfull channel width.

3. Hydromodification-Water Withdrawals

Significant flow in the Applegate River mainstem and Little Applegate River is allocated for irrigation, mining and domestic use (Map 5). The Applegate Subbasin has the two oldest water rights in the state, granted in 1854 when Oregon was still a territory. Appropriation of water is based on both water right seniority and water availability. As stream flows recede, those users with junior rights are the first required to curtail their water use. Senior water right holders are allowed to continue using water, even in dry years and low flow conditions, as long as water is available to meet the demand under their priority date.

No new consumptive water rights for live stream flows have been issued in the Applegate Subbasin since July 1934, when it was determined that natural stream flows were insufficient to meet existing consumptive rights during the irrigation season. However, consumptive rights for stored water from the Applegate reservoir are still available. In addition, domestic (in-house human consumption) rights may still be obtained if the applicant can demonstrate that surface water is the only available source for their use.

Water withdrawals have the potential to greatly impact surface water temperatures within the Applegate Subbasin. However, the management of water withdrawals fall under the jurisdiction of the Oregon Water Resources Department and as such DEQ has no authority in this area. No flow targets will be set or changes in water use required as part of this TMDL. Although modeling under the current system potential scenario does not include changes in flow, the calibrated HeatSource 6.0 model can be used to examine the effect of changes in flows on stream temperature if water rights do become available.



Map 5: Water Diversion Points in the Applegate

4. Natural Sources

Natural events may impact riparian vegetation and result in elevated stream temperatures. These events include floods, drought, disease, insect damage and naturally occurring fires, windthrow and blowdown in riparian areas. The processes in which natural conditions affect stream temperatures include increased stream surface exposure to solar radiation and decreased summertime flows. These natural events and their effects on stream temperature are considered natural background and no attempt is made to quantify the impact or frequency of such events in this TMDL.

Applegate Dam

Flows

The hydrology of the Applegate River is dominated by flows from the Applegate Dam; however, operations are not allowed to negatively impact water temperatures (OAR340-041-0485(2)(b)(i) (see sidebar)). Watershed yields for the project have ranged from 100,000 to over 750,000 acre-feet annually. Daily flow data in the Applegate River, approximately 0.5 miles downstream of the dam (USGS #1436200, Applegate River at Copper, OR) are summarized for the periods 1960-1980 (pre-dam) and 1981-2002 (post-dam) (Figure 4, Symbiotics LLC, 2002). The dam has resulted in higher low flows and lower high flows. The largest difference in the pre-dam and post-dam curves is seen in the post-dam low flows. Prior to the dam, the 80th percentile flows (low flows) was 57 cfs which increased to 154 cfs post-dam. The 20th percentile flows (high flows) have been reduced from 678 cfs to 508 cfs as a result of the dam. The 50th percentile flows have remained unchanged at 250 cfs.

Figure 4. Flow Exceedance Curves Pre- and Post-Applegate Dam.

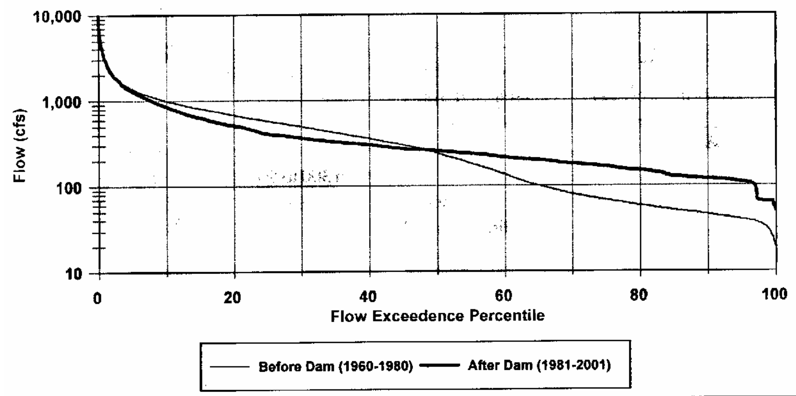
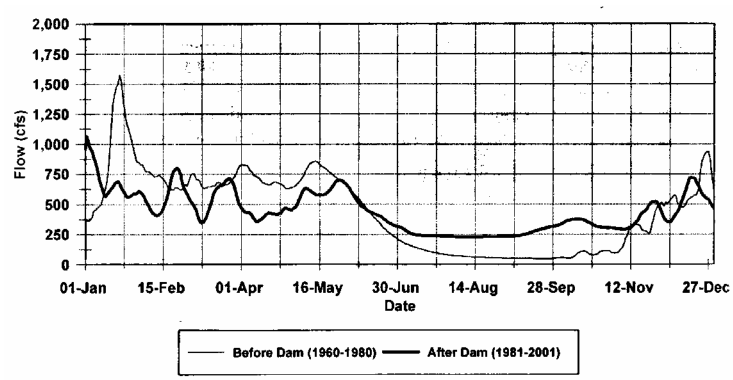


Figure 5 shows the average daily flows for the two time periods (1960-1980 pre-dam and 1981-2002 post-dam) at the same USGS site. These data indicate that there has been a reduction in daily average flows from January through May and an increase between June and October. No change is readily apparent in November to December. ODFW reports that the higher flows caused by the dam in the June through October period result in a cooler river which reduces chinook salmon rearing density in late spring and early summer. This causes an extension of the rearing period and improvement in the growth and condition of juvenile Chinook (changes observed but not statistically significant for the period of 1976-1984. Source: Fustich et.al, 1988).

Figure 5. Flow Exceedance Curves Pre- and Post-Applegate Dam.



Temperature

Data taken from the USGS Gage located 0.6 miles downstream of the Applegate Dam (14362000 Applegate River at Copper, OR) details the number of exceedances of the 7-day criteria near the dam for a 22-year period. These data indicate that the site should be 303(d) listed for both spawning and rearing criterion exceedance (Listing Criteria: DEQ, 2003). An analysis of the daily high temperature at the gauge for the period of time from 12-1-1980 to 4-9-2003 (*n* = 7457), revealed there were 947 exceedances of the spawning criteria (55°F October 1 to July 31 7-day criteria) and 56 exceedances of the rearing criteria (64°F August 1 to September 30 7-day criteria) (Table 16).

Table 16. 7-day Temperature Criteria Exceedances Downstream of Applegate Dam at Copper, OR.

Number Exceedances[1]	May-July	Aug-Sept	October	November	Dec-April	Summary	Peak 7DMAX
Spawning (55°F)	787	---	147	13	0	947	20.2
Rearing (64°F)	---	56	---	---	---	56	21.2
n =	1834	1148	628	600	3247	7457	

[1]USGS Gage 14362000 Applegate River. 0.6 miles downstream of Applegate Dam

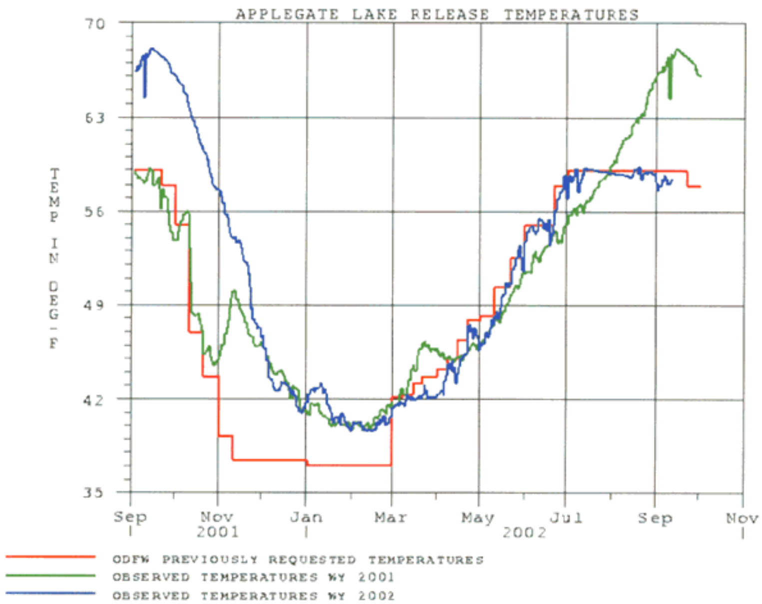
ODFW has determined that the operation of the Applegate Dam, while resulting in lower temperatures during March through September, has resulted in temperature increases October through February (Figure 6) (ODFW, 1995). These temperature differences where based on actual measurements at Copper, OR (river mile 45.7) located 0.6 miles downstream of the dam as compared to temperature simulations (no dam scenario) for the period of 1981-1987. In the months of October through February dam releases resulted in warming the river an average of 3.4°F. This increase in temperature has been linked to the accelerated development and lowered survival of fall chinook salmon eggs in the Applegate River near the dam (Fustich et.al. 1988, Fustich et.al. 1995). During the months of March through September dam releases result in an average water temperature 6.4°F lower than estimated temperatures without the dam.

Figure 6. Comparison of Unregulated and Regulated River Temperatures Copper, OR, 1981-1987

Month	Unregulated Mean (Simulated)	Regulated Mean (Measured)	Difference
January	38.12	40.1	1.98
February	40.46	40.82	0.36
March	45.68	42.44	-3.24
April	51.26	44.24	-7.02
May	55.94	49.28	-6.66
June	61.16	53.24	-7.92
July	63.5	54.5	-9
August	63.68	54.86	-8.82
September	57.74	55.4	-2.34
October	51.26	52.88	1.62
November	41.36	48.2	6.84
December	36.14	42.26	6.12

Clearly the dam is the dominant factor in controlling the flow and temperature of the Applegate River. The USACE has worked with ODFW to develop a release schedule that would maximize benefits to chinook salmon and winter steelhead. (Fustich et.al. 1988, Fustich et.al. 1995). These target temperatures compared to the temperatures of the Applegate River detected at the USGS station Copper, OR #1436200 where compared in 2001 and 2002 (Figure 7). In 2002 the release temperatures follow the ODFW target temperatures closely especially during the critical temperature window of June 1 through October 31. In 2001 temperatures were seen to be above the target in August, September, and October as reservoir levels dropped.

Figure 7. Applegate Release Temperature at Copper, OR, Versus Target Temperatures



TMDL - LOADING CAPACITIES AND ALLOCATIONS

Loading Capacity: for the Applegate Subbasin Temperature TMDL is reached when: (1) NPDES permitted point source effluent discharge and Applegate Dam releases result in no measurable temperature increases in surface waters (2) solar loading is reduced to that of system potential.

Loading Capacity – 40 CFR 130.2(f)

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)). It provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards.

The Water Quality Standard mandates a Loading Capacity based on the condition: "no measurable surface water temperature increase resulting from anthropogenic activities".

The water quality standard states that *no measurable surface water temperature increase resulting from anthropogenic activities is allowed* in the Applegate Subbasin because the 64^{o}F numeric criteria for salmonid fish rearing is exceeded (OAR 340-041-0365(2)(b)(A)(i). The pollutants of concern are human-caused increases in solar loading (non-point sources) and potential warm water discharges (point sources). When anthropogenic sources of heat are eliminated the temperature standard will be achieved and the Applegate will be in compliance with this TMDL for temperature.

The loading capacity is expressed as the sum of nonpoint source background solar radiation heat loading and the allowable point source heat load (nonpoint sources) [40 CFR 130.2(i)]. For the Applegate Subbasin the waste load allocation that applies to all NPDES permitted point sources is "*no measurable surface water temperature increase…*". The load allocation for all nonpoint sources is solar loading reduced to that of system potential.

WATER QUALITY STANDARD ATTAINMENT ANALYSIS – CWA §303(D)(1)

Stream temperatures displayed in Figures 8 and 9 will occur when all sources in the subbasin achieve system potential. Although the 64°F 7-day statistic is not expected to be met everywhere during the hottest time of year, system potential represents the attainment of the temperature standard

Simulations were performed to calculate the water temperatures that will result when all sources (both point and nonpoint) are managed to meet the TMDL loading capacity.

A total of 47.2 river miles on the Applegate River, and 19.6 miles on the Little Applegate were analyzed using the Heat source 6.0 model. Current and system potential conditions were simulated during the warmest time of year (Applegate: July 19, 1999; Little Applegate: July 21, 1999). For both the Applegate and Little Applegate Rivers, the system potential scenario used current condition flows and channel widths with riparian vegetation set to system potential (Figures 8 and 9). Temperatures under current conditions are shown in red, while system potential temperatures are shown as a blue line.

NOTE: *For an in depth description of the system potential future condition analysis, the reader is referred to Appendix A.*

Figure 8. Temperature Profile for the Applegate River:

Temperatures under current conditions (red line)
Temperatures at system potential (blue line)

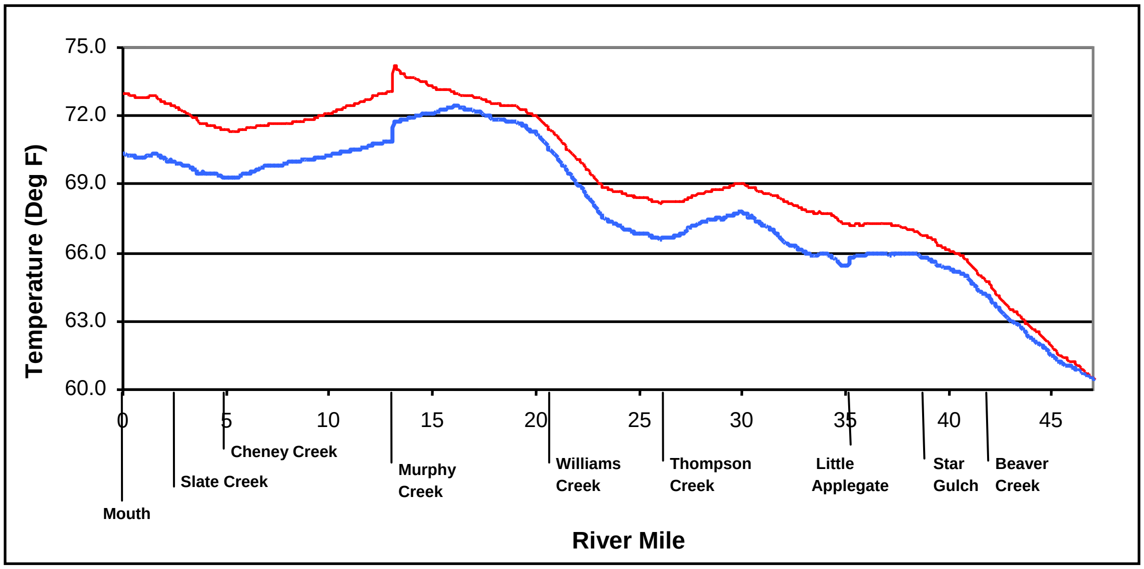
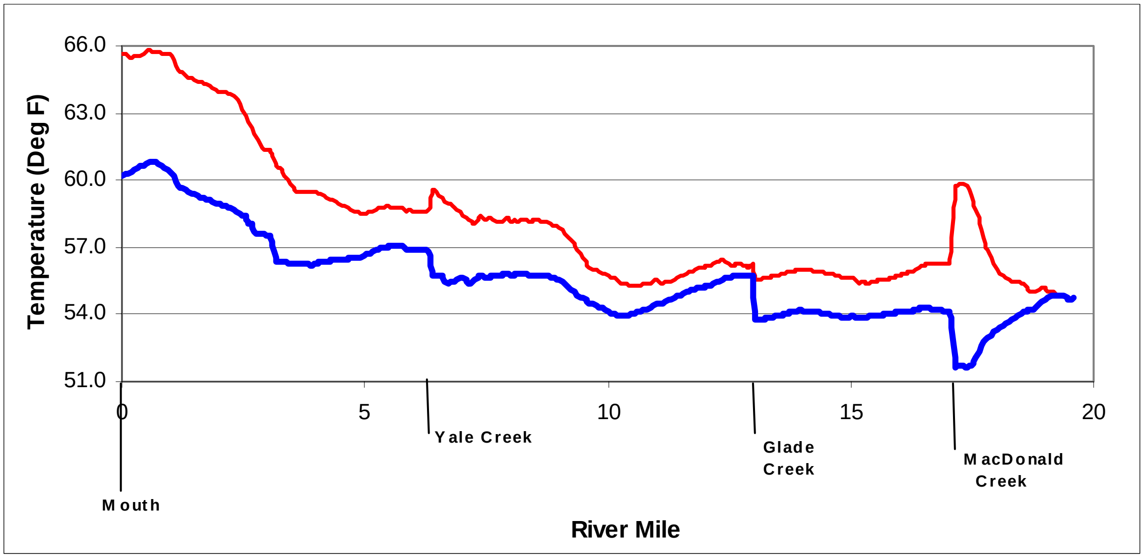


Figure 9. Temperature Profile for the Little Applegate River:

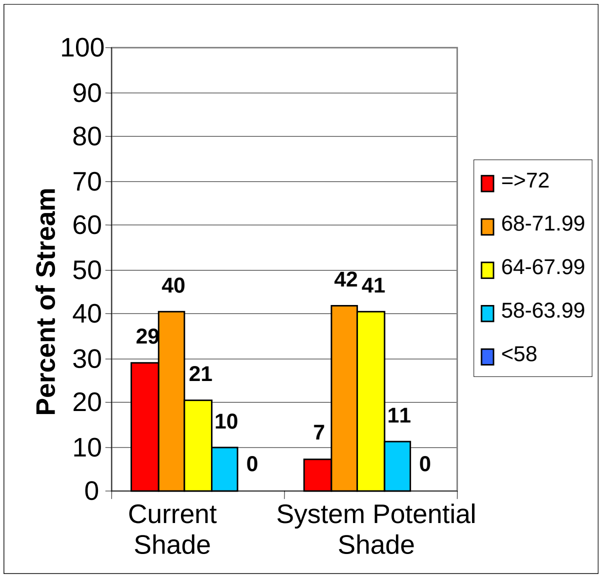
Temperatures under current conditions (red line)
Temperatures at system potential (blue line)



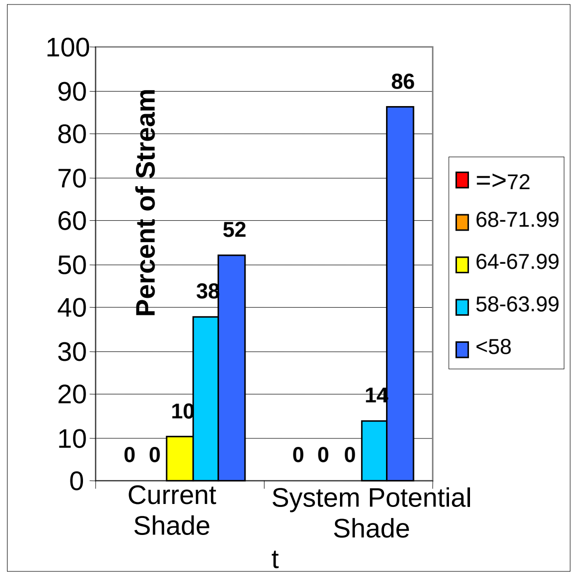
Model outputs predict that increasing the average percent-effective shade on the Applegate River from 4% currently to 13% at system potential will result in a decrease in the percentage of stream exceeding 64°F. Under current conditions during the hottest time of year, 90% of the streams reach a maximum temperature greater than 64°F and 69% is greater than 68°F. At system potential, 89% will reach a maximum temperature greater than 64°F and only 48% will be greater than 68°F (Figure 10). Although this may not seem to be much of an improvement, at *system potential* a total of 52% or approximately 25 miles of the Applegate will be lower than 68°F on the hottest day of the year. This is an increase of 8 miles of habitat with a predicted temperature in the sub-lethal category for cold water fish. For the Little Applegate, the increase in shade from 75% current effective shade to 95% at *system potential* will result in a decrease in temperature from 10% of the stream exceeding 64°F currently to 0% of the steam exceeding 64°F at system potential. At system potential the entire 21.0 miles of the Little Applegate River would be expected to be less than 64°F on the day simulated (Figure 10).

Figure 10. Temperature Distributions on Applegate and Little Applegate

Applegate



Little Applegate



ALLOCATIONS – 40 CFR 130.2(G) AND 40 CFR 130.2(H)

There is no temperature load allocation available for anthropogenic sources in the Applegate Subbasin. 100% of the Loading Capacity is allocated to natural sources.

Portions of the loading capacity are divided among natural background, human, and future point and nonpoint pollutant sources. Under conditions where surface water temperatures are predicted to meet the standard at system potential, a load may be available to assign to anthropogenic point or nonpoint sources. The Applegate River at system potential is not predicted to meet the temperature criteria of 64°F (17.8°C) during the hottest time of year, 100% of the load allocation for this subbasin is assigned to natural sources. Any activity that results in anthropogenic-caused heating of the stream is unacceptable. Table 17 lists load allocations (portions of the loading capacity) according to pollution sources, and land-uses in the subbasin.

Table 17. Temperature TMDL Allocations

Nonpoint Sources: Load Allocations by Land Use	
Source	***Load Allocation*** ***Distribution of Solar Radiation Loading Capacity***
Natural	100%
Agriculture	0%
Forestry	0%
Urban	0%
Transportation	0%
Future Sources	0%
Point Sources: Waste Load Allocations by Source	
Source	***Waste Load Allocation*** ***Distribution of Point Source Loading Capacity***
Current and Future NPDES Permit holders	No Measurable Increase[1] over System potential Surface Water Temperatures
NPDES Permitted Activities: Recreational Mining	No Measurable Increase[1] in Surface Water Temperatures
Dams: Load Allocation	
Source	***Waste Load Allocation*** ***Distribution of Point Source Loading Capacity***
Applegate Dam	No Measurable Increase in Surface Water Temperatures[1] above that which would occur under natural conditions

[1]No measurable increase is defined no more than 0.25°F

The following section provides a brief overview of the Load Allocations listed in Table 16 by source.

Point Sources:

NPDES Permitted Sources

Loading Capacity for permitted sources in the Applegate is based on the condition: "no measurable surface water temperature increase resulting from anthropogenic activities when the temperature criterion is exceeded." No measurable increase means an increase in stream temperature of more than 0.25ºF (OAR340-41-006 (55)). The equation for calculating the heat load from point sources is provided below.

$$WLA_{PS} = (\Delta T \text{ x } (Q_R + Q_s)/4)/1.1$$

Where WLA_{PS} = the point source waste load allocation

ΔT = no measurable increase equal to 0.25ºF

Q_R = receiving stream flow

Q_S = point source flow

1.1 is a factor of safety (i.e. 10%) that is applied as required by the Clean Water Act

The above equation is derived as follows from a conventional mass balance equation:

$$(Q_R \text{ x } T_R) + (Q_s \text{ x } T_S) = (Q_R + Q_s) \text{ x } (T_R + \Delta T)$$

$$Q_R T_R + Q_s T_S = Q_R T_R + Q_s T_R + \Delta T(Q_R + Q_s)$$

$$\Delta T(Q_R + Q_s) = Q_s (T_S - T_R)$$

Both sides of the equation represent the heat load discharged to the stream. If ΔT is set at 0.25ºF, then this is the maximum allowable heat load which could be allowed and be considered not measurable. The equation is divided by 4 because ODEQ intends to allow a source to use no more than ¼ of the stream for mixing. When calculating actual permit limits, permit writers will allow either ¼ of the stream flow or the dilution provided at the edge of the mixing zone whichever is less. A safety factor of 1.1, was chosen by DEQ as an acceptable safety factor to meet the requirements of federal rule.

Critical Period

The equation for calculating the WLA during the critical period (June 1 through October 31) is provided shown above. ODEQ did not develop a waste load allocation for the Hidden Valley High School discharge because no discharge is permitted between May 1 and October 31 under the limitations of their current permit (NPDES Permit #102221). ODEQ did not develop a WLA for recreational mining operating under NPDES 700J permits because they are not considered to have a thermal discharge. All current and future recreational mining permits under the NPDES system stipulate "no measurable increases in surface water temperature" are allowed from this activity (Table 17).

Non-Critical Period

During non-critical periods temperature limits must still be set so as to not violate water quality criteria in the receiving stream or in water bodies down stream to which the receiving stream is a tributary. Non-critical period for the Applegate is set as November 1 through May 31. During the non-critical period as well, point sources will only be allowed to discharge to surface waters in the Applegate River Subbasin if it can be demonstrated that they will not cause a measurable increase (>0.25F) in stream temperature outside of the mixing zone. Table 17 details what that heat load may look like during the non-critical period for Hidden Valley High School. Table 18 uses hypothetical flows in the Applegate to determine approximate loadings. The WLAs set forth in Table 18 are calculated on the low end of the river flow range and the high end of the discharge flow range so the numbers are considered conservative. Once the Applegate Subbasin TMDL is approved by the USEPA, ODEQ will reissue this permit to be consistent with the intent of the designated Waste Load Allocations. At that time, ODEQ will obtain specific information about actual flows and effluent temperatures so that the resulting permit limits reflect actual conditions.

The equation for calculating the WLA during the non-critical period is:

$$WLA_{PS} = (\Delta T \text{ x } (Q_R + Q_S)/4)/1.1$$

Table 18. NPDES Point Sources Waste Load Allocations

Hidden Valley High School (NPDES Permit #102221		
Flow at Outfall[1] CFS	**Waste Load Allocation within the Critical Period[2]** (kcal/day)	**Waste Load Allocation[4] outside the Critical Period[3]** (kcal/day)
200-300	No discharge allowed under current permit WLA = 0 kcal/day	1.5E+07
300-400		2.3E+07
400-500		3.1E+07
500-600		3.9E+07
>600-		4.6E+07
Recreational Suction Dredging NPDES general permit 0700J		
All flows	Not considered to have a thermal discharge WLA = 0 kcal/day	Not considered to have a thermal discharge WLA = 0 kcal/day

[1]The lower end of the range of flow was used to in calculating the WLA provide an explicit margin of safety.
[2] Critical period defined as June 1 through October 31
[3.] Non Critical period defined as November 1 through May 30
4 WLA is based on the permitted maximum flow of Hidden Valley High School of 0.037 Million gallons per Day (MGD)

Applegate Dam

The load allocation assigned to the Applegate Dam is no measurable increases in surface water temperature above that which would naturally occur if the dam were not present. The equation listed below is used to determine the amount of heat that the reservoir and dam can add and meet the requirement of "No measurable increases in surface water temperature above that which would naturally occur if the dam were not present" at the specified flow.

$$\text{Load (kcal/day)} = [(\Delta T) \times (Q_R) \times (86400 \text{ sec/day}) \times (62.4\text{\#water/ft}^3)]/(SF \times 3.968\text{BTU/kcal})$$

ΔT = change in temperature ºF
Q_R = flow in the river (cfs)
SF = Safety factor

Critical Period

The equation for calculating the Applegate Dam heat load during the critical period (June 1 through October 31) is provided below. The equation determines the amount of heat that the reservoir and dam can add and meet the requirement of "No measurable increases in surface water temperature above that which would naturally occur if the dam were not present" at the specified flow.

$$\text{Load} = [(0.25^{\circ}F) \times (Q_R \text{ ft}^3\text{/sec}) \times (86400\text{sec/day}) \times (62.4\text{\#water/ ft}^3)]/[(3.968\text{BTU/kcal}) \times (1.1)]$$

NOTE: A safety factor (SF) of 1.1 (i.e. 10%) was included in this calculation because it is during a condition when the waterbody is potentially water quality limited for temperature. A factor of safety is required by federal rule. ODEQ believes that an explicit safety factor of 10% is approvable and provides for sufficient protection.

Non-Critical Period

The equation for calculating the heat load allocation outside of the critical period (November 1 through May 31) is the same as that used above without the inclusion of the safety factor. The numeric load allocation for non-critical period is shown in Table 19 below.

$$\text{Load} = [(0.25^{\circ}F) \times (Q_R \text{ ft}^3\text{/sec}) \times (86400\text{sec/day}) \times (62.4\text{\#water/ ft}^3)]/(3.968\text{BTU/kcal})$$

NOTE: The safety factor (SF) was not included in this calculation because it is during a time outside of the critical period when the waterbody is not expected to be water quality limited for temperature.

Table 19. Calculated Load Allocation for Applegate Dam (kcal/day)

Flow at Applegate Dam Outfall[1]	Load Allocation[2] (kcal/day) within the Critical Period[3]	Load Allocation[2] (kcal/day) outside the Critical Period[4]
200-250	6.2E+07	6.8E+07
250-300	7.7E+07	8.5E+07
300-350	9.3E+07	1.0E+08
350-400	1.1E+08	1.2E+08
400-450	1.2E+08	1.4E+08
450-500	1.4E+08	1.5E+08
500-550	1.5E+08	1.7E+08
550-600	1.7E+08	1.9E+08
600-650	1.9E+08	2.0E+08

[1] In calculating the load allocations during the spawning period, ODEQ used the lower river flow value of the range.
[2] Load allocation shown is the amount of heat that the reservoir and dam can add and meet the requirement of "No measurable increases in surface water temperature[1] above that which would naturally occur if the dam were not present" at the specified flow.
[3] The critical period in the Applegate Subbasin is from June 1 through October 31 – this is the period when stream temperatures exceed the numeric criterion.
[4] November 1 through May 31

Temperature Management Plan

The Oregon Administrative Rule that applies to the Applegate Dam is “unless specifically allowed under a DEQ-approved surface water temperature management plan as required under OAR 340-041-0026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:” The actual heat load values in kcal/day based on flow are shown in Table 19, where no measurable increase is to be no more than a 0.25°F. ODFW data indicates that the 0.25°F increase is exceeded October through February. The USACE has worked with ODFW to develop a release schedule that would maximize benefits to chinook salmon and winter steelhead. (Fustich et.al. 1988, Fustich et.al. 1995). These target temperatures and flow recommendations form the foundation of a temperature management plan; however, DEQ requests that the USACE work with the Department to submit a formal temperature management plan.

In addition, if the permitting process continues for the Applegate Dam Hydroelectric Project (FERC#11910 - Submitted September 2002, Symbiotics LLC), Symbiotics LLC will need to obtain a water quality standards compliance certification statement for the Project from the DEQ, pursuant to requirements of section 401 in the Federal Clean Water Act and Oregon Administrative Rules Chapter 340, Division 48. Section 401 of the Federal Clean Water Act establishes requirements for State certification of proposed projects or activities that may result in any discharge of pollutants to navigable waters. This certification will require additional analysis on the effect of the dam and its operations on water quality and requires that the facility be operated in accordance with established load allocations adopted pursuant to this TMDL.

Nonpoint Sources: Agriculture, Forestry, Urban, Transportation

For nonpoint sources in the Applegate Subbasin the load allocation is system potential vegetation quantified as average percent shade

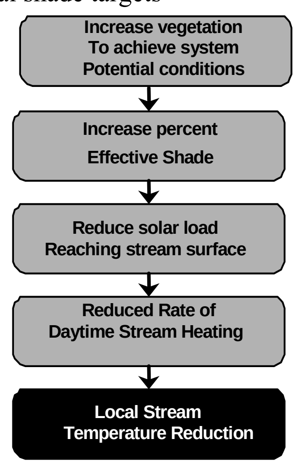
The nonpoint source loading capacity in the Applegate Subbasin is defined as the amount of solar radiation that reaches a stream surface when riparian vegetation and stream channels have achieved system potential (Table 20). The following section sets average percent shade targets for every perennial stream in the Applegate Subbasin (Table 21). When these targets are realized, the loading capacity will be met and the TMDL will be achieved.

Table 20. Nonpoint Sources Load Allocation

Nonpoint Source	Temperature Load Allocation	DMA with Authority
All perennial or fishbearing streams in the Applegate Subbasin	Amount of solar radiation that reaches a stream surface when riparian vegetation and stream channel has achieved system potential (See Table 17).	Jackson County, Josephine County, ODA, ODF, BLM, USFS,ODOT

A TMDL allows for the use of "*other appropriate measures*" or surrogate measures as provided under EPA regulations [40 CFR 130.2(i)]. Percent-effective shade serves as the other appropriate or surrogate measure for meeting the temperature TMDL. Although loading capacity for heat energy can be determined in BTU/ft^2/day, it is difficult to measure and therefore of limited value in the field. Percent-effective shade is an appropriate measure because it can be measured in the field and relates directly to solar loading.

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 (BTU/ft^2/day). System potential shade targets (percent-effective shade) and the subsequent reduction in solar load (BTU/ft^2/day) have been calculated for all streams within the Applegate Subbasin (Table 20). A detailed account of how these values were determined is included in Appendix A.



The factors that affect water temperature are interrelated. The surrogate measure (percent-effective shade) that requires the protection or restoration of riparian vegetation to increase stream surface shade levels will also reduce stream bank erosion, stabilize channels, reduce the near-stream disturbance zone width and reduce the surface area of the stream exposed to solar radiation.

Table 21. Thermal Loads and Percent-Effective Shade Targets for All Streams

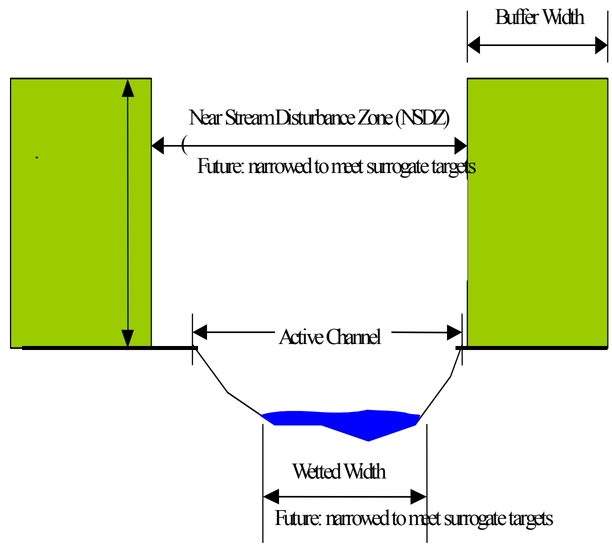
Applegate River Mainstem						
	Analysis Method[1]	Current Shade[2]	Future Shade[2]	Current Load[3]	Future Load[3]	Time to Recovery[4]
Applegate River – mouth to dam	Tier I	4	13	2409	2173	ND
Upper Applegate River HUC#17100309-01						
All streams use Tier IV potential vegetation maps and tables to estimate system potential effective shade						
Applegate River – McKee Bridge HUC#17100309-02						
	Analysis Method[1]	Current Shade[2]	Future Shade[2]	Current Load[3]	Future Load[3]	Time to Recovery
Armstrong Gulch	Tier II	90.8	93.8	239	161	0
Bailey Gulch	Tier II	94.2	96.8	151	83	0
Beaver Creek	Tier II	83.0	90.6	442	244	0
Brushy Gulch	Tier II	92.8	98	187	52	0
Charlie Buck Gulch	Tier II	92.5	94.4	195	146	0
Hanley Gulch	Tier II	92.2	92.7	203	190	0
Haskins Gulch	Tier II	91.6	92.0	218	208	0
Kinney Creek	Tier II	76.8	97.9	603	55	129
Lime Gulch	Tier II	91.3	92	226	208	0
Mule Creek	Tier II	84.8	92.6	395	192	0
Nine Dollar Gulch	Tier II	93.0	93.0	182	182	0
Palmer Creek	Tier II	79.1	93.8	544	161	127
Petes Camp Creek	Tier II	91.3	93.9	226	158	0
Rock Gulch	Tier II	86.0	96.0	364	104	0
Waters Gulch	Tier II	84.5	97.6	403	62	0
Star Gulch	Tier II	60	86	1040	364	74
Benson Gulch	Tier II	64	94	936	156	103
Lightning Gulch	Tier II	82	93	468	182	0
1918 Gulch	Tier II	62	90	988	260	83
1917 Gulch	Tier II	63	89	962	286	76
Ladybug Gulch	Tier II	70	92	780	208	125
Alexander Gulch	Tier II	75	92	650	208	72
Deadman Gulch	Tier II	94	97	156	78	0
All other streams use Tier IV potential vegetation maps and tables to estimate system potential shade						
Little Applegate River HUC#17100309-03						
	Analysis Method[1]	Current Shade[2]	Future Shade[2]	Current Load[3]	Future Load[3]	Time to Recovery
Little Applegate	Tier I	75	93	617	177	ND
Yale	Tier II	96	97.4	104	67	ND
Glade	Tier II	91.9	95.3	210	122	ND
Sterling	Tier II	85.3	95.6	382	114	ND
All other streams use Tier IV potential vegetation maps and tables to estimate system potential shade						

Middle Applegate River HUC#17100309-04						
	Analysis Method[1]	Current Shade[2]	Future Shade[2]	Current Load[3]	Future Load[3]	Time to Recovery
Thompson	Tier III	ND	89	ND	281	ND
All other streams use Tier IV potential vegetation maps and tables to estimate system potential shade						
Williams Creek HUC#17100309-05						
	Analysis Method[1]	Current Shade[2]	Future Shade[2]	Current Load[3]	Future Load[3]	Time to Recovery
Williams Creek (mouth to Forks)	Tier II	56	73	1144	702	60
Powell	Tier II	71	90	754	260	66
Wallow	Tier II	92	96	208	104	0
Honeysuckle	Tier II	91	91	234	234	0
WF Williams	Tier II	75	85	650	390	64
Munger	Tier II	83	93	442	182	0
North Fork Munger	Tier II	76	92	624	208	80
Goodwin	Tier II	79	96	546	104	67
Lone	Tier II	79	96	546	104	78
Tree Branch	Tier II	88	94	312	156	0
Bill	Tier II	76	95	624	130	87
Rt Hand Fk, WF Williams	Tier II	87	92	338	208	0
Bear Wallow	Tier II	80	95	520	130	0
EF Williams	Tier II	85	91	390	234	0
Clapboard	Tier II	91	93	234	182	0
Sugarloaf	Tier II	89	95	286	130	0
Rock	Tier II	87	92	338	208	0
Rt Hand Fk, Rock	Tier II	89	97	286	78	0
Glade	Tier II	94	97	156	78	0
All other streams use Tier IV potential vegetation maps and tables to estimate system potential shade						
Lower Applegate River HUC#17100309-06						
	Analysis Method[1]	Current Shade[2]	Future Shade[2]	Current Load[3]	Future Load[3]	Time to Recovery
Cheney Creek	Tier III	ND	94	ND	148	ND
Slate Creek	Tier III	ND	83	ND	438	ND
Waters Creek	Tier III	ND	91	ND	231	ND
All other streams use Tier IV potential vegetation maps and tables to estimate system potential shade						

1. Tier refers to the method of analysis used to determine vegetation and percent-effective shade targets: **Tier I:** Heatsource Model with highest level of assessment. Data used includes full description of instream temperatures measured at calibration points, flow volume, channel characteristics and adjacent riparian vegetation characterized. **Tier II:** shadow model used to determine shade. Extensive riparian vegetative and active channel descriptions taken from aerial photographs and ground measurements. **Tier III**: Modified *Heatsource* model (only shade calculation subroutines are used, energy thermodynamics are ignored). STATSGO soils database are used to

define vegetative communities, shade heights and canopy densities. Oregon Department of Fish and Wildlife stream surveys define active channel widths. Average percent-effective shade targets are determined for each stream. **Tier IV**: STATSGO soils database are used to define vegetative communities, shade heights and canopy densities. Shade curves are used by land manager to determine percent shade if the NSDZ, soil type, dominant vegetation and compass aspect are known.

2. Current Shade and Future Shade refer to percent-effective shade defined as the percent reduction of solar radiation load delivered to the water surface. 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 (BTU/ft^2/day).



3. Loads are expressed in BTU/Ft^2/day. Loads are based on 2,601 BTU/ft^2/day (maximum July insolation at Medford, OR; collector: flat-plat, facing south at a fixed tilt; +/- 9% uncertainty). Calculations is (1.0 - decimal percent shade) * 2,601 BTU/ft^2/day = load.

4. If current shade is >80% the time to recovery is listed as 0 years. If current shade is <80%, the time to recovery is listed as that time needed to reach full system potential percent-effective shade. However it is important to note that any increase over 80% effective shade is considered a margin of safety. At 80% further reduction in stream temperature as a function of vegetation may not be measurable for all stream flows (Boyd, 1996). At values of >80% effective shade stream is considered recovered and the stream should not be a candidate for active restoration. Additional shade should come from passive management of the riparian area.

For those streams not listed in Table 20 above, shade targets are determined through the use of the potential vegetation map (Map 6) and the shade tables that follow (Table 21). This method uses generalized data, averaged over a greater area to result in the least precise method for determining percent-effective shade targets described in this document. However, this method can provide useful information for the land manager as a quick method to estimate the TMDL percent-effective shade target for any stream in the Applegate Subbasin.

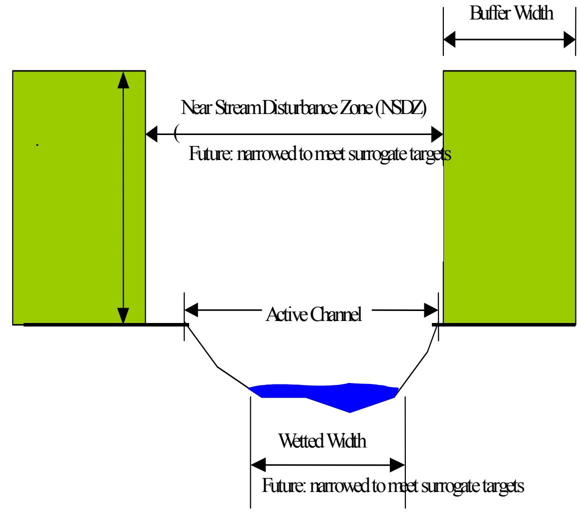
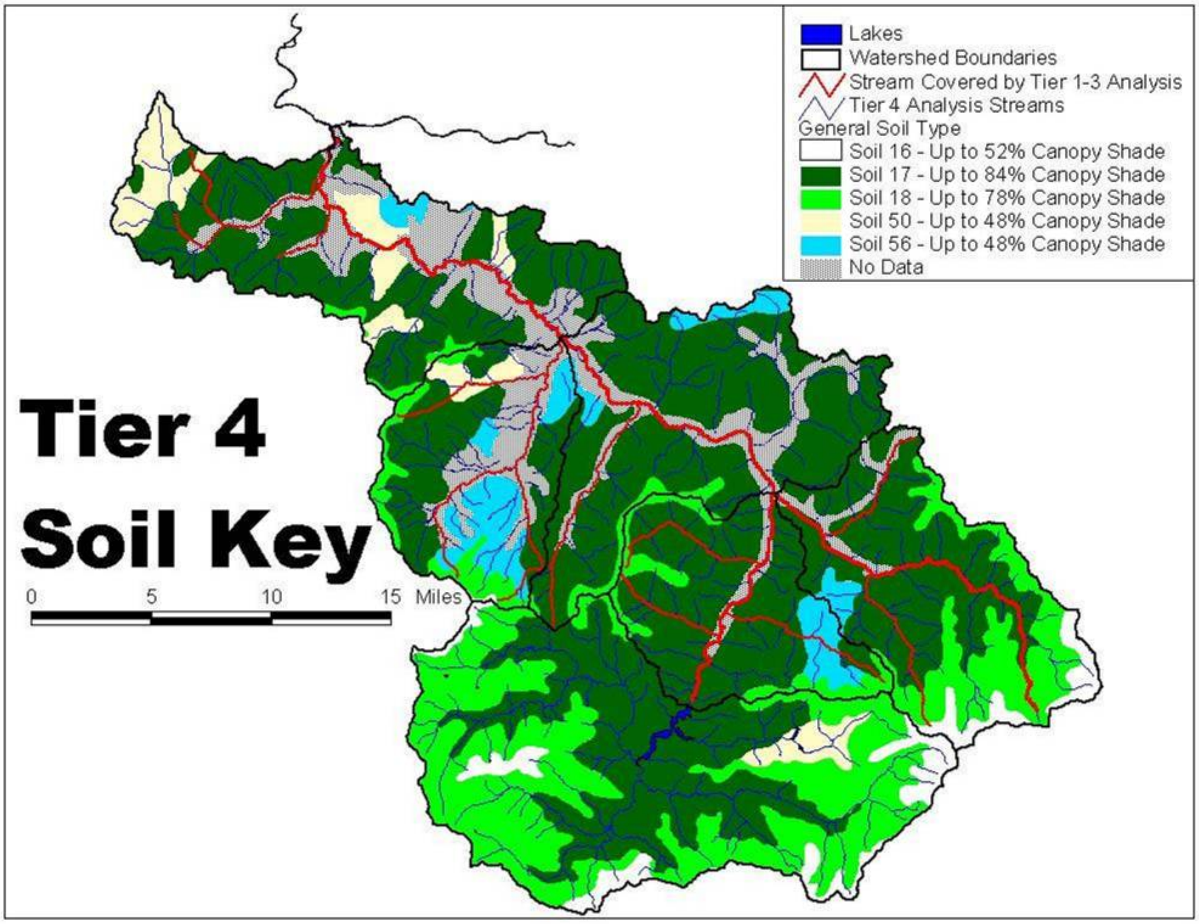


Figure 11. Generalized Channel Characteristics

The method uses soil data to describe associated vegetative communities. General community characteristics determine the height of the vegetation and the canopy density under system potential conditions (Figure 11). These characteristics were entered into a modified *Heatsource* model which calculated the percent-effective shade targets at a range of near stream disturbance zone widths (NSDZ). Output from multiple simulations was used to construct a series of tables showing the NSDZ verses percent-effective shade relationship for a stream at different compass aspects (Table 21).

Using Tier IV to Determine Percent-Effective Shade

To determine the system potential shade for a specific site, the user must first identify the stream location on a map and then determine the appropriate soil zone using Map 6. Applicable zones in the Applegate Subbasin are 16, 17, 18, 50, and 56. The next step is to visit the site and identify the dominant vegetation. The user then measures the near stream disturbance zone distance (the distance from a tree on one bank to a tree and the opposite bank) and determines the compass aspect measured from due North. Dominant species can be Douglas Fir or White fir for Soil 16, Douglas Fir or Ponderosa Pine for soil 17, Douglas Fir or White Fir for soil 18, Douglas Fir, Ponderosa Pine, Jeffery Pine or Incense Cedar for soil 50, Douglas Fir or Ponderosa Pine for soil 56. Using the soil number and dominant species the user gets the system potential tree height from Table 22. Using the soil type and system potential tree height (SP Height) along with aspect and NSDZ the user can determine the percent-effective shade using the appropriate cell in Table 23.



Map 6. Applegate Potential Vegetation

Table 22. Dominant Species System Potential Tree Height

Soil Type	Typical Canopy Shade (%)	Dominant Species	Species Site Index	System Potential Tree Height (ft)
16	52	Douglas Fir	95	105
Crannler-Bigelow-Woodseye	52	White Fir	70	130
17	84	Douglas Fir	65 - 94	105 - 145
Beekman-Josephine-Vannoy	84	Ponderosa Pine	75 - 115	140 - 190
18	78	Douglas Fir	60 - 95	105 -145
Jayer-Althouse-Woodseye	78	White Fir	70 - 80	130
50	48	Douglas Fir	76 - 90	105 - 145
Pearsoll-Dubakella-Cornutt	48	Ponderosa Pine	60	120
	48	Jeffery Pine	60	70
	48	Incense Cedar	60	95
56	48	Douglas Fir	60 - 110	105 - 185
Tallowbox-Siskiyou-Shefflein	48	Ponderosa Pine	90 - 114	160 - 190

Table 23. System Potential Shade Calculator Table

	Soil Type 16	SP Height 105	SP Density 52	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.5%	97.4%	96.3%	**97.7%**
20	99.5%	97.4%	96.3%	**97.7%**
40	94.5%	88.3%	87.3%	**90.1%**
60	78.4%	58.1%	69.5%	**68.7%**
80	78.4%	58.1%	69.5%	**68.7%**
100	4.7%	49.5%	53.9%	**36.0%**
120	4.7%	49.5%	53.9%	**36.0%**
140	3.7%	35.5%	41.4%	**26.9%**
160	3.7%	35.5%	41.4%	**26.9%**
180	2.9%	24.1%	31.8%	**19.6%**
200	2.9%	24.1%	31.8%	**19.6%**
220	2.4%	17.6%	24.7%	**14.9%**
240	2.4%	17.6%	24.7%	**14.9%**
260	1.9%	12.6%	19.4%	**11.3%**
280	1.9%	12.6%	19.4%	**11.3%**
300	1.5%	9.4%	15.6%	**8.8%**

	Soil Type 17	SP Height 140	SP Density 84	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.9%	99.5%	99.4%	**99.6%**
20	99.9%	99.5%	99.4%	**99.6%**
40	96.3%	92.7%	92.7%	**93.9%**
60	86.7%	72.0%	79.0%	**79.2%**
80	86.7%	72.0%	79.0%	**79.2%**
100	65.7%	54.3%	66.3%	**62.1%**
120	65.7%	54.3%	66.3%	**62.1%**
140	4.6%	50.8%	55.1%	**36.8%**
160	4.6%	50.8%	55.1%	**36.8%**
180	3.8%	39.1%	45.5%	**29.5%**
200	3.8%	39.1%	45.5%	**29.5%**
220	3.2%	29.4%	37.6%	**23.4%**
240	3.2%	29.4%	37.6%	**23.4%**
260	2.7%	22.3%	31.1%	**18.7%**
280	2.7%	22.3%	31.1%	**18.7%**
300	2.3%	18.2%	25.9%	**15.5%**

	Soil Type 16	SP Height 130	SP Density 52	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	98.8%	95.7%	94.0%	**96.2%**
20	98.8%	95.7%	94.0%	**96.2%**
40	94.8%	88.3%	86.8%	**90.0%**
60	84.0%	65.4%	72.1%	**73.8%**
80	84.0%	65.4%	72.1%	**73.8%**
100	56.3%	49.8%	58.8%	**55.0%**
120	56.3%	49.8%	58.8%	**55.0%**
140	4.3%	43.9%	47.3%	**31.9%**
160	4.3%	43.9%	47.3%	**31.9%**
180	3.5%	32.3%	38.0%	**24.6%**
200	3.5%	32.3%	38.0%	**24.6%**
220	2.9%	23.5%	30.6%	**19.0%**
240	2.9%	23.5%	30.6%	**19.0%**
260	2.5%	17.9%	24.8%	**15.0%**
280	2.5%	17.9%	24.8%	**15.0%**
300	2.1%	14.4%	20.3%	**12.3%**

	Soil Type 17	SP Height 145	SP Density 84	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.9%	99.5%	99.3%	**99.6%**
20	99.9%	99.5%	99.3%	**99.6%**
40	96.4%	92.9%	92.8%	**94.1%**
60	87.3%	73.1%	79.6%	**80.0%**
80	87.3%	73.1%	79.6%	**80.0%**
100	68.6%	54.6%	67.3%	**63.5%**
120	68.6%	54.6%	67.3%	**63.5%**
140	4.7%	51.3%	56.3%	**37.4%**
160	4.7%	51.3%	56.3%	**37.4%**
180	3.9%	40.7%	46.8%	**30.5%**
200	3.9%	40.7%	46.8%	**30.5%**
220	3.3%	31.0%	38.9%	**24.4%**
240	3.3%	31.0%	38.9%	**24.4%**
260	2.8%	23.5%	32.4%	**19.6%**
280	2.8%	23.5%	32.4%	**19.6%**
300	2.4%	19.1%	27.1%	**16.2%**

	Soil Type 17	SP Height 105	SP Density 84	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.9%	99.6%	99.6%	**99.7%**
20	99.9%	99.6%	99.6%	**99.7%**
40	94.9%	90.5%	90.6%	**92.0%**
60	78.9%	60.2%	72.7%	**70.6%**
80	78.9%	60.2%	72.7%	**70.6%**
100	4.7%	51.6%	57.1%	**37.8%**
120	4.7%	51.6%	57.1%	**37.8%**
140	3.7%	37.4%	44.3%	**28.5%**
160	3.7%	37.4%	44.3%	**28.5%**
180	2.9%	25.6%	34.4%	**21.0%**
200	2.9%	25.6%	34.4%	**21.0%**
220	2.4%	18.9%	26.9%	**16.1%**
240	2.4%	18.9%	26.9%	**16.1%**
260	1.9%	13.6%	21.4%	**12.3%**
280	1.9%	13.6%	21.4%	**12.3%**
300	1.6%	10.1%	17.2%	**9.6%**

	Soil Type 17	SP Height 190	SP Density 84	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.9%	99.1%	98.6%	**99.2%**
20	99.9%	99.1%	98.6%	**99.2%**
40	97.2%	94.1%	93.6%	**95.0%**
60	91.0%	80.6%	83.4%	**85.0%**
80	91.0%	80.6%	83.4%	**85.0%**
100	81.7%	63.3%	73.6%	**72.9%**
120	81.7%	63.3%	73.6%	**72.9%**
140	62.5%	53.4%	64.5%	**60.1%**
160	62.5%	53.4%	64.5%	**60.1%**
180	4.7%	51.0%	56.2%	**37.3%**
200	4.7%	51.0%	56.2%	**37.3%**
220	4.1%	43.6%	48.7%	**32.2%**
240	4.1%	43.6%	48.7%	**32.2%**
260	3.6%	35.5%	42.2%	**27.1%**
280	3.6%	35.5%	42.2%	**27.1%**
300	3.2%	28.7%	36.6%	**22.8%**

Table 23. Continued: System Potential Shade Calculator

	Soil Type	SP Height	SP Density	
	18	105	78	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.9%	99.5%	99.4%	**99.6%**
20	99.9%	99.5%	99.4%	**99.6%**
40	94.9%	90.4%	90.5%	**91.9%**
60	78.9%	60.1%	72.6%	**70.5%**
80	78.9%	60.1%	72.6%	**70.5%**
100	4.7%	51.5%	57.0%	**37.7%**
120	4.7%	51.5%	57.0%	**37.7%**
140	3.7%	37.4%	44.2%	**28.4%**
160	3.7%	37.4%	44.2%	**28.4%**
180	2.9%	25.5%	34.3%	**20.9%**
200	2.9%	25.5%	34.3%	**20.9%**
220	2.4%	18.8%	26.8%	**16.0%**
240	2.4%	18.8%	26.8%	**16.0%**
260	1.9%	13.5%	21.3%	**12.2%**
280	1.9%	13.5%	21.3%	**12.2%**
300	1.6%	10.1%	17.2%	**9.6%**

	Soil Type	SP Height	SP Density	
	50/56	70	48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.7%	98.6%	98.1%	**98.8%**
20	99.7%	98.6%	98.1%	**98.8%**
40	91.9%	82.9%	84.7%	**86.5%**
60	28.4%	51.9%	59.5%	**46.6%**
80	28.4%	51.9%	59.5%	**46.6%**
100	3.5%	33.3%	40.4%	**25.7%**
120	3.5%	33.3%	40.4%	**25.7%**
140	2.5%	19.6%	27.5%	**16.5%**
160	2.5%	19.6%	27.5%	**16.5%**
180	1.8%	11.9%	19.4%	**11.0%**
200	1.8%	11.9%	19.4%	**11.0%**
220	1.3%	8.7%	14.2%	**8.1%**
240	1.3%	8.7%	14.2%	**8.1%**
260	0.9%	7.0%	10.8%	**6.2%**
280	0.9%	7.0%	10.8%	**6.2%**
300	0.6%	5.7%	8.5%	**4.9%**

	Soil Type	SP Height	SP Density	
	18	130	78	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.9%	99.4%	99.1%	**99.5%**
20	99.9%	99.4%	99.1%	**99.5%**
40	96.0%	92.0%	91.9%	**93.3%**
60	85.1%	69.1%	77.2%	**77.1%**
80	85.1%	69.1%	77.2%	**77.1%**
100	57.2%	53.4%	63.8%	**58.1%**
120	57.2%	53.4%	63.8%	**58.1%**
140	4.3%	47.4%	52.1%	**34.6%**
160	4.3%	47.4%	52.1%	**34.6%**
180	3.6%	35.3%	42.3%	**27.1%**
200	3.6%	35.3%	42.3%	**27.1%**
220	3.0%	25.9%	34.4%	**21.1%**
240	3.0%	25.9%	34.4%	**21.1%**
260	2.5%	19.9%	28.2%	**16.9%**
280	2.5%	19.9%	28.2%	**16.9%**
300	2.1%	16.1%	23.2%	**13.8%**

	Soil Type	SP Height	SP Density	
	50/56	95	48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.4%	97.3%	96.1%	**97.6%**
20	99.4%	97.3%	96.1%	**97.6%**
40	93.9%	87.0%	86.2%	**89.1%**
60	73.7%	53.7%	66.7%	**64.7%**
80	73.7%	53.7%	66.7%	**64.7%**
100	4.4%	46.5%	50.2%	**33.7%**
120	4.4%	46.5%	50.2%	**33.7%**
140	3.4%	30.6%	37.4%	**23.8%**
160	3.4%	30.6%	37.4%	**23.8%**
180	2.6%	20.2%	28.0%	**16.9%**
200	2.6%	20.2%	28.0%	**16.9%**
220	2.1%	15.0%	21.3%	**12.8%**
240	2.1%	15.0%	21.3%	**12.8%**
260	1.6%	9.9%	16.6%	**9.4%**
280	1.6%	9.9%	16.6%	**9.4%**
300	1.3%	8.2%	13.2%	**7.6%**

	Soil Type	SP Height	SP Density	
	18	145	78	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.9%	99.2%	98.8%	**99.3%**
20	99.9%	99.2%	98.8%	**99.3%**
40	96.4%	92.6%	92.3%	**93.8%**
60	87.3%	72.8%	79.1%	**79.7%**
80	87.3%	72.8%	79.1%	**79.7%**
100	68.6%	54.3%	66.8%	**63.2%**
120	68.6%	54.3%	66.8%	**63.2%**
140	4.7%	51.0%	55.8%	**37.2%**
160	4.7%	51.0%	55.8%	**37.2%**
180	3.9%	40.5%	46.4%	**30.2%**
200	3.9%	40.5%	46.4%	**30.2%**
220	3.3%	30.8%	38.4%	**24.2%**
240	3.3%	30.8%	38.4%	**24.2%**
260	2.8%	23.3%	32.0%	**19.4%**
280	2.8%	23.3%	32.0%	**19.4%**
300	2.4%	18.9%	26.7%	**16.0%**

	Soil Type	SP Height	SP Density	
	50/56	105	48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	99.2%	96.5%	95.1%	**96.9%**
20	99.2%	96.5%	95.1%	**96.9%**
40	94.2%	87.4%	86.2%	**89.3%**
60	78.1%	57.2%	68.3%	**67.9%**
80	78.1%	57.2%	68.3%	**67.9%**
100	4.7%	48.6%	52.8%	**35.4%**
120	4.7%	48.6%	52.8%	**35.4%**
140	3.7%	34.8%	40.4%	**26.3%**
160	3.7%	34.8%	40.4%	**26.3%**
180	2.9%	23.5%	30.9%	**19.1%**
200	2.9%	23.5%	30.9%	**19.1%**
220	2.3%	17.2%	23.9%	**14.5%**
240	2.3%	17.2%	23.9%	**14.5%**
260	1.9%	12.3%	18.8%	**11.0%**
280	1.9%	12.3%	18.8%	**11.0%**
300	1.5%	9.1%	15.1%	**8.6%**

Table 23. Continued: System Potential Shade Calculator

	Soil Type 50/56	SP Height 120	SP Density 48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	98.6%	95.3%	93.5%	**95.8%**
20	98.6%	95.3%	93.5%	**95.8%**
40	94.3%	87.3%	85.6%	**89.1%**
60	81.9%	61.9%	69.9%	**71.2%**
80	81.9%	61.9%	69.9%	**71.2%**
100	41.1%	48.7%	55.8%	**48.5%**
120	41.1%	48.7%	55.8%	**48.5%**
140	4.0%	40.0%	44.0%	**29.4%**
160	4.0%	40.0%	44.0%	**29.4%**
180	3.3%	28.5%	34.7%	**22.1%**
200	3.3%	28.5%	34.7%	**22.1%**
220	2.7%	20.2%	27.4%	**16.8%**
240	2.7%	20.2%	27.4%	**16.8%**
260	2.2%	15.9%	22.0%	**13.4%**
280	2.2%	15.9%	22.0%	**13.4%**
300	1.9%	11.6%	17.8%	**10.4%**

	Soil Type 50/56	SP Height 185	SP Density 48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	94.4%	88.9%	85.7%	**89.7%**
20	94.4%	88.9%	85.7%	**89.7%**
40	91.6%	83.8%	80.6%	**85.3%**
60	85.1%	69.8%	70.2%	**75.0%**
80	85.1%	69.8%	70.2%	**75.0%**
100	75.4%	52.4%	60.4%	**62.7%**
120	75.4%	52.4%	60.4%	**62.7%**
140	55.1%	43.8%	51.5%	**50.1%**
160	55.1%	43.8%	51.5%	**50.1%**
180	4.4%	41.5%	43.8%	**29.9%**
200	4.4%	41.5%	43.8%	**29.9%**
220	3.8%	34.1%	37.1%	**25.0%**
240	3.8%	34.1%	37.1%	**25.0%**
260	3.3%	27.1%	31.5%	**20.6%**
280	3.3%	27.1%	31.5%	**20.6%**
300	2.9%	21.5%	26.8%	**17.1%**

	Soil Type 50/56	SP Height 145	SP Density 48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	97.3%	92.9%	90.6%	**93.6%**
20	97.3%	92.9%	90.6%	**93.6%**
40	93.7%	86.4%	84.1%	**88.0%**
60	84.6%	66.6%	70.8%	**74.0%**
80	84.6%	66.6%	70.8%	**74.0%**
100	66.1%	48.3%	58.7%	**57.7%**
120	66.1%	48.3%	58.7%	**57.7%**
140	4.6%	45.1%	48.1%	**32.6%**
160	4.6%	45.1%	48.1%	**32.6%**
180	3.8%	35.2%	39.3%	**26.1%**
200	3.8%	35.2%	39.3%	**26.1%**
220	3.2%	26.4%	32.1%	**20.6%**
240	3.2%	26.4%	32.1%	**20.6%**
260	2.7%	19.7%	26.4%	**16.3%**
280	2.7%	19.7%	26.4%	**16.3%**
300	2.3%	15.9%	21.8%	**13.3%**

	Soil Type 50/56	SP Height 190	SP Density 48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	94.0%	88.4%	85.1%	**89.2%**
20	94.0%	88.4%	85.1%	**89.2%**
40	91.3%	83.4%	80.2%	**84.9%**
60	85.0%	70.0%	70.0%	**75.0%**
80	85.0%	70.0%	70.0%	**75.0%**
100	75.8%	53.0%	60.4%	**63.1%**
120	75.8%	53.0%	60.4%	**63.1%**
140	57.6%	43.6%	51.7%	**51.0%**
160	57.6%	43.6%	51.7%	**51.0%**
180	4.4%	41.3%	44.1%	**30.0%**
200	4.4%	41.3%	44.1%	**30.0%**
220	3.8%	34.8%	37.6%	**25.4%**
240	3.8%	34.8%	37.6%	**25.4%**
260	3.3%	27.8%	32.0%	**21.1%**
280	3.3%	27.8%	32.0%	**21.1%**
300	2.9%	22.2%	27.3%	**17.5%**

	Soil Type 50/56	SP Height 160	SP Density 48	
NSDZ(ft)	%Shade E-W (90)	%Shade 45 Deg	%Shade N-S (0)	Avg
0	96.3%	91.4%	88.7%	**92.1%**
20	96.3%	91.4%	88.7%	**92.1%**
40	93.1%	85.5%	82.8%	**87.1%**
60	85.2%	68.3%	70.8%	**74.8%**
80	85.2%	68.3%	70.8%	**74.8%**
100	71.4%	48.1%	59.7%	**59.7%**
120	71.4%	48.1%	59.7%	**59.7%**
140	19.3%	44.7%	49.8%	**37.9%**
160	19.3%	44.7%	49.8%	**37.9%**
180	4.0%	38.4%	41.4%	**27.9%**
200	4.0%	38.4%	41.4%	**27.9%**
220	3.4%	29.7%	34.3%	**22.5%**
240	3.4%	29.7%	34.3%	**22.5%**
260	2.9%	22.7%	28.6%	**18.1%**
280	2.9%	22.7%	28.6%	**18.1%**
300	2.5%	17.7%	23.9%	**14.7%**

MARGINS OF SAFETY – CWA §303(D)(1)

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

The MOS may be implicit, as in conservative assumptions used in calculating the loading capacity, Waste Load Allocation, and Load Allocations. The MOS may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the MOS documented. The MOS is not meant to compensate for a failure to consider known sources. Table 24 presents six approaches for incorporating a MOS into TMDLs.

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

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

A TMDL and associated MOS, which results in an overall allocation, represent 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.

Table 24. Approaches for Incorporating a Margin of Safety into a TMDL

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

Explicit Margins of Safety
For point source waste load allocations, DEQ applies a safety factor of 10%.

Implicit Margins of Safety
The Applegate Subbasin temperature TMDL relies upon implicit assumptions used in the temperature TMDL assessment methodology.

- Groundwater inflow was assumed to be zero and its cooling influence on stream temperatures via mass transfer/mixing was not accounted for. Further, cooler microclimates associated with late seral conifer riparian zones were not accounted for in the simulation methodology.

- The Heat Source model (Appendix A) did not change current vegetative shade overhang values as part of its future conditions prediction. The present overhang values are very low and are likely to increase in the future. This will provide a MOS as vegetative overhang will add additional effective shade to Applegate and Little Applegate systems.

- Applegate and Little Applegate modeling used current tributary temperatures as inputs into the future condition scenario. Improvements in effective shade on the tributaries is expected to have a cooling effect on water temperatures. This additional cooling was not factored into the model and is considered a MOS.

- Modeling was conducted using worst case scenarios of low flow and seasonal maximum air temperatures.

- Current NSDZ and wetted channel width are used in the system potential scenario for Applegate and Little Applegate. Both NSDZ and wetted channel widths are expected to decrease as riparian vegetation increases and moves towards a late seral stage further decreasing that amount of solar radiation reaching the stream's surface. This conservative estimate of the potential for stream narrowing is considered a MOS.

- When interpreting the Heat Source model simulation results to determine Loading Capacity, a predicted exceedance of a temperature of 64°F for 1 day was interpreted as a violation of the 7-day moving average of the daily maximum temperatures (7 day statistic). One-day maximum temperatures can be expected to be higher than a 7-day moving average of maximum temperatures. This conservative approach results in an additional margin of safety.

SECTION 3. SEDIMENTATION TMDL

Why Is Sedimentation Important?

The measurable dimensions of a river develop over time to move the amount of water and sediment supplied by surrounding uplands. Human activities or natural events may result in more sediments being delivered than the channel morphology and flow characteristics are capable of moving downstream. An excess of sediments is important because it can adversely affect fish and other aquatic organisms by: 1) killing salmonids, 2) reducing growth, or reducing disease resistance; 3) interfering with the development of eggs and larvae; 4) modifying natural movements and migration of salmonids, and 5) reducing the abundance of food organisms (Newcombe and McDonald, 1991)..

Applying Oregon's Water Quality Standards to Sedimentation

The state has a narrative criteria that applies to sedimentation: "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."

Beaver Creek (mouth to the headwaters 8.7 miles) is included on the 1998 303(d) list as sediment impaired. This listing was determined after an analysis of macroinvertebrate populations determined an impairment due to fine sediments (USFS, 1994). Beaver Creek is also on the 1998 303(d) list for temperature, biological criteria, habitat modification, and flow modification.

Scope

The Beaver Creek sedimentation 303(d) listing applies to all lands within the Beaver Creek Analytical Watershed: 14,108 acres (This is a portion of the Applegate River – Beaver Creek HUC#171003090202). All land uses and ownerships are included in this TMDL including the U.S. Forest Service (USFS), Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, and transportation uses.

Sedimentation TMDL Overview

Sources of instream sedimentation have been identified throughout the Beaver Creek Analytical Watershed as being deriving from forestry activities, natural surface roads and road-stream crossings. The results of biomonitoring trend analysis (1992-2000) indicates that macroinvertebrate scores, while remaining low to moderate, have remained stable or have been improving in Beaver Creek. Analysis of the bottom sediments in the Beaver Creek Analytical Watershed indicates that the PACFISH target of <20% fine sediments is currently being met. For this sedimentation TMDL, the numeric target of ≤33% cobble embeddedness has been identified as the loading capacity for Beaver Creek. Long-term monitoring of macroinvertebrate populations and V(the measure of the fraction of pool volume filled with fine sediment) will be used to evaluate the trends in the watershed over time. To achieve the loading capacity and meet the TMDL, the following three surrogate measures have been identified: 1) system potential riparian vegetation for the length of Beaver Creek, 2) road density targets set for each drainage, 3) road-stream crossing targets set for each drainage.*

Table 25. Sedimentation TMDL Component Summary

State/Tribe: Oregon
Waterbody: Beaver Creek Analytical Watershed: 14,108 acres (This is a portion of the Applegate River – Beaver Creek HUC#1710030902-02).
Point Source TMDL: NO **Nonpoint Source TMDL: YES**
Date: December 2003

Component	*Comments*
Pollutant Identification	Sedimentation. *Anthropogenic Contribution:* excess inputs of fine sediment
Target Identification *CWA §303(d)(1)* *40 CFR 130.2(f)*	*Applicable Water Quality Standards:* **Sedimentation (OAR 340-041-0285 (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." *Numeric Target:* <33% cobble embeddedness as measured in Beaver Creek
Existing Sources *CWA §303(d)(1)*	*Anthropogenic sources of sediment:* • Surface erosion from roads • Ditches accelerating peak flows • Road/stream crossings • Increased peak flows, bank erosion, and surface erosion from timber harvest and agricultural land management. • Increased mass wasting from timber harvest
Seasonal Variation *CWA §303(d)(1)*	*Time period of interest:* Year-round. Sediment inputs are dependent on quantity and intensity of precipitation. Winter is the time of maximum sediment input and maximum movement of sediments through the system. Impacts from sediment are yearlong.
TMDL/Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Wasteload Allocations*: None. *Load Allocations:* 100% allocation to background nonpoint sources. *Load Capacity (numeric target):* <33% cobble embeddedness in Beaver Creek *Surrogate Measures:* 1) *System potential* vegetation, 2) Road density target, 3) Stream crossings target.
Margin of Safety *CWA §303(d)(1)*	*Implicit Margin of Safety:* Conservative assumptions in surrogate measures.
WQS Attainment Analysis *CWA §303(d)(1)*	Measurement of V* and monitoring of macroinvertebrate populations will be used to confirm sedimentation trends over time.
Public Participation (40 CFR 25)	See Appendix B for public hearing information. See also response to comment documentation.

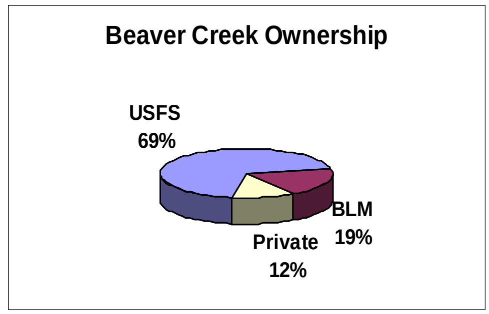
INTRODUCTION:

This TMDL Summary seeks to clearly address the elements required by EPA to meet the requirements for Total Maximum Daily Load (TMDL) development for sedimentation within the Beaver Creek Analytical Watershed in the Applegate Subbasin. These elements are addressed in this TMDL with references to the accompanying Water Quality Management Plan (WQMP). The TMDL and WQMP were prepared by the Oregon Department of Environmental Quality (DEQ) with assistance from state, federal and local partners.

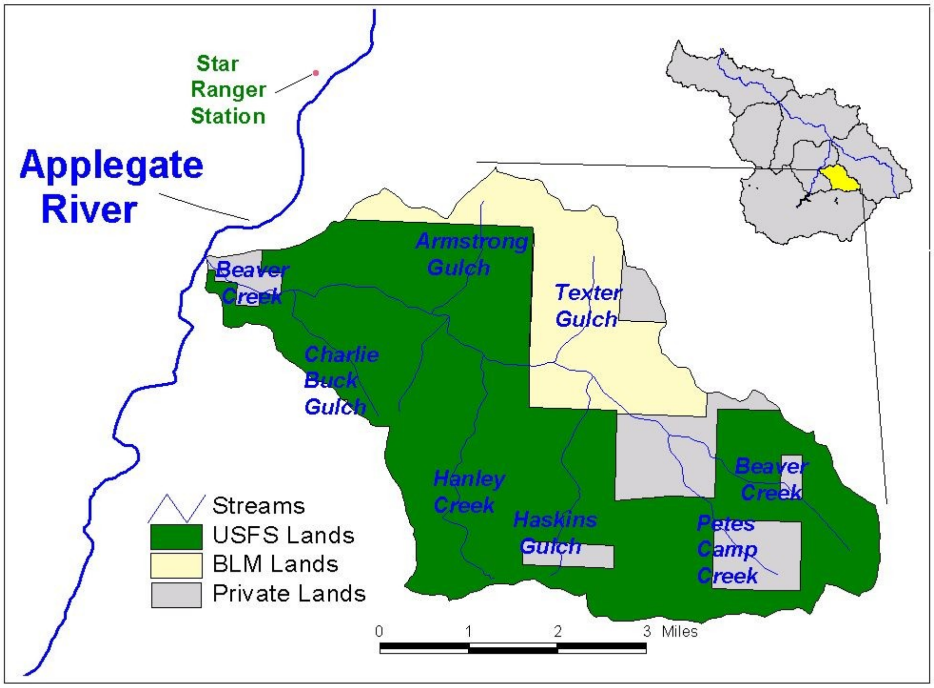
The current TMDL addresses depositional sediment in the Beaver Creek Analytical Watershed.

SUBWATERSHED DESCRIPTION AND OWNERSHIP

The Beaver Creek Analytical Watershed encompasses an area of approximately 14,018 acres in the Applegate River – Beaver Creek watershed, in the Applegate Subbasin (Map 7). It is located in the Klamath Mountains Physiographic Province and ranges in elevation from 1600 feet to over 5200 feet. Ownership in the analytical watershed consists of 69% Rogue River National Forest, 19% BLM, 12% private.



Map 7. Beaver Creek Location and Drainages



SENSITIVE BENEFICIAL USE IDENTIFICATION

Beneficial uses are defined in the Oregon Administrative Rules for the Applegate Subbasin and apply to all waterways within the subbasin, including Beaver Creek (Table 26). Sedimentation affects the beneficial uses of Salmonid Fish Spawning, Salmonid Fish Rearing, Resident Fish and Aquatic Life (DEQ, 2003).

Table 26. Sediment impacted beneficial uses in the Applegate Subbasin

(OAR 340–41–362) *Sedimentation 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	

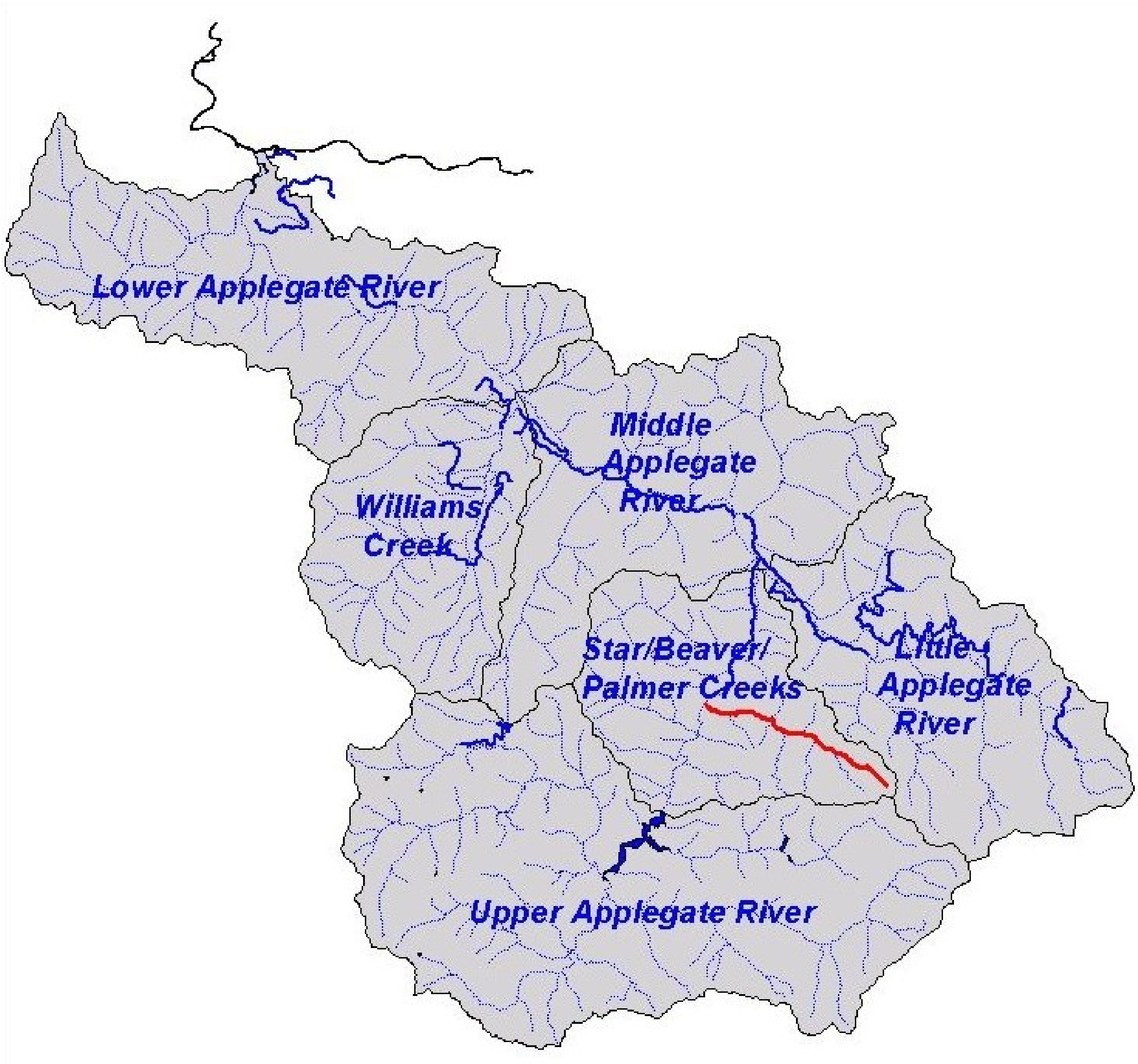
DEVIATION FROM WATER QUALITY STANDARDS AND 303(D) LISTINGS

The Beaver Creek Analytical Watershed from mouth to headwaters is included on the 1998 303(d) list for sedimentation due to the impairment of macroinvertebrates (Table 27). The impairment was based on a survey of the stream by USFS fisheries biologists in 1991 (USFS, 1994). Based on best professional judgment, the creek was given a severe to moderately impaired rating due to habitat limitations. As stated, "Fine sediment is a problem and many positive macroinvertebrate indicator groups were not present." The 8.7 miles of Beaver Creek on the 303(d) list for sedimentation are shown in red on Map 8.

Table 27. 303(d) Sedimentation Listed Stream Reaches in the Applegate Subbasin

Stream Segment	Listed Parameter	Applicable Rule	Miles Affected
Beaver Creek, mouth to Headwaters	Sedimentation	OAR 340-41-362 OAR 340-041-0365(2)(j)	8.7
		Total stream miles listed for sedimentation	**8.7**

Map 8. Sedimentation-Listed Stream Reaches in the Applegate Subbasin (Stream Reaches Listed for Sedimentation are Shown in Red)



WATER QUALITY STANDARD IDENTIFICATION

State of Oregon water quality standards related to sedimentation include:

> *Sedimentation* OAR 340-041-0365(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."
>
> *Turbidity* OAR 340-41-0365(2)(c) - "No more than a ten percent cumulative increase in natural stream turbidities shall be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity."

POLLUTANT IDENTIFICATION

The sedimentation listing is based on the findings of a 1991 USFS benthic macroinvertebrate study. This study indicated that Beaver Creek is moderately to severely impaired due to habitat limitations. Fine sediment is a problem and many positive indicator groups are not present (USFS, 1994). Subsequent to this, additional benthic macroinvertebrate studies (96, 98, 99, 00) have determined a low abundance of intolerant and cold-water taxa suggest excessive summer temperatures are a factor as well (Schroeder, 2002).

The current TMDL addresses only depositional sediment. There are currently little data or evidence that the listing should be broadened to address suspended sediments (e.g., turbidity).

The sediments found in Beaver Creek may be from nonpoint sources associated with forestry activities, roads and crossings, and agricultural maintenance of riparian areas. Fine sediments can adversely affect fish and other aquatic organisms by: 1) killing salmonids, 2) reducing growth, or reducing disease resistance; 3) interfering with the development of eggs and larvae; 4) modifying natural movements and migration of salmonids, and 5) reducing the abundance of food organisms (Newcombe and McDonald, 1991).

HISTORICAL INFLUENCES

A variety of influences in the Applegate Subbasin have resulted in historically altered streambeds and potentially excessive streambed fines. With the discovery of Gold in the Rogue River Valley in 1851-52, the Applegate River valley saw intensive placer mining with rocker and sluice box systems. During the 1870s hydraulic mining came to the Siskiyou Mountains and continued on a large scale through the 1880s. Palmer Creek, Flumet Gulch, China Gulch, and the Applegate River all experienced extensive mining during the 1880s. Beaver Creek, except for a few medium-sized mining ditches, was largely unaffected.

Beginning with the mining era agricultural settlers began farming the terraces of the Applegate River. During the period between 1890 and 1930, the main human impact to the area came from the activities of local farmers. These activities included heavy livestock grazing and water diversions for irrigation. Forest cover would have changed due to the miners' and settlers' intensive cutting of easily accessible, mature sugar pine and ponderosa pine for shakes, flume boards, and so on. In addition, nineteenth-century prospectors regularly set extensive fires in order to enhance the visibility of bedrock and colluvial deposits. Ranchers carried on the regional tradition of seasonal burning to maintain and promote grass on the lower southwest aspect slopes and to clear brush and small trees (USFS 94).

During the period following 1950, USDA Forest Service and USDI Bureau of Land Management lands became the major suppliers for new large-capacity lumber and plywood mills in Jackson and Josephine Counties. This period of intensive timber harvesting and road construction was a major factor in changing the overall appearance of the Beaver Creek Analytical Watershed. A large amount of timber was harvested from the Beaver Creek Analytical Watershed especially during the last 30-40 years. A large percentage of units were harvested using clear-cut harvest methods. Clear-cuts have resulted in severe erosion particularly in the granitics of the Squaw Creek pluton. Active debris slides are currently found in the large clear-cut units in Petes, Medite, Hanley and Haskins Drainages within the Beaver Creek Analytical Watershed (USFS 94). See Map 7 for designation of drainages.

Timber sales, recreation, some mining activity, and livestock grazing play an important role in shaping the present day economic uses and extraction of the federally managed watersheds. The importance of these uses are constantly changing as social values change, and demands for resources evolve as the government applies an ecosystem approach to forest management. (USFS, 1994).

CURRENT CONDITIONS

Fish Usage

Beaver Creek contains a diversity of fish and aquatic life. Beaver Creek is particularly important to the health of Applegate River fish stocks because: 1) it is one of the largest streams accessible to anadromous salmonids below the Applegate Dam (a total migratory block for all fish), 2) it is one of four subwatersheds in the Applegate (Beaver, Palmer, Yale, and Little Applegate Creeks) listed as key under the Presidents Plan substantially under federal ownership, 3) it has important diverse aquatic microhabitats for some aquatic species not found in the main channel of the Applegate River.

Coho salmon in Beaver Creek are listed as threatened by the National Marine Fisheries Service (NOAA Fisheries) (Federal Register, 2002). Coho salmon in the Rogue and Applegate River Basins belong to the Southern Oregon-Northern California Coast (SONCC) Evolutionary Significant Unit (ESU) which occurs between Cape Blanco, Oregon and Punta Gorda, California and it is this ESU that is listed as threatened by NOAA Fisheries. Steelhead in the Rogue and Applegate basins belong to the Klamath Mountain Province ESU, which is inclusive of the Klamath River in California north to the Elk River in Oregon. A recent status review concluded that the listing of this ESU was not warranted (Federal Register, 2001).

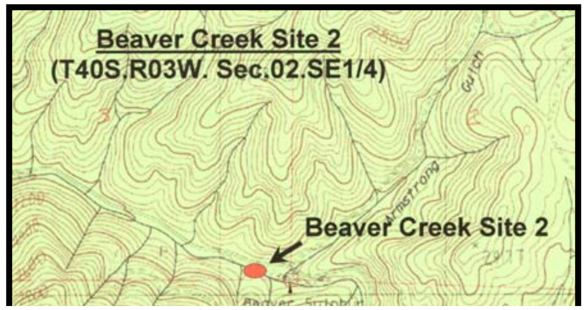
Macroinvertebrates

The designation of Beaver Creek as exceeding biological criteria due to excessive sedimentation and the resulting placement on the 1998 303(d) list came from a macroinvertebrate study performed in 1991 (Bob Wisseman 1991- Aquatic Biology Associates 503-752-1568). This study determined that macroinvertebrate populations in Beaver Creek were impaired due to excessive fine sediments. The key points derived from the 1991 study included:

- Macroinvertebrate impairments are due to habitat quality limitations, rather than water quality limitations.
- Overall habitat complexity in Beaver Creek is moderately to severely impaired (the stream tends to be wide and shallow, is sluiced to bedrock in many reaches, fine sediment has filled in hyporheic interstitial spaces, reduced crevice space in the surface armor layer of riffles, and filled in pools.
- Fine sediment is a problem in the system. Both silt and sand are a problem. Silt levels are moderate in slack water areas. High levels of silt can smother margin and pool invertebrate communities. Low or moderate levels of silt greatly depress invertebrate abundance on the margins and inhibit scrapers. High levels of sand were common in many of the streams sampled. Sand can fill in hyporheic interstitial space, embed crevices in the surface armor rocks of riffles, and fill in pools and spawning gravel. Sand appears to be mobilized during high flow, causing moderate to severe scour of surface substrates. Scour can cause direct mortality of many invertebrate taxa, or indirectly impact them by affecting their food source or habitat (e.g. Nostoc algae and moss).

- Highly intolerant taxa were not present in high numbers and richness in most systems. The small numbers can be attributed to the above habitat factors, plus in some systems high water temperatures and reduced base flows probably contributed to their low levels.
- Many of the positive-indicator groups or taxa in a healthy stream system are absent from Beaver Creek or present in very low numbers.

The site that was sampled appeared to have a long history of impairment. This impairment comes not only from logging and roading, but also from catastrophic floods which have greatly influenced habitat structure. No Sensitive, Threatened, or Endangered aquatic invertebrate taxa were encountered at the Beaver Creek 1991 sampling site.



Map 9. Macroinvertebrate Monitoring Site

Macroinvertebrate collection (biomonitoring) was continued at the Beaver Creek site in 1996, 1998, 1999, and 2000. The study site is located just downstream of the Beaver Sulphur Campground (T40S.RO3W. Sec. 02.SE1/4 Map 9). The cumulative results of the 96-00 biomonitoring are contained in the report entitled; "Benthic Invertebrate Biomonitoring Trend Analysis 1992-2000 (Schroeder, 2002).

Table 28. Beaver Creek Macroinvertebrates: Scores and Trends 96-00

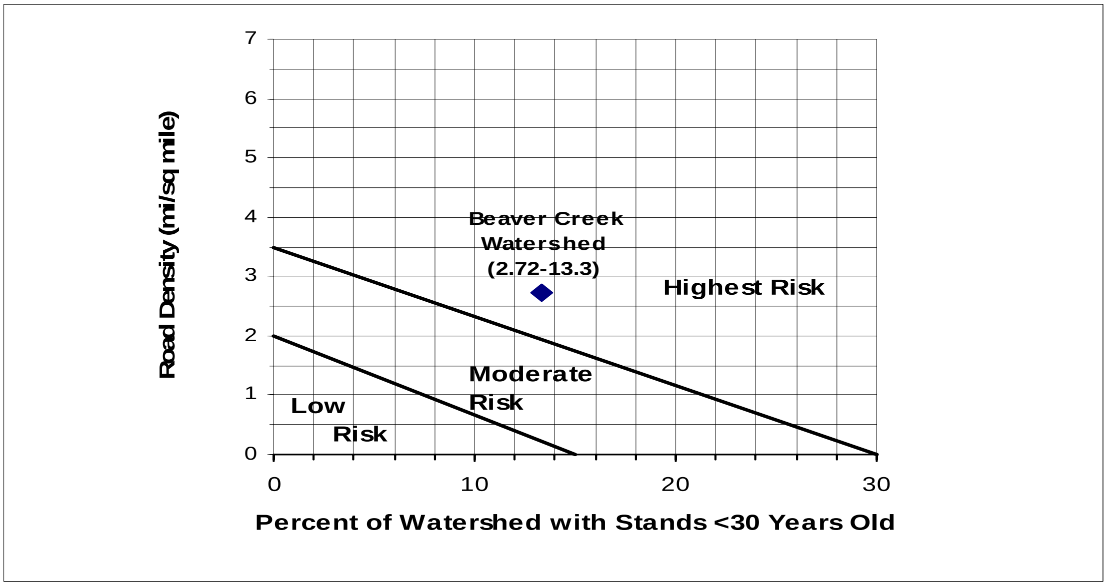
Habitat Type	Scores	Trend
Erosional	Low to Moderate	Static
Margin	Moderate to High	Improved
Detritus	Low to Moderate	Improved

The summary scores from this period (96, 98, 99, 00) indicate that macroinvertebrate populations have remained stable or have been improving at this site during the study period (Table 28). Scores in the detritus and margin habitats have improved as evidenced by an increased abundance of positive indicators. Increased total taxa richness also improved scores in the detritus habitat. Moderate to high percentage of collector taxa indicates higher than optimal fine particulate organic matter (fine sediment) inputs within Beaver Creek. In addition, results from 96-00 show a low abundance of intolerant and cold-water taxa suggesting excessive summer temperatures are present in the creek.

Watershed Condition (Cumulative Effects)

Forest harvest and related road building are by far the primary human influences on sediment delivery to Beaver Creek. By altering surface runoff patterns and effective ground cover, these activities can influence both upland erosional processes and the way that forest stream channels process sediment. The potential for surface erosion is directly related to the amount of bare, compacted soil exposed to rainfall and runoff. Hence, road surfaces, landings, skid trails, ditches, and disturbed clear-cut areas have the potential to contribute excessive quantities of fine sediment to stream channels. According to the Region 6 USFS methodology for determining risk of cumulative watershed effects (CWE) (USFS, 1993), the probability of experiencing negative effects (i.e. increases in runoff and/or sediment) increases with the amount of watershed that is harvested and roaded. The cited USFS methodology utilizes a Watershed Risk Rating based on three factors: average watershed slope, the percent of watershed with timber stands less than 30 years of age, and road densities. Utilizing that strategy, the overall Beaver Creek Watershed Risk Rating is considered "high" (Figure 12). This is based on an overall road density of between 2.72 (USFS, 1994) and 3.89 (USFS, 2002) miles per square mile, clearcut harvested areas accounting for approximately 13% of the basin, and the steep slopes (>30 percent) that generally characterize the watershed. The following Beaver Creek drainages have high risk ratings owing largely to steep slopes and high road densities; several of them have also experienced extensive clearcutting: Baldy, Beaver Creek headwaters, Haskins Gulch, Hanley Gulch, and Charley Buck Gulch. Petes Camp Creek with moderate slopes and the steeper Medite Drainage have moderate road densities but have relatively high percentages of clearcutting impacts and thus rate a high watershed risk rating as well. Several of these tributaries are also largely comprised of highly erosive granitic soils. By reducing road densities and allowing harvested timber sites to recover, the implicit understanding is that sedimentation of Beaver Creek and its tributaries will gradually decline to acceptable levels.

Figure 12. Watershed Risk for Beaver Creek Analytical Watershed (USFS, 1994)



Riparian Vegetation

There is a close linkage between streams and terrestrial ecosystems. Logging, livestock grazing, mining, and other activities may have numerous effects on the stream ecosystem and its salmonid populations. Most effects of land uses on streams are mediated through changes in riparian vegetation (Meehan, 1991). Riparian vegetation provides shade and an insulating canopy, preventing adverse water temperatures during both summer and winter. It also acts as a filter to prevent addition of sediment, and its roots provide stream bank stability and cover for rearing salmonids. Riparian vegetation directly influences the food chain of a stream ecosystem by providing organic detritus and terrestrial insects, and by controlling aquatic productivity that depends on solar radiation. Road construction near streams often removes riparian vegetation directly.

In the Beaver Creek Analytical Watershed, data reveal that within the riparian reserves the overall percentage of medium to large diameter class trees with 71-100% canopy closure is extremely low (USFS, 1994). This may be due in part to road construction within the riparian zone (e.g., FSRoad 20, FSRoad 1095). Survey work done by the USFS (Zan, 2000) 300 feet on either side of the stream indicated that the age of the riparian along Beaver Creek and several primary tributaries averaged in the middle to late seral stage, although several tributaries had significant percentages of the riparian area in the early seral stage (Charlie Buck 41% and Haskins 60%) (Table 29). The seral stage of riparian vegetation is significant because data has indicated that fines are expected to decrease with an increase in the amount and age of woody riparian vegetation (ODFW data, 1996).

Table 29. Riparian Characteristics for Beaver Creek (USFS, Zan, 2000)

Beaver Creek Drainage	Average Age of Riparian Vegetation in years	Percent Early Seral Stage[1]
Armstrong Creek	81	0%
Beaver Creek	71	8%
Charley Buck	89	41%
Hanley	110	0%
Haskins	69	60%
Petes Camp	77	0%

[1]**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*: 0-39 years of age, *Mid*: 40-100 years of age, *Late*: 100+ years of age

Livestock Grazing

The most apparent effects of livestock grazing on habitat is the reduction of shade and cover and resultant increases in stream temperature (grazing on shrubs and herbaceous vegetation), water quality (livestock defecation and addition of sediment by streambank trampling), changes in stream morphology, and the addition of sediment through bank degradation and off-site soil erosion (livestock trails along a streambank cause channel widening and downcutting).
Grazing impacts in Beaver Creek are most prevalent in the headwaters areas. Livestock movement appears to depend on seasonal climatic conditions. In years of higher precipitation livestock tend to stay higher in the drainage. In drier years they tend to concentrate lower in the drainage and along the mainstem of Beaver Creek. The headwaters have sustained the greatest impact from grazing. If current grazing patterns are maintained, these impacts may increase, thereby increasing recovery times (USFS, 1994).

Road Density

Road density, use, design, and location can be important in affecting the extent and magnitude of road-related sediment impacts (Reiter et al, 1995). King and Tennyson (1984) observed altered hydrology when roads constituted more than 4% of the drainage area. This correlates to approximately four miles of road per square mile of area. Other studies evaluating storm response to road construction indicate sediment effects begin when over 15% of the area is road surface. Results are extremely variable because the effects of roads are not well defined and are difficult to detect, especially as the size of floods increases (Grant, Megahan, and Thomas, 1999).

Road impacts include cutbanks, fill slopes, ditch lines, and road surfaces themselves. As road surfaces increase, the potential for sedimentation in a watershed increases. Wider road prisms, and thus a greater area of road disturbances and potential erosion, are found on steeper slopes. In those Beaver Creek drainages where granitics predominate, such as Haskins and Hanley Gulches, soil erosion and sedimentation from roads are more severe than elsewhere in the watershed.

A normal function of intermittent channels is the storage and transfer of sediment. Many system and nonsystem roads and landings are located in or adjacent to intermittent channels. During periodic drought conditions, such as that which existed through the early 1990s, sediment from roads and other sources has accumulated and been stored in these channels. During ensuing major flood events, such as occurred in 1997, large concentrations of the sediment stored in these tributaries entered Beaver Creek. This is in addition to sediment directly derived from roads. Roads also have an impact on the sinuosity of a stream system if constructed within the flood-prone area. Such roads confine the stream's ability to migrate laterally. This forced straightening of the channel results in energy dissipation in a downward direction and/or against the banks, thereby resulting in accelerated channel erosion. Many of the roads, skid trails, and landings in their current locations near channels will continue to directly produce sediment, prevent lateral stream migration, divert and concentrate overland flow, and inhibit the growth of streamside vegetation which protects stream temperatures as well as provides coarse woody debris recruitment which aids in the trapping, storage, and sorting of sediment (USFS, 1994).

Road densities for Beaver Creek drainages are displayed in Table 29; the drainages are displayed in Map 7. These values are taken from the Beaver/Palmer Watershed Analysis (USFS, 1994); they are considered conservative because the recent detailed USFS Rogue River NF Draft Roads Analysis for the Siskiyou Mountain Area (USFS, 2002) found the overall road density for Beaver Creek was higher (3.89 miles/square mile) than described in the 1994 Watershed Analysis (2.72 miles/square mile). According to the Draft Roads Analysis, there are 75.70 miles of classified roads distributed over 19.5 square miles for the average density of 3.89 miles of road per square mile. While not all private roads or private lands are included in this analysis, public lands comprise 90% of the Beaver Creek Analytical Watershed, so that the final road density including private lands is likely to be very close to the 3.89 miles/square mile in the Draft Roads Analysis. Both the sub-watershed road densities in Table 30, and Beaver Creek's 3.89 miles/square mile road density value would be even higher if they included unclassified roads. Unclassified roads are not included in this analysis. Unclassified roads are not part of the USFS forest transportation system and include unplanned roads, abandoned roads, off-road vehicle tracks, and once authorized roads that were not decommissioned at the end of authorization. These roads are usually not surfaced and are not maintained and have the potential to deliver as much or more sediment than classified roads.

Table 30. Roads Density in the Beaver Creek Analytical Watershed*

Beaver Creek Drainage	Current System Road Density*
Armstrong Creek	2.1
Baldy Creek	3.44
Beaver Headwaters	3.98
Beaver Middle	0.60
Boaz	1.66
Charley Buck	3.30
Hanley	4.64
Haskins	4.18
Jackson	1.62
Medite	2.11
Petes Camp	2.26
Texter	1.14

*Classified roads only (USFS, 1994)

Drainages with excessive classified road densities in the Beaver Creek Analytical Watershed include Hanley Gulch (4.64 miles/square mile), Haskins Gulch (4.18 miles/square mile), Beaver Creek Headwaters (3.98 miles/square mile), Baldy Creek (3.44 miles/square mile), and Charley Buck Creek (3.30 miles/square mile).

Drainage-ways Crossed

The potential for sediment input to streams is greatest where roads cross drainages. The sediment derives from road surface, ditch line, cut slope, and fill slope erosion, which is routed directly into the stream. Drainage crossings on USFS classified roads and main private roads occur primarily low in the Beaver Creek Analytical Watershed adjacent to the main stem and large tributaries. The number of drainage crossings is particularly high in the following sub-watersheds: Baldy, Beaver headwaters, Boaz, Charley Buck, Hanley Gulch, Petes Camp, and Texter (Beaver/Palmer Watershed Analysis – USFS, 1994). Where roads cross drainages the potential for direct sediment input increases. Data are only available for system roads; no nonsystem road crossings are included.

Table 31. Number of Drainage-Ways Crossed by Roads in the Beaver Creek Analytical Watershed

Creek	Number of Drainage-Ways Crossed (system roads only) Position in drainage High, Middle, Low
Armstrong Creek	7 low
Baldy Creek	23 low disconnected class 4
Beaver Headwaters	20 low, 4 high
Beaver Middle	4 middle
Boaz	11 low
Charley Buck	10 low, 9 high
Hanley	16 low, 30 middle
Haskins	6 low, 6 high
Jackson	3 high
Medite	1 middle
Petes Camp	12 low, 8 high
Texter	15 low

Channel Morphology/Cross Sections

A 1998 stream survey (Tioga Resources Inc., 1999) determined Rosgen channel types for Beaver Creek as *B* and *A* (Table 32, Channel types after Rosgen, 1996). *B channel* types are described as moderately entrenched, moderate gradient, riffle dominated with infrequently spaced pools. Very stable plan and profile with stable banks. *A channel* types are defined as steep, entrenched, cascading, step/pool streams.

Reach 1
The 2% gradient stream is in a 400-foot-wide trough-like valley. Entrenchment ratios averaged 1.7 indicating moderate entrenchment. High proportion of riffles (80%) and moderate width/depth ratio (12) suggests a B-type Rosgen channel.

Reach 2
The 3% gradient stream was in a 200-foot-wide trough-like valley. Bordering the stream were floodplains, older terraces and moderately steep hill slopes. Forest Road 20 parallels the stream and in some areas road fill and rip rap is in the stream channel which restricts meandering and reduces sinuosity. The channel was moderately entrenched with a high proportion of riffles (66%) which suggests a B-type Rosgen channel.

Reach 3
The 4% gradient stream was in a 100- to 200-foot-wide valley confirmed by moderate to steep hill slopes. The stream was bordered by terraces and floodplains. The channel was moderately entrenched with a high proportion of riffles (86%) which suggests a B-type Rosgen channel. Surveyors reported the presence of high water relief channels in floodplains which is consistent with channel measurements indicating moderate entrenchment. Forest Road 20 encroached on floodplains and resulted in localized channelization.

Reach 4
The 6% gradient stream was in an 80- to 200-foot-wide valley confirmed by moderate to steep hill slopes. The upper portion of the reach had a few small floodplains where the valley widened to 200 feet and estimated sinuosity increased to 1.3. These areas are Rosgen B channels. Other portions of the reach had narrow valley widths and steep stream gradients where bedrock and boulder cascades were common: Rosgen A channel.

Reach 5
The 9% gradient stream was in a 30- to 200-foot-wide valley mostly confined by steep hill slopes. Above this steep gradient area the valley widened, stream gradient decreased, and sinuosity increased. The stream channel on private lands had been disturbed from logging. Steep gradient channels in canyons are Rosgen A-type channels while lower gradient areas in 200-foot- wide valleys are Rosgen B-type channel.

Table 32. Beaver Creek Reaches and Channel Types

Stream Reach number*	1	2	3	4	5*
River Mile	0-1.2	1.2-3.9	3.9-5.2	5.2-6.4	6.4-7.5
Rosgen Channel Type	B	B	B	B/A	A/B

The upper portion of Beaver Creek above the Petes Camp drainage is in a stable hydraulic condition. This means that the stream is neither aggrading or degrading. Measurements taken of the cross-sectional area, plan and profiles show moderate entrenchment, stable banks, moderate channel slope and low sinuosity. This stable hydraulic condition is not considered a healthy system for fish. The lack of coarse woody debris and zero flow during the summer months have created a simplified stream system and reduced habitat connectivity (USFS, 1994). Coarse woody debris (CWD) was removed from Beaver Creek in the 1970s. This standard procedure had been carried out to remove fish barriers, to minimize damage during flood events and to aid in water movement downstream (USFS, 1994).

Sedimentation

USFS Beaver Palmer Watershed Assessment did not quantitatively measure landslide volumes nor determine sediment delivery from landslides and surface erosion. However, the assessment did estimate the percent of total volume delivered from active landslides. On the mid to lower 1/3 slopes of the granitics of Beaver Creek approximately 15% of the material from landslides has been delivered to a stream on lower and mid slopes. On the upper 1/3 slopes approximately 10% is delivered to a stream. These figures were based on landslide data sheets filled out from the granitics in the Little Applegate Watershed and are assumed to be generally applicable to granitics located here. Debris flows, debris slides and debris avalanches are the typical features (other than surface erosion) in the granitics. These landslides are very rapid events and tend to travel long distances down slope, thus more sediment is usually delivered than with other landslide types.

A target of 20% (maximum) streambed fines in spawning areas (riffles and glides) has been used as an indicator of fine sediment impairment to salmonids in other areas of Oregon (DEQ Nestucca TMDL, 2002). It is based on documentation that formed the basis for interim guidance for managing federal lands (PACFISH), ODFW habitat benchmarks (Foster et al, 2001), and other studies of sediments in salmonid habitats (Phillips et al, 1975; Hausle and Cobel, 1976; McCuddin, 1977; Bjornn and Reiser, 1991; Rhodes, 1995; Anderson et al,1992; Rhodes et al, 1994). However, the 20% percent fines target is not a useful determinate of the impact of stream fines within the Beaver Creek Analytical Watershed. Beaver Creek is high gradient (mostly Rosgen B and some A channels); and sand-sized and finer sediment is largely transported downstream through high shear-stress zones such as riffles and glides, and is either deposited in pools or is carried to the Applegate River (USFS – Mike Zan personal communication). The most recent USFS Level II Stream Survey reports fines in the 7.5 miles of Beaver Creek at between 8% and 18% (Tioga Resources, Inc., 1999).

Another indirect measurement of the presence of sediment in streams relates to embeddedness. Embeddedness is a measurement of the average proportion of gravel/cobble substrate that is buried, or embedded, by fine sediments. While low percentages of surface fines were found in riffle and glides in Beaver Creek, sediment embeddedness of spawning and macro-invertebrate habitat (gravels and small to medium cobbles) has been found to be widespread (USFS, 1994, Tioga Resources, Inc., 1999). Biological activity in the gravel/cobble substrate, whether the incubation of salmonid eggs or the early stages of the life cycle of many macro-invertebrates, depends on the maintenance of inter-gravel flows for the replenishment of nutrients and oxygen, and the removal of metabolic wastes. Unacceptable embeddedness refers to the filling of these inter-gravel, or interstitial spaces to the point where the processes of nutrient and oxygen replenishment and waste removal are disrupted resulting in the suffocation of eggs, the trapping of emergent fry, and the reduction in diversity and numbers of desirable but highly sediment-sensitive taxa, such as caddisflies. Above this condition, however, insect populations decline substantially as habitat spaces become smaller and filled. Studies by Bjorn et al (1974, 1977) concluded that approximately one-third embeddedness (33%) or less is probably the normal condition in proper functioning streams. Current recommendations consider a stream impaired when cobble embeddedness of a particular riffle or glide reaches or exceeds 33% (USFS, 2003 Su Maiyo personal communication, USFS, 1994 Level II Handbook), which is the case in much the lower 3.9 miles (Reach 1 and 2) of Beaver Creek (Table 33, Tioga Resources, Inc., 1999).

Table 33. Beaver Creek Reaches and Embeddedness

Reach Number*	River Mile	Channel Condition
1	0-1.2	Spawning gravels are quite common but decomposed gravel fines had most all habitats very embedded (>33%).[1]
2	1.2-3.9	Streambed dominated by gravel and cobble. Surveyors report that most habitats were embedded[1] (>33%) with decomposed granite.
3	3.9-5.2	Streambed dominated by gravel and cobble. Exposed bedrock was 17% at one site indicating that portions of the reach are scouring.
4	5.2-6.4	Coarse textured streambed dominated by boulders and cobbles. Channel indicates scouring.
5	6.4-7.5	Coarse textured streambed dominated by boulders and cobbles. Channel indicates scouring.

[1]Embedded refers to >33% embeddedness as determined by a Wolman Pebble Count procedure

An effective way to determine sediment for trends in an aquatic ecosystem is to measure the percentage of scoured pool volume that is filled by fine sediment. The fraction of total scoured pool volume filled, V* (V star), is a qualitative measure of fine sediment deposition in pools (Hilton and Lisle, 1993). This method offers a direct indication of the potential impact of sediment on crucial rearing and resting habitat for salmonids. Studies indicate a strong correlation between V* and the sediment budgets calculated for a watershed. In these studies the greatest amount of sedimentation of pools (highest V*s) were found in those watersheds with the highest level of logging and roading. Specifically Lisle et. al. found V* values of <10% corresponded to low sediment yields, V* >10%<20% related to a moderate sediment yield and V* values >20% were associated with high sediment yields (Lisle and Hilton, 1992). Comparable to the Beaver Creek area in the Applegate Subbasin were those studies preformed in the granitic watersheds of Bear Creek and GrassValley. Bear Creek, with very little management-related disturbance (1% logged), had a V* value of 9%. In contrast, the Grass Valley Watershed with 84% logged had a V* value of 50%. According to data provided by the Applegate River Watershed Council (Mike Mathews, unpublished data), the current average V* for Beaver Creek is 35% and ranges from 13% to 60% (Table 34).

Table 34. V* Values for Beaver Creek

Site (pool number)[1]	Date	V* Value
1	9/27/2000	0.5
2	9/27/2000	0.6
3	9/28/2000	0.27
4	9/28/2000	0.54
5	9/28/2000	0.13
6	10/3/2000	0.2
7	10/3/2000	0.26
8	10/3/2000	0.29
9	10/3/2000	0.45
10	10/4/2000	0.35
11	10/4/2000	0.3

[1]The 11 pools are located in reaches from RM 1.0 to RM 3.5

TMDL LOADING CAPACITY AND ALLOCATIONS

Loading Capacity: For purposes of this TMDL, the numeric target is <33% cobble embeddedness within Beaver Creek. This is defined as the greatest amount of sediment loading that this 303(d)-listed waterway can contain and still attain water quality standards. Thus the sediment loading capacity is that amount of sediment coming from all streams in the analytical watershed resulting in <33% cobble embeddedness within Beaver Creek.

Long-term monitoring and the adaptive management nature of this TMDL will be used to evaluate this goal over time. It is recommended that in addition to monitoring the embeddedness target, monitoring continues to incorporate V* and macroinvertebrates as trend indicators for sedimentation in the Beaver Creek Analytical Watershed.

Numeric Target Identification and Loading Capacity 40 CFR 130.2(f)

The loading capacity for the Beaver Creek analytical watershed is that amount of sediment resulting in <33% cobble embeddedness in Beaver Creek

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 "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. OAR 340-041-0365(2)(j)". As recommended by USFS Fish Biologists, the target of <33% cobble embeddedness has been utilized in Beaver Creek as an indicator of fine sediment impairment to salmonids (the most sensitive "resident biological community").

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 sediment loading capacity for all streams listed for sedimentation in the Beaver Creek Analytical Watershed is that amount of sediment resulting in <33% cobble embeddedness in Beaver Creek.

Long-term monitoring and the adaptive management nature of this TMDL will be used to evaluate this goal over time. It is the recommendation that in addition to measuring cobble embeddedness directly, that collection of V* and macroinvertebrate data continue and be used to determine sedimentation trends in the watershed.

Load Allocations/Surrogate Measures

For sediment the Load Allocation is given 100% to natural background sources; therefore, any activity that increases the sediment load is not allowed (Table 35). While load allocations are traditionally expressed as "mass per time", the TMDL regulations also provide for the expression of allocations in "other appropriate measures". Given the data available, it is not possible for sedimentation to be expressed as a load other than to state that it is the amount of sediment resulting in <33% cobble embeddedness within Beaver Creek. In this TMDL other appropriate measures will be utilized to achieve the loading capacity. These surrogate measures apply to all designated management agencies and landuses occurring in the Beaver Creek Analytical Watershed. Surrogate measures that apply are: 1) *system potential* riparian vegetation, 2) decreases in road densities, 3) improvements to drainage-ways.

Table 35. Sedimentation TMDL Allocations

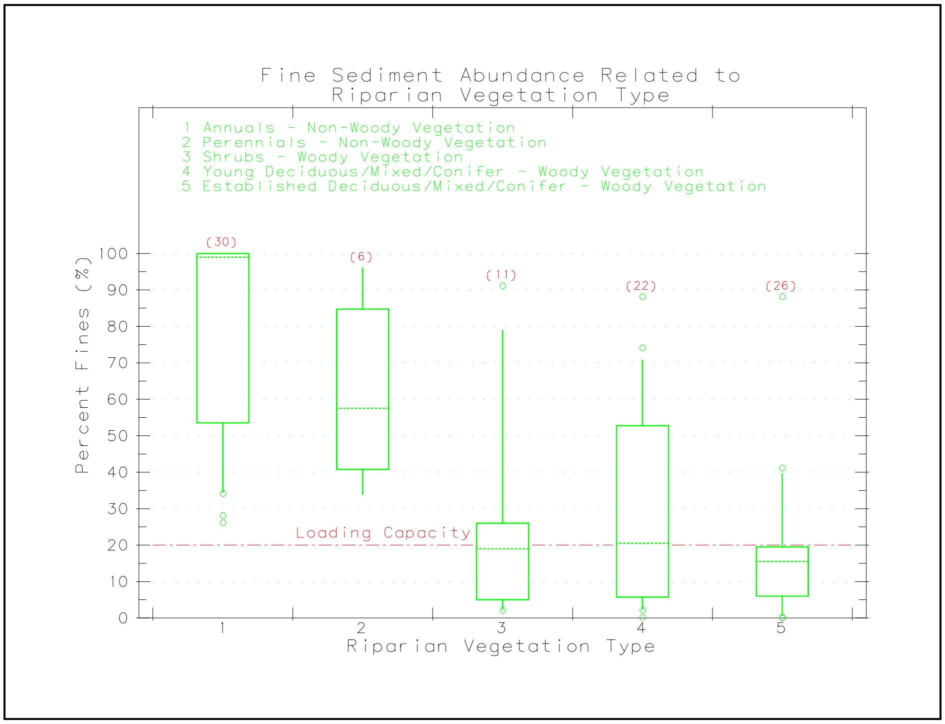
Nonpoint Sources: Beaver Creek Load Allocations by Land Use	
Source	***Load Allocation*** ***Distribution of Sedimentation Loading Capacity to nonpoint sources***
Natural	100%
Agriculture	0%
Forestry	0%
Urban	0%
Transportation	0%
Future Sources	0%
Point Sources: Beaver Creek Waste Load Allocations by Source	
Source	***Waste Load Allocation*** ***Distribution of Sedimentation Loading Capacity to point sources***
Current and Future NPDES Permit holders	0%
NPDES Permitted Activities: Recreational Mining	0%

Surrogate Measure #1: System Potential Riparian Vegetation.

System potential riparian vegetation is a surrogate measure to meet the sedimentation TMDL. It is identical to the targets set in the Temperature TMDL. Therefore, the measures implemented to meet the Temperature TMDL will also meet the surrogate measure targets for the sedimentation TMDL.

Note: A wider mature riparian vegetation buffer than is required to meet the temperature TMDL may be needed to filter sediment from upslope sources. On Federal Lands, which comprise over 88% of the Beaver Creek Analysis Watershed, Riparian Reserve zones managed for late successional purposes must be a minimum of 150 feet on either side of nonfish-bearing streams and 300 feet on either side of fish-bearing streams. This may be more than that required to meet the percent-effective shade targets determined in the temperature TMDL but will provide additional protection from sediments.

Figure 13. Stream Bed Percent Fines Related to Various Riparian Vegetation Types (ODFW Data, 1996)



Surrogate Measure #2: Decrease Road Densities and Mitigate Impacts from Retained Roads

Reduction of road densities is one of the most important and effective measures for reducing sediment production from roads and is prescribed for several Beaver Creek drainages. The DEQ target for the next 10 years for classified roads has been developed in conjunction with the USFS (Table 36):

- Reengineer all portions of roads on unstable geology to minimize risk of slope failure, particularly where those lands are within draws or on the lower 1/3rd of the slope;
- Reroute roads around sensitive areas including floodplains, wetlands, and Riparian Reserves to the maximum extent possible;
- Where it is not possible to reroute roads around floodplains and Riparian Reserves, provide for road surfacing sufficient to prevent surface erosion in those sensitive zones. Also stabilize all road cuts and fills in floodplains and Riparian Reserves, as well as stream crossings, using all vegetative and mechanical means available;
- Resize all culverts (including dipping/hardening of associated crossings) on fish-bearing streams to convey 100-year floods including associated bedload and debris without loss of crossings (or replace with bridges).

Since they are associated with the transportation system, restore landings within sensitive areas (Riparian Reserves, floodplains, wetlands) to natural conditions. This involves reshaping and/or ripping if necessary, and planting with native species.

Guidelines to use for reducing road densities are as follows:

- Review unclassified roads first and "add" those to classified roads that are absolutely essential. Decommission all remaining unclassified roads. On decommissioned roads one or more of the following actions will be taken: steam crossings will be reestablished to the natural stream gradient. This will be accomplished by removing the culvert and road fill within the stream-crossing areas. Fill material will be removed to bankfull width. Stream side slopes will be reestablished to natural contours then seeded with native or approved seed and mulched. Excavated material will be removed from stream crossing areas and placed at stable locations;

- When reducing classified road density to attain the long-term target, attempt to reduce roads in the most sensitive locations in the following descending order of importance:
  - ✓ Unstable terrain, identified in the Rogue River NF GIS data base;
  - ✓ Floodplains, wetlands and seep areas;
  - ✓ Riparian Reserves (300 feet for fish-bearing streams and 150 feet for nonfish-bearing streams) as described in the Northwest Forest Plan;
  - ✓ The lower 1/3rd of the slope;
  - ✓ On soils with very severe and severe soil erosion potential as described in the Rogue River NF Soil Resource Inventory (USFS, 1977).
- Classified roads that are determined no longer needed, either short term or long term, should be decommissioned as previously described;
- If it is necessary to retain classified road densities greater than the target road density, then as many Level 2 maintenance roads as possible should be placed in Level 1 status. This involves pulling culverts and fills at stream crossings, providing proper long-term road drainage, possibly seeding, and closing roads with barriers such as boulders, earth mounds, or gates.

Table 36. Long-Term Road Density Targets for Beaver Creek Analytical Watershed (Zan, USFS, 2002)

Tributary to Beaver Creek	Area (acres)	Current Road Density (miles/sq mile)**	10-year Target Road Density (miles/sq mile)**	% Reduction
Armstrong Creek	963	2.10	2.10	0
Baldy Creek	761	3.44	2.50	27%
Beaver Headwaters	1570	3.98	2.50	37%
Beaver Middle	187	0.60	0.60	0
Boaz	1171	1.66	1.66	0
Charley Buck	638	3.30	2.50	24%
Hanley	2112	4.64	2.50	46%
Haskins	1098	4.18	2.50	40%
Jackson	232	1.62	1.62	0
Medite	383	2.11	2.11	0
Petes Camp	2172	2.26	2.26	0
Texter	2165	1.14	1.14	0

**System road miles only

Surrogate Measure #3: Improve Drainage-ways

On Federal Lands in the Beaver Creek Analytical Watershed, 20 road crossings per year will be assessed to ensure that they can convey a 100-year flood event. In those drainages where the crossing frequencies currently exceed the centerpoints of the medium frequency ranges, or 2.0 crossings/stream mile and 3.0 crossings/road mile (USFS, 2002), the target crossing frequencies are a maximum of 2.0 crossings/stream mile and 3.0 crossings/road mile (Table 37). In drainages where targets are already met or exceeding this goal, there will be no net increase in crossing frequency from current conditions.

Table 37. Stream Crossings and Percent Reduction Targets

Drainage Name	Number of Drainage Crossings and Position in Drainage*	Miles of Stream	Miles of Roads	Number of Crossings per mile of stream.	Number of Crossings per mile of road	Percent Reduction: Crossings per mile of stream	Percent Reduction: Crossings per mile of road
Armstrong	7 low	5.47	3.62	1.3	1.9	0%	0%
Baldy	23 low	8.29	4.51	2.8	5.1	29%	41%
Beaver Head	20 low, 4 high	9.54	11.24	2.5	2.1	20%	0%
Beaver Mid	4 middle	1.5	NA	2.7	NA	26%	0%
Boaz	11 low	8.14	3.04	1.4	3.6	0%	17%
Charley Buck	10 low, 9 high	8.56	3.36	2.2	5.6	9%	46%
Hanley	16 low, 30 middle	15.96	16.64	2.9	2.8	31%	0%
Haskins	6 low, 6 high	6.38	7.24	1.9	1.6	0%	0%
Jackson	3 high	1.14	0.96	2.6	3.1	23%	3%
Medite	1 middle	2.13	NA	0.5	NA	0%	NA
Petes Camp	12 low, 8 high	13.5	9.58	1.5	2.1	0%	0%
Texter	15 low	1.52	7.47	9.9	2.0	80%	0%

* Low refers to the lower third of the slope, middle to the middle third, and high to the upper third of the slope between ridge top and stream bottom
NA = data not available

Wasteload Allocations

A *Waste Load Allocation (WLA*) applies to point sources. It is that portion of the loading capacity that a particular source may provide without causing the water quality criteria to be violated. There are no NPDES-permitted point source discharges of sediment within the Beaver Creek Analytical Watershed. This would include dischargers operating under individual permits as well as recreational suction dredgers operating under NPDES 0700J general permits.

MARGIN OF SAFETY – CWA §303(D)(1)

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

The margin of safety for sedimentation is based the use of conservative analytical assumptions.

- On Federal Lands, which comprise over 88% of the Beaver Creek Analysis Watershed, Riparian Reserve zones managed for late successional purposes must be a minimum of 150 feet on either side of nonfish-bearing streams and 300 feet on either side of fish-bearing streams. This may be more than that required to meet the percent-effective shade targets determined in the temperature TMDL but will provide additional protection from sediments.
- Macroinvertebrate population trends indicate habitat conditions are static or improving under the current management. However even though conditions are improving under current management the TMDL specifies additional activities including: 1) system potential riparian vegetation, 2) decreases in road densities, and 3) improvements to road crossings/drainage-ways.

Long-term monitoring and the adaptive management nature of this TMDL will be used to ensure that the Sedimentation TMDL will be met.

SECTION 4. BIOLOGICAL CRITERIA TMDL

Summary of Biological Criteria Development and Approach

Why is an exceedance of the biological criterion important and what does it tell us?
Biological criteria impairment in Beaver Creek is the direct result of impairments to macroinvertebrate communities. Aquatic macroinvertebrates are the bugs commonly found in lakes, streams, ponds, marshes, and puddles. As well as serving as an important food source for fish and other aquatic organisms, macroinvertebrates play an important role in maintaining the health of the aquatic ecosystem by eating bacteria and dead, decaying plants and animals. These organisms are good indicators of watershed health since overall water and habitat quality determines which types of macroinvertebrates can survive in a body of water. In Beaver Creek populations have been moderately to severely impaired as a result of poor habitat quality (excessive fine sediments) and water quality limitations (high summer temperatures) (Schroeder, P. C., 2002).
Scope: *The Beaver Creek biological criteria 303(d) listing applies to all lands within the Beaver Creek Analytical Watershed: 14,108 acres (This is a portion of the Applegate River – Beaver Creek HUC#171003090202). All land uses and ownerships are included in this TMDL including the U.S. Forest Service (USFS), Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, and transportation uses.*

Biological Criteria TMDL Overview
Biological Criteria is a water quality limiting feature in Beaver Creek from its mouth to the headwaters (8.7 miles) due the impairment of macroinvertebrate populations (1998 303(d) list). In Beaver Creek the 303(d) listing is the result of habitat limitations created by an excess of fine sediments (USFS, 1994) and excessive summertime temperatures (Schroeder, P. C., 2002). *Beaver Creek is also on the 1998 303(d) list for temperature, sedimentation, habitat modification, and flow modification. The Applegate Subbasin TMDL does not directly set loading capacities and allocations for biological criteria because it is believed that TMDL allocations set to meet both the temperature and sedimentation TMDLs (riparian shade, streambank and channel restoration, stabilization of sediment sources) will restore the condition of the biological communities in Beaver Creek and throughout the Subbasin.*

Applying Oregon's Biological Criterion

The biological criterion standard applicable to Beaver Creek states "Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities." The Department considers attainment of the loading capacities set for both the temperature TMDL and the Sedimentation TMDL to be the loading capacities that will lead to the attainment of the biological criterion.. The temperature TMDL surrogate is defined as increasing riparian vegetation to meet the percent-effective shade targets. The Sedimentation TMDL is defined as meeting a <33% cobble embeddedness numeric target achieved by implementing surrogate measures related to riparian vegetation, road densities, and number of road crossings.

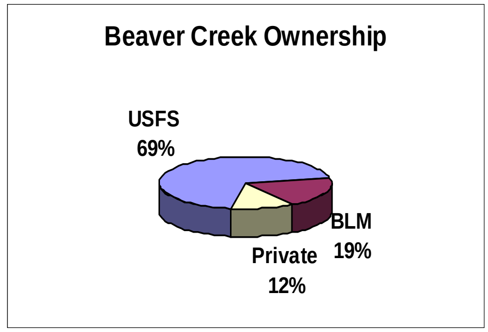
Table 38. Biological Criteria TMDL Component Summary	
State/Tribe: <u>Oregon</u> **Waterbody: <u>Beaver Creek Analytical Watershed: 14,108 acres (This is a portion of the Applegate River – Beaver Creek HUC#1710030902-02.)</u>** **Point Source TMDL: NO** **Nonpoint Source TMDL: YES** **Date: December 2003**	
Pollutant Identification	**Pollutants:** Excessive fine sediments, Excessive Summer water temperatures. **Anthropogenic Contribution***:* Excessive solar energy input from changes in riparian vegetation and excess inputs of fine sediments due to land management practices: logging, roading, agriculture, rural residential development.
Target Identification: CWA §303(d)(1)40 CFR 130.2(f)	*<u>Applicable Water Quality Standards</u>* **Biological Criteria OAR 340-41-027** *"Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the residential biological communities."*
Existing Sources **CWA §303(d)(1)**	*<u>Anthropogenic sources of thermal gain and sedimentation</u>* Road and crossings management, forest management practices in both upland and riparian areas, agriculture, rural residential development.
Seasonal Variation **CWA §303(d)(1)**	*<u>Stream Biological criteria period of primary interest</u>*: June 1 through September 15 for solar energy inputs and year-round for sedimentation.
TMDL/Allocations *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Wasteload Allocations*: None. *Load Allocations:* 100% allocation to natural sources. *Load Capacity (numeric target):* System potential Riparian Vegetation and <33% cobble embeddedness in Beaver Creek. *Surrogate Measures:* 1) System potential vegetation (as per Temperature TMDL), 2) Road density target (as per Sedimentation TMDL), 3) Stream crossings target (as per Sedimentation TMDL).
Margin of Safety *CWA §303(d)(1)*	*Implicit margin of safety:* Conservative assumptions in modeling and adaptive nature of TMDL
WQS Attainment Analysis *CWA §303(d)(1)*	• Identification of temperature and fine sediments as causes for macroinvertebrate community impairment in Beaver Creek (Schroeder, 2002). • Demonstration of attainment is included in sediment and temperature TMDLs.
Public Participation (40 CFR 25)	See Appendix B for public hearing information. See also response to comment documentation.

INTRODUCTION:

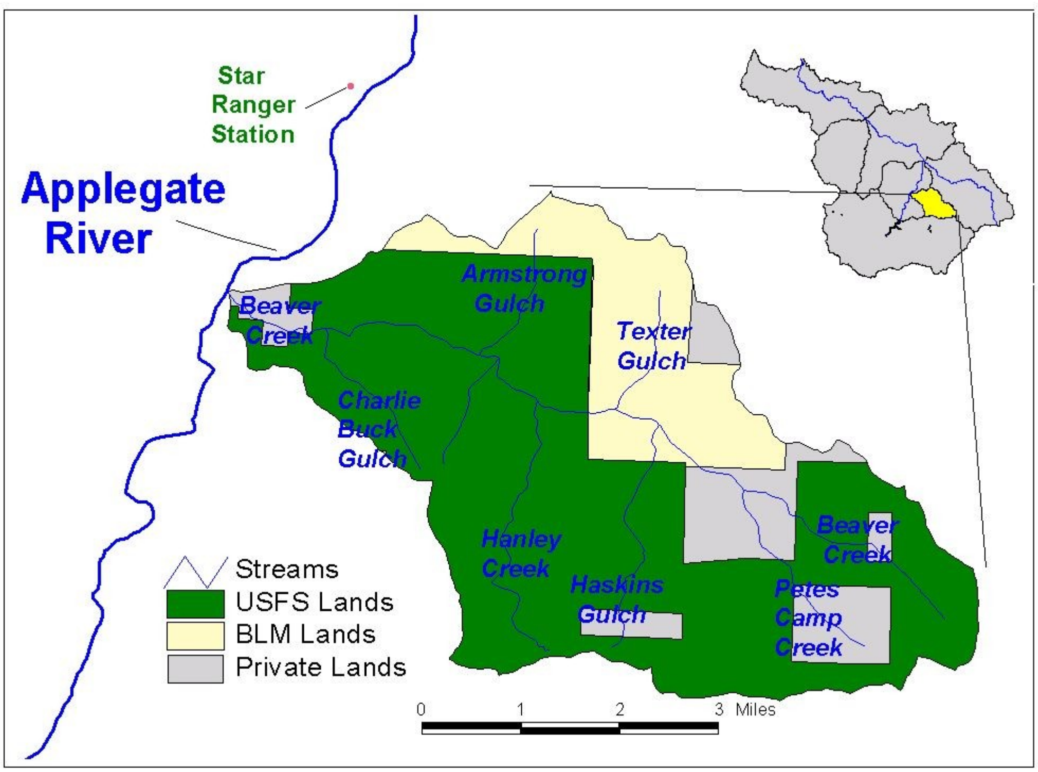
This TMDL Summary seeks to clearly address the elements required by EPA to meet the requirements for Total Maximum Daily Load (TMDL) development to address a biological criteria 303(d) listing within the Beaver Creek Analytical Watershed in the Applegate Subbasin. These elements are addressed in this TMDL with references to the accompanying Water Quality Management Plan (WQMP). The TMDL and WQMP were prepared by the Oregon Department of Environmental Quality (DEQ) with assistance from state, federal and local partners.

SUBWATERSHED DESCRIPTION AND OWNERSHIP

The Beaver Creek Analytical Watershed encompasses an area of approximately 14,018 acres in the Applegate River – Beaver Creek Watershed, in the Applegate Subbasin (Map 10). It is located in the Klamath Mountains Physiographic Province and ranges in elevation from 1600 feet to over 5200 feet. Ownership in the analytical watershed consists of 69% Rogue River National Forest, 19% BLM, and 12% private.



Map 10. Beaver Creek Location and Drainages



Beneficial Uses Sensitive to Biological Criteria.
The beneficial uses affected by the biological criterion standard include Resident Fish and Aquatic Life (DEQ, 1996) (Table 39).

Table 39. Biological Criteria Impacted Beneficial Uses in the Applegate Subbasin

(OAR 340–41–362) *Biological Criteria 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	

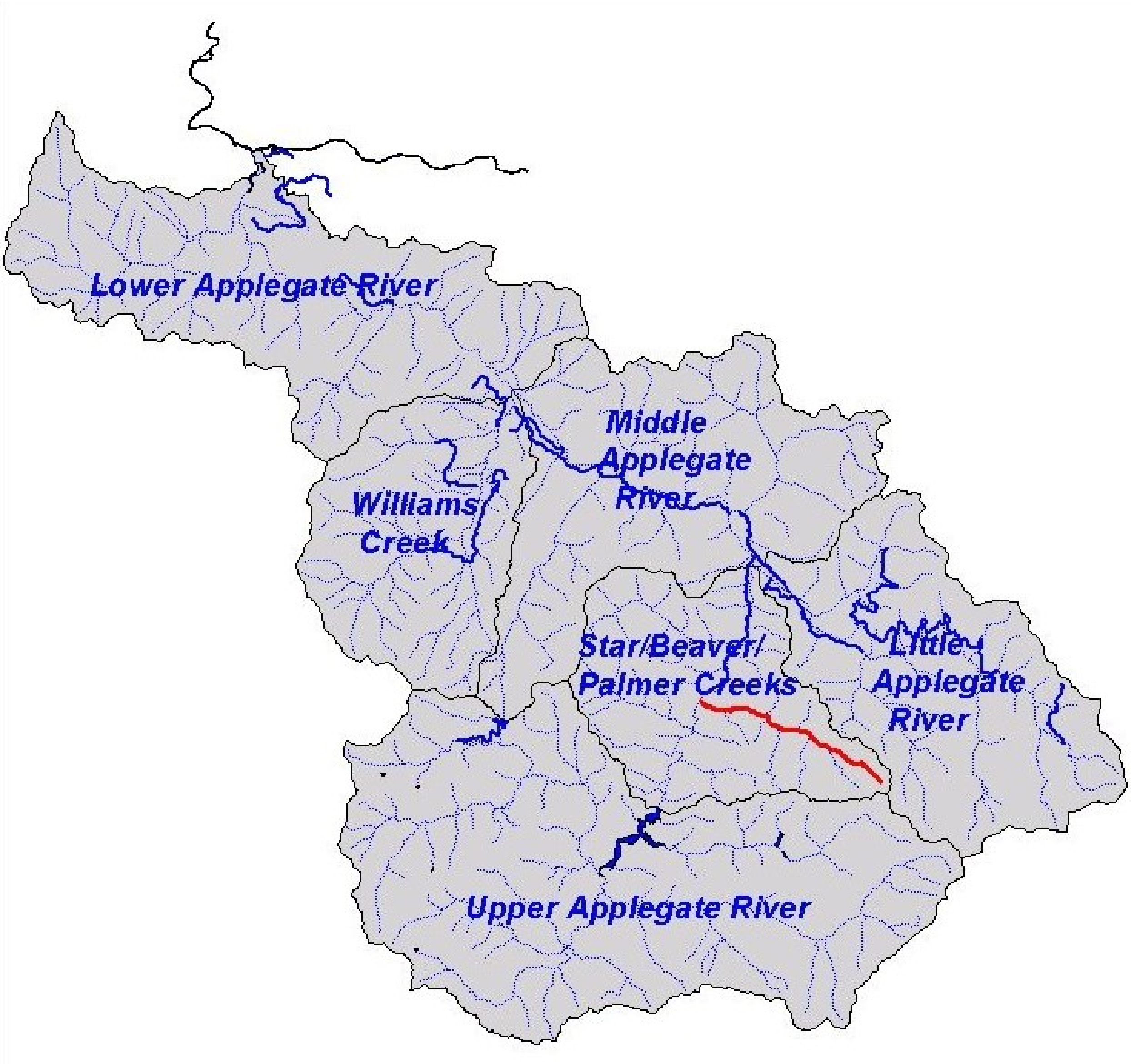
DEVIATION FROM WATER QUALITY STANDARDS

Beaver Creek is on the 1998 303(d) list for sedimentation, temperature, flow modification, habitat modification, and biological criteria. Beaver Creek was listed for biological criteria based on USFS data. This benthic macroinvertebrate study indicated that Beaver Creek is moderately to severely impaired due to habitat limitations; “fine sediment is a problem and many positive indicator groups are not present” (USFS, 1994). The criteria used for listing included *“where monitoring methods determined a Biotic Condition Index, Index of Biotic Integrity or similar metric rating of poor or a significant departure from reference conditions utilizing a suggested EPA biomonitoring protocol or other technique acceptable to DEQ.”* Beaver Creek is on the 1998 303(d) list for exceeding this criteria (Table 40 and Map 11).

Table 40. 1998 303(d) List: Applegate Subbasin Biological Criteria Listed Streams

Stream Segment	Listed Parameter	Applicable Rule	Miles Affected
Beaver Creek, mouth to Headwaters	Biological Criteria	OAR 340-41-027 OAR 340-41-362	8.7
		Total Stream Miles Listed for Biological Criteria	**8.7**

Map 11: Biological Criteria-Listed Stream Reaches in the Applegate Subbasin (Stream Reaches Listed for Biological Criteria are Shown in Red)



WATER QUALITY STANDARD IDENTIFICATION

A water body is considered water quality limited for biological criteria if 1) aquatic community status data demonstrates impaired conditions or 2) fisheries have declined due to water quality conditions.

A waterbody is considered water quality limited for biological criteria if data on aquatic community status shows impaired conditions. Impaired conditions include: 1) metric scores (using EPA bioassessment protocols) below 76% of the metric score at an appropriate reference site/region, 2) a Biotic Condition Index, Index of Biotic Integrity, or similar rating of poor, 3) a significant departure from referenced conditions utilizing a suggested EPA biomonitoring protocol, 4) other techniques acceptable to DEQ (fishery data on escapement, redd counts, population survey, etc. show that fish species have declined due to water quality problems) (DEQ, 2003). The standard for biological criteria is given in **OAR 340-41-027** *"Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the residential biological communities."*

HISTORICAL INFLUENCES

A variety of influences in the Beaver Creek Analytical Watershed have historically resulted in altered streambeds and excessive streambed fines. With the discovery of Gold in the Rogue River Valley in 1851-52, the Applegate River valley saw intensive placer mining with rocker and sluice box systems. During the 1870s hydraulic mining came to the Siskiyou Mountains and continued on a large scale through the 1880s. Palmer Creek, Flumet Gulch, China Gulch, and the Applegate River all experienced extensive mining during the 1880s. Beaver Creek, being primarily used as a water source for hydraulic mining elsewhere in the area, was largely unaffected (USFS, Randy Frick pers. comm., 2003).

Beginning with the mining era, agricultural settlers began farming the terraces of the Applegate River. Between 1890 and 1930 the main human impact to the area came from the activities of local farmers including heavy livestock grazing and water diversions for irrigation. Forest cover changed due to intensive cutting of easily accessible sugar and ponderosa pine for shakes, flume boards and other uses. In addition, nineteenth-century prospectors regularly set extensive fires in the area in order to enhance the visibility of bedrock and colluvial deposits. Ranchers carried on a regional tradition of seasonal burning to clear brush and small trees and to maintain and promote grass on lower southwest aspect slopes (USFS 94).

During the period following 1950, Forest Service and Bureau of Land Management became the major suppliers for new large-capacity lumber and plywood mills in Jackson and Josephine Counties. This period of intensive timber harvesting and road construction was a major factor in changing the overall appearance of the Beaver Creek Analytical Watershed. A large amount of timber was harvested from the Beaver Creek Analytical Watershed especially during the last 30-40 years. A large percentage of units were harvested using clear-cut harvest methods resulting in severe erosion particularly in the granitics of the Squaw Creek pluton (USFS, 1994). Active debris slides are currently found in the large clear-cut units in Petes, Medite, Hanley and Haskins Drainages within the Beaver Creek Analytical Watershed (USFS 94).

CURRENT CONDITIONS

Macroinvertebrates

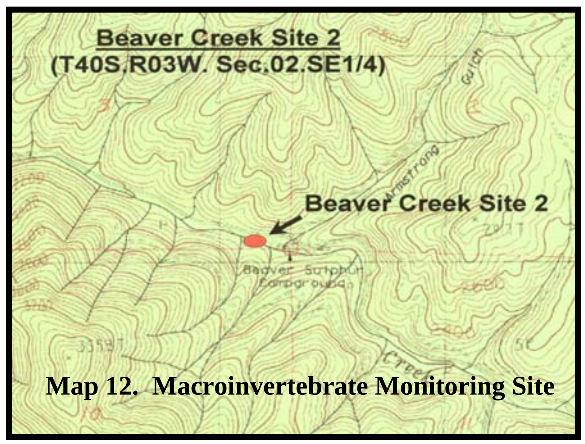
The designation of Beaver Creek as exceeding biological criteria and resulting placement on the 1998 303(d) list came from a study performed in 1991 (Wisseman, 1992). This study determined that macroinvertebrate populations in Beaver Creek were impaired due to excessive fine sediments. The key points derived from this study included:

- Impairment is due to habitat quality limitations rather than water quality limitations.

- Overall habitat complexity in Beaver Creek is moderately to severely impaired (the stream tends to be wide and shallow, is sluiced to bedrock in many reaches, fine sediment has filled in hyporheic interstitial spaces, reduced crevice space in the surface armor layer of riffles, and filled in pools.
- Fine sediment is a problem in the system. Both silt and sand are a problem. Silt levels are moderate in slack water areas. High levels of silt can smother margin and pool invertebrate communities. Low or moderate levels of silt greatly depress invertebrate abundance on the margins and inhibit scrapers. High levels of sand were common in many of the streams sampled. Sand can fill in hyporheic interstitial space, embed crevices in the surface armor rocks of riffles, and fill in pools and spawning gravel. Sand appears to be mobilized during high flow, causing moderate to severe scour of surface substrates. Scour can cause direct mortality of many invertebrate taxa or indirectly impact them by affecting their food source or habitat (e.g. Nostoc algae and moss).
- Highly intolerant taxa were not present in high numbers and richness in most systems. The small numbers can be attributed to the above habitat factors, plus in some systems, high water temperatures and reduced base flows probably contributed to their low levels.
- Many of the positive indicator groups or taxa in a healthy stream system are absent from Beaver Creek or are present in very low numbers.

The site that was sampled appeared to have a long history of impairment. This impairment comes not only from logging and roading but also from catastrophic floods which have greatly influenced habitat structure. No Sensitive, Threatened or Endangered aquatic invertebrate taxa were encountered at the Beaver Creek 1991 sampling site.

The 1991 macroinvertebrate study site on Beaver Creek is located just downstream of the Beaver Sulphur Campground (T40S.RO3W. Sec.02.SE1/4 Map 12). Biomonitoring has continued at this site in 1996, 1998, 1999, and 2000. The results of this biomonitoring are contained in Benthic Invertebrate Biomonitoring Trend Analysis (1992-2000) (Schroeder, 2002). The summary scores from this period (96, 98, 99, 00) as well as trends are shown in Table 41.



Map 12. Macroinvertebrate Monitoring Site

Table 41. Beaver Creek Macroinvertebrates; Scores and Trends 96, 98, 99, 00

Habitat Type	Scores	Trend
Erosional	Low to Moderate	Static
Margin	Moderate to High	Improved
Detritus	Low to Moderate	Improved

The macroinvertebrate scores have remained stable or have been improving at this site during the study period (Table 41). However, moderate to higher than optimal fine sediment and excessive summer temperatures are still causing population impairments (Schroeder, 2002).

EXISTING SOURCES – CWA §303(D)(1)

Sedimentation and high summer temperatures have been determined as the cause of the macroinvertebrate impairments in Beaver Creek and are therefore the focus of this TMDL. Riparian vegetation, geology, stream morphology, hydrology, climate, and geographic location influence stream sedimentation and stream temperatures. While climate and geographic location are outside of our control, human activities that contribute to degraded water quality (temperature) and habitat conditions (sediment) in the Applegate Subbasin include agricultural activities, forestry practices, road development and maintenance, and rural residential-related riparian disturbance. For the Beaver Creek Analytical Watershed biological criteria TMDL, three source categories are examined and discussed as they relate to increases in temperature and sedimentation. A more thorough discussion of the role of stream temperature and sedimentation is found in the temperature and sedimentation sections of this TMDL.

1. Near stream vegetation disturbance/removal

Near stream vegetation disturbance/removal reduces stream surface shading via decreased riparian vegetation height, width, and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is measured as percent-effective shade). Riparian vegetation also plays an important role in shaping the channel by intercepting sediments, resisting erosive high flows, and maintaining floodplain roughness.

2. Sediment sources

Sediment sources are briefly covered here but the reader is referred to the Sedimentation TMDL for more complete information. Sediment sources in the Beaver Creek Analytical Watershed include: agricultural practices, timber harvest, roads, and stream crossings. Timber removal due to harvest can accelerate surface erosion and increase sediment delivery to streams. Accelerated sediment production and delivery occurs when bare soil is exposed to heavy rainfall and the runoff reaches streams. Generally, the accelerated surface erosion dissipates when vegetative cover is established. Landslides can be triggered by timber harvest due to a loss of tree root strength and increased soil saturation from reduced tree canopy. Studies in Oregon and Washington generally indicate that the harvesting of trees increases the rate of mass failures by 2 to 4 times over that experienced on uncut areas (Reiter and Beschta, 1995, Norris et al, 1999). Lack of forest canopy can increase rain-on-snow event peak flows leading to increased fluvial erosion. Harvest, particularly in riparian areas, also affects the amount and size of woody debris that reaches streams. Woody debris increases stream habitat complexity and serves as a storage mechanism for sediment.

Roads have an influence on sediment production and delivery in forested watersheds. In addition to the effects of land types, road density/use/design/location can affect the extent and magnitude of road-related sediment impacts (Reiter et al, 1995). King and Tennyson (1984) observed altered hydrology when roads constituted more than 4% of the drainage area. This correlates to approximately 4 miles per square mile of area. Roads have the greatest potential for hydrologic effects where they parallel streams, particularly where road fills have been placed in the floodplain (BLM, 2000). In valley bottoms, roads can affect stream morphology by hardening stream banks and constricting streams during high flows. Hill slopes, road fills and cut slopes that become saturated with water can fail and deliver sediment to streams. Surface erosion from inadequate (native) surfaces, rutting, and lack of cross drains is more likely to be delivered to streams when a road is close to a stream and there is little vegetative buffer. Associated with roads are ditch lines that collect water drained from the road surface and cut slopes. When ditches flow into streams (effectively serving as an extension of the stream network), water is delivered more quickly than in roadless situations thereby accelerating peak flows. Stream crossings are the places where roads intersect streams. A drainage structure is normally installed to allow vehicle passage. In most cases, this structure consists of a culvert with soil and rock around it. Culverts can constrict the natural flow of water and restrict the normal transport of sediment and debris. When culverts become plugged they can cause fills to become saturated, leading to failure. Plugged culverts can cause water to rise up into the road prism and spill into ditches where it is diverted to another stream.

3. Natural Sources

Natural events may impact riparian vegetation and result in increased sediment inputs into streams. These events include flood, drought, fires, insect damage, disease and windthrow/blowdown in riparian areas. These are natural events and their effects on stream temperature, sediment inputs, and resulting channel morphology are considered natural background and no attempt is made to quantify the impact or frequency of such events in this TMDL.

TMDL LOADING CAPACITY AND ALLOCATIONS

Loading Capacity:
Biological Criteria TMDL applies to the Beaver Creek Analytical Watershed and is defined as 1) system potential riparian vegetation (as defined in the Temperature TMDL) and 2) that amount of sediment coming from all streams in the analytical watershed resulting in <33% cobble embeddedness within Beaver Creek.

Long-term monitoring and the adaptive management nature of this TMDL will be used to evaluate this goal over time. Long-term monitoring of embeddedness, riparian vegetation and macroinvertebrate populations will serve as direct measures of change over time.

Numeric Target Identification and Loading Capacity 40 CFR 130.2(f)

The Environmental Protection Agency (EPA) and the State of Oregon do not have numeric water quality standards and habitat standards for Biological Criteria. However, since fine sediments and excessive summer water temperatures have been identified as the limiting factors in Beaver Creek (Schroeder, 2002), these standards become the targets to meet the Biological Criteria TMDL.

Load Allocations

A *Load Allocation* (LA) applies to nonpoint sources. It is that portion of the loading capacity that a particular source may provide without causing the water quality criteria to be violated. For sediment the LA is given 100% to natural sources; therefore, any activity that increases the sediment load is not allowed. Three surrogate measures as defined in the sedimentation TMDL will serve to meet this goal: 1) system potential riparian vegetation, 2) decreases in road densities, 3) improvements to drainage-ways. The LA for temperature is also assigned 100% to natural sources. Therefore, any activity that reduces percent shade density below that of system potential is not allowed (unless prior approval is granted through a temperature management plan).

Wasteload Allocations

A *Waste Load Allocation (*WLA) applies to point sources. It is that portion of the loading capacity that a particular source may provide without causing the water quality criteria to be violated. There are no permitted point source inputs of fine sediment in the Beaver Creek Analytical Watershed; therefore, there should be no effect from point sources on sedimentation.
The WLA for temperature is 0% for point sources; therefore, the condition that applies is: “no measurable surface water temperature increase resulting from anthropogenic activities when the temperature criteria is exceeded.” No measurable increase means an increase in stream temperature of no more than 0.25ºF (OAR340-41-006 (55) – please see the temperature TMDL for more information.

MARGIN OF SAFETY – CWA §303(D)(1)

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

The margin of safety for Biological Criteria is both implicit and explicit and is defined in the MOS sections for Temperature and Sedimentation.

For Sedimentation as it impacts Biological Criteria :

- On Federal Lands, which comprise over 88% of the Beaver Creek Analysis Watershed, Riparian Reserve zones managed for late successional purposes must be a minimum of 150 feet on either side of nonfish-bearing streams and 300 feet on either side of fish-bearing streams. This may be more than that required to meet the percent-effective shade targets determined in the temperature TMDL but will provide additional protection from sediments.

- Macroinvertebrate population trends indicate habitat conditions are static or improving under the current management. However even though conditions are improving under current management this TMDL specifies additional activities including: 1) system potential riparian vegetation, 2) decreases in road densities, and 3) improvements to road crossings/drainage-ways.
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For Temperature as it impacts Biological Criteria

- Groundwater inflow was assumed to be zero and its cooling influence on stream temperatures via mass transfer/mixing was not accounted for. Further, cooler microclimates associated with late seral conifer riparian zones were not accounted for in the simulation methodology.

- The Heat Source model (Appendix A) did not change current vegetative shade overhang values as part of its future conditions prediction. The present overhang values are very low and are likely to increase in the future. This will provide a MOS as vegetative overhang will add additional effective shade to Applegate and Little Applegate systems.

- Applegate and Little Applegate modeling used current tributary temperatures as inputs into the future condition scenario. Improvements in effective shade on the tributaries is expected to have a cooling effect on water temperatures. This additional cooling was not factored into the model and is considered a MOS.

- Modeling was conducted using worst case scenarios of low flow and seasonal maximum air temperatures.

- Current NSDZ and wetted channel width are used in the system potential scenario for Applegate and Little Applegate. Both NSDZ and wetted channel widths are expected to decrease as riparian vegetation increases and moves towards a late seral stage further decreasing that amount of solar radiation reaching the stream's surface. This conservative estimate of the potential for stream narrowing is considered a MOS.

Long-term monitoring and the adaptive management nature of this TMDL will be used to ensure that the sedimentation and temperature TMDL surrogates will be met and that this results in the achievement of the biological criteria standard.

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