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Salmon River, Siskiyou County, California

Total Maximum Daily Load for Temperature and Implementation Plan

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Prepared by

North Coast Regional Water Quality Control Board

Total Maximum Daily Load Development Unit Staff

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Acknowledgements

A number of individuals and organizations contributed data, information, and analysis.

Editorial Author:	Bruce Gwynne
Model Runs:	Carey Wilder
GIS Layouts	Bruce Gwynne
Contributors:	Carey Wilder
	Robert Klamt
	Salmon River Restoration Council members
	USEPA Region 9 staff
	Patrick Higgins, Kier Associates
Technical Support:	UC Davis Information Center for the Environment,
	Josh Viers,
	Josh Johnson,
	Carlos Ramirez
	USFS, Klamath National Forest staff
GIS Data:	Data provided by USFS, Klamath National Forest, used in conjunction with other readily available data.
Senior Editor:	David Leland
Additional Assistance	Katherine Spivak
	Elmer Dudik
	Matt St. John
	Bill Hobson
	Bryan McFadin
	Rebecca Fitzgerald
	Zak Wellman

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Total Maximum Daily Load for Temperature and Implementation Plan

1 INTRODUCTION

1.1 Overview

The Salmon River Total Maximum Daily Load (TMDL) for temperature has been developed in accordance with Section 303(d) of the Clean Water Act. In accordance with Section 303(d), the State of California periodically identifies those waters that are not meeting water quality standards. In 1994, the State of California and USEPA determined that the water quality standards for the Salmon River are exceeded as a result of impairments associated with temperature and nutrients. This report addresses only the temperature conditions in the Salmon River watershed. A separate report detailing the findings of North Coast Regional Water Quality Control Board (Regional Water Board) analysis and recommendation to delist the Salmon River for nutrient impairment has been submitted to the State Water Resources Control Board (SWRCB) for action during the 2004 update of the 303(d) list.

The primary adverse impacts associated with elevated temperatures in the Salmon River pertain to the anadromous salmonid fishery. Anadromous fish (Table 1.1), including salmon species, rely on both ocean and freshwater habitat for various life stages. The water quality conditions present in the Klamath River basin, including the Salmon River and its tributaries, are not fully supportive of anadromous salmonid species, contributing to severe population declines. California Department of Fish and Game (Fish and Game) administers the listing of threatened or endangered species pursuant to the California Endangered Species Act (CESA). Fish and Game has indicated that coho salmon (*Oncorhynchus kisutch*) within the northern California Ecologically Significant Unit (ESU) are threatened. All California coho stocks have been listed as threatened pursuant to the federal Endangered Species Act (ESA) since the mid-1990s. Steelhead (*Oncorhynchus mykiss*) have been listed, pursuant to the federal ESA, as threatened in Northern California, but specifically not in the Klamath Mountains Province. Additionally present in the watershed are fall and spring run chinook (*Oncorhynchus tshawytscha*), summer and winter run steelhead (*O. mykiss*), sea run Pacific lamprey (*Lampreta tridentata*), and green sturgeon (*Acipenser medirgstris; A. medirostris*). These species are important in the traditional lifestyles of the various Native American peoples in the Klamath River watershed.

Table 1.1: Species Key for Anadromous Fish in the Salmon River Watershed

Species	Common Name
Oncorhynchus kisutch	Coho
Oncorhynchus tshawytscha	Chinook
Oncorhynchus mykiss	Steelhead
Acipenser medirgstris; A. medirostris	Sturgeon
Lampreta tridentata	Pacific lamprey

The objective of the Salmon River temperature TMDL is to provide estimates of the assimilative capacity of the river by identifying the total load of thermal inputs that can be delivered to the Salmon River and its tributaries without causing exceedence of water quality standards. The total load must then be allocated among the sources of thermal loading in the watershed. The load allocation, when achieved, is expected to result in the attainment of the applicable water quality standard for temperature for the Salmon River and its tributaries. This TMDL focuses on stream temperature conditions in the watershed, for which the Salmon River is listed under Section 303(d). The Regional Water Board will adopt the TMDL and action plan (Implementation Strategy) to implement the TMDL in accordance with 40 CFR 130.6.

1.2 Information Sources

Information for this TMDL came from a variety of sources. Appendix A, Anadromous Salmonids in the Salmon River, California: A Summary From the Literature, provides detailed background on the affected beneficial uses which have been identified as most sensitive to temperature impairments within the Salmon River watershed. Appendix B, Temperature Analysis, is the analysis on which the TMDL is based. This TMDL report also summarizes information from the Salmon River Sub-basin Restoration Strategy (Elder et. al., 2002), as well as a set of ecosystem analyses and watershed assessments performed by the United States Forest Service, Pacific Southwest Region (USFS 1994; USFS 1995a; USFS 1995b; USFS 1997) (Table 1.2). The Standards, Guidelines, Target Conditions, and Action Plan contained in these documents forms the primary basis for the Implementation Strategy for the Salmon River TMDL for temperature, as detailed in Chapter 5 of this report.

Table 1.2: Key Documents Relied Upon in Implementation Strategy

Documents Addressing Riparian Recovery Analysis and Actions		
Abbreviation	Title	Date
LRMP	Land and Resource Management Plan Klamath National Forest, 1995 (Including all amendments as of 11/21/01) Siskiyou County, CA and Jackson County, OR "Klamath National Forest Plan Chapter 4, Management Area 10 – Riparian Reserves	1995 Et seq. 11/21/01
SRSRS	Salmon River Sub-basin Restoration Strategy: Steps to Recovery and Conservation of Aquatic Resources Don Elder, Brenda Olson, Alan Olson Klamath National Forest, Yreka, CA, and Jim Villeponteaux, Peter Brucker Salmon River Restoration Council Sawyers Bar, CA Report Prepared for: The Klamath River Basin Fisheries Restoration Task Force Interagency Agreement 14-48-11333-98-h019	June 14, 2002
USFS 1994	Upper South Fork of the Salmon River Ecosystem Analysis Klamath National Forest Salmon River & Scott River Ranger Districts USDA, Forest Service, Pacific Southwest Region	December 1994
USFS 1995a	Main Salmon Ecosystem Analysis Klamath National Forest USDA, Forest Service, Pacific Southwest Region	May 1995
USFS 1995b	North Fork Watershed Analysis Klamath National Forest USDA, Forest Service, Pacific Southwest Region	December 1995
USFS 1997	Lower South Fork of the Salmon River Ecosystem Analysis Salmon River Ranger District Klamath National Forest USDA, Forest Service, Pacific Southwest Region	July 1997
USFS 1993	Salmon Sub-Basin Sediment Analysis Juan de la Fuente and Polly A. Haessig USDA – Forest Service, Klamath National Forest	May 1993

1.3 Report Organization

This report is divided into six chapters. Chapter 2 (Watershed Characteristics) describes the physical and cultural history and setting of the watershed. Chapter 3 (Problem Statement) describes the nature of the environmental problems addressed by these TMDLs. Chapter 4 (Temperature) examines sources of increased stream temperatures and Temperature TMDL and allocations. Chapter 5 (Implementation Strategy) describes the controls and timeframes to attain improved water quality. Chapter 6 (Monitoring Plan) describes the level of effort needed to measure success and modify practices accordingly. Appendix A, Anadromous Salmonids in the Salmon River, California: A Summary From the Literature provides a detailed background for the beneficial uses addressed in Chapter 3. Appendix B provides the technical analysis for the temperature TMDL.

2 WATERSHED CHARACTERISTICS

2.1 Area and Location

Located in Siskiyou County, near the northwest corner of California, the Salmon River is tributary to the Klamath River, thence to the Pacific Ocean. The River drains an area of 480,626 acres [751 mile^2]. The Salmon River Basin can be logically divided into four major sub-watersheds, which correspond to Hydrologic Sub-Areas (HSAs), as mapped by SWRCB. These sub-areas are: Wooley Creek, Sawyers Bar (North Fork), Cecilville (South Fork), and Lower Salmon (Main Stem) (Figure 2.1 and Table 2.1).

Table 2.1: Sub-Watershed (Hydrologic Sub-Area) Statistics

Watershed Name (HSA)	HSA #	Area (acres)	Square miles	Perennial Stream Miles
Main Stem Salmon River	105.21	69,362	108	109
Sawyers Bar (North Fork) Salmon River	105.23	130,468	204	257
Cecilville (South Fork) Salmon River	105.24	185,608	290	339
Wooley Creek	105.22	95,188	149	212
Totals	-na-	480,626	751	917

These sub-watersheds correspond to sub-basins used in the various Ecosystem Analysis Reports performed by the United States Forest Service (USFS, 1994, 1995a, 1995b, 1997). These are the same bounded drainage areas designated by the State as Hydrologic Sub-Areas of the Salmon River hydrologic area (Figure 2.1). Each sub area is a division of the watershed of the Salmon River and its associated tributaries.

The total length of perennial stream channel is approximately 917 miles (1474 kilometers) (USFS/GIS Data). Elevations in the watershed range from below 500 feet to nearly 9,000 feet. Along much of its course through the tributary and main stem valleys, the river flows through a rugged gorge where rock outcrops and bluffs are common. At elevations of 4,000 feet and above, particularly on north slopes, much of the land was sculpted by glacial erosion that resulted in broad glacial valleys and glacial lakes along the mountain crests (Figure 2.2).

2.2 Ownership and Population

Approximately 98.7% of the Salmon River watershed falls under United States Forest Service (USFS) administration (USFS, March 2002). Various individuals, corporations, Siskiyou County, and the State of California own the remaining 6,398 acres, about 1.3% of the watershed. Of those lands managed by the USFS, 217,433 acres, approximately 45% of the watershed, are managed as wilderness. An additional 25% is managed as late successional reserve (de la Fuente and Haessig, 1994).

The total resident population of the Salmon River basin as of 2002 was estimated at about 250 (USFS, March 2002). Population is concentrated in and around the communities of Cecilville, Forks of the Salmon, Sawyers Bar, and Somes Bar, with some residences scattered throughout the watershed. The overall density is 0.3 people per square mile. Karuk and New River Shasta people continue to utilize the landscape of these ancestral lands (USFS, July 1997). Karuk ancestral territory included about 60% of the Salmon River watershed (USFS, July 1997).

2.3 Topography

The topography of the Salmon River watershed is mostly steep and mountainous. It can be generally described as comprised of three main valleys. These are the South Fork Salmon River, the North Fork Salmon River, and Wooley Creek. Elevation ranges from about 459 feet downstream of Somes Bar near the confluence with the Klamath River to over 8900 feet at Caesar Peak at the southeast edge of the watershed. The watershed is surrounded by a rim of ridges and peaks, which generally exceed 5280 feet in elevation, except the gap where the river discharges into the Klamath, near Somes Bar (Figure 2.2).

2.4 Geology

The Salmon River watershed is situated within the Klamath Mountains physiographic province, and includes three distinct rock belts: the Western Paleozoic and Triassic Belt, the Central Metamorphic Belt, and small portions of the Eastern Klamath and Western Jurassic Belts (Irwin 1960) (Figure 2.3). The belts consist primarily of metasedimentary rock such as chert, argillite, and marble, metavolcanic (primarily basaltic lavas), and ultramafic rock, such as serpentinite and peridotite. Numerous granitic batholiths are also present, the largest of which are the Wooley Creek and the English Peak Batholiths. Metamorphic rock occupies about 322,000 acres (~67%), granitic rock about 143,000 acres (~30%), and ultramafic rock about 15,000 acres (~3%). At various locations in the river basin, ancient terrace deposits as well as older erosional surfaces are preserved. The older river terraces occur up to several hundred feet above the present river channel and are identified by their deeply weathered, red, clayey soils. More recent terrace deposits occur near the active channel of the stream and consist of sand, gravel, and boulder deposits (de la Fuente and Haessig, 1994).

The soils in the watershed exhibit physical properties that are directly related to the underlying bedrock. Soils developed on metamorphic rock are typically shallow to deep, gravelly loams that are deeper in areas where past landsliding has formed thick surficial deposits. Those soils developed on granitic rock are shallow to moderately deep, gravelly, coarse sandy loams, along with some deep gravelly loams. In areas where old erosional surfaces have been preserved, soils consist of clay loams. Soils on ultramafic rock are shallow to moderately deep clay loams to gravelly loams, with locally deep gravelly loams. Erosion rates on soils under forest cover are very low; however, when cover is removed, the erosion rates rise sharply. In general, soils derived from granitic rock are the most erodable (de la Fuente and Haessig, 1994).

2.5 Climate

In the central Klamath Mountains, the mountains to the west moderate the coastal climatic influence. Summers are warm and dry; winters are cool and wet. Summer high temperatures are about 90° to >100° Fahrenheit (32° to > 38 Celsius); low temperatures are about 55° Fahrenheit (13° Celsius). Winter high temperatures are about 40° to 55° Fahrenheit (5° to 13° Celsius) while raining and cooler under clear skies.

Mean annual precipitation in the Salmon River watershed ranges from about 35 inches in the South Fork Salmon River Canyon to about 85 inches in the headwaters of North Fork/Little North Fork and Wooley Creek. The amount of precipitation generally decreases in an easterly direction, and increases with elevation due to orographic effects. Seasonal precipitation patterns include considerable snow, particularly at higher elevations. The data shown in Figure 2.4 represent the longest continuous data set available at the time this report was prepared (California Isohyet, 1900-1960) (Figure 2.4). More recent data covering a shorter period do not present a significantly different distribution of rainfall within the Salmon River watershed. Approximately 90% of the precipitation occurs from October to May from the north Pacific cyclonic storms. The remainder occurs during summer thunderstorms. Winter precipitation occurs mainly as snow above 4,000 feet, and mainly as rain below 4,000 feet elevation. Fluctuation of the snow level occasionally results in rain falling on snow, causing rapid snow melt. Intense, localized summer showers occur frequently, and have been associated with soil erosion and debris torrents (de la Fuente and Haessig, 1994).

Hot, dry summers are punctuated by thunderstorms, which are a common ignition source for wildfires. Wildfires have caused considerable damage to forest vegetation during the period since the early 1900s. The valley areas along the Salmon River main stem, South Fork, and Lower North Fork are the driest parts of the watershed, and have been impacted with extensive and severe fire damage (USFS Fire History GIS Coverage; California Isohyet, 1900-1960). Of note is the historic practice of salvage logging after fires. Prior to 1987, salvage logging often resulted in clear-cutting large areas after major fires, including river corridors. After the 1987 fires and during the subsequent salvage harvesting, the USFS Salmon River District implemented riparian management zones with prescriptions, including buffers, developed by an interdisciplinary team in collaboration with members of the restoration community. The next fire of any size was the 1994 Specimen Fire, where riparian reserves were delineated and eliminated from salvage (USFS correspondence to NCRWQCB, March 21, 2005). Lack of mature forest vegetation along rivers and streams can influence local climate, referred to as microclimate. This influence is an important consideration within the temperature TMDL technical analysis, Chapter 3 of this document.

2.6 Hydrology

Average annual discharge for the Salmon River is approximately 1.3 million acre-feet. Salmon River discharge records [U. S. Geological Survey, 1927-2001, Water-Data Reports for California] reveal that exceptionally high flows occurred during the winters of 1952-1953, 1955-1956, 1964-1965, 1969-1970, 1970-1971, 1971-1972, 1973-1974, and 1996-1997. Additionally, historic accounts describe floods in 1861-1862, and 1889-1890 (McGlashan and Briggs, 1939, as cited in de la Fuente and Haessig, 1994). Impacts included channel migration, aggradation, scour, and widespread loss of riparian vegetation, with most low gradient floodplains stripped of riparian vegetation and covered with fresh sediment.

2.7 Vegetation

The Salmon River watershed is primarily a forested landscape with about 90% in forest cover (Figure 2.5). The majority of the watershed, 81%, is coniferous forest, with hardwood forest comprising approximately 9% of the watershed, though declining. The coniferous forest can be divided into the mixed conifer, Douglas fir, and true fir types. There is also a small amount of knobcone pine forest type (<1%). The conifer and Douglas fir forest type occupies the western portion of the watershed while the mixed conifer occupies the eastern portion. The true fir/hemlock type is found at elevations above about 6000 feet. Other vegetation types in the watershed include brush lands (34,610 acres; ~7%), meadow and grasslands (2,497 acres; <1%), rocky and relatively barren areas (10,814 acres; ~2%), developed areas, such as building sites and agricultural fields, (1,367 acres; < 1%), and lakes (357 acres; <<1%) (de la Fuente and Haessig, 1994).

The vegetation of the watershed, as in all places, is dynamic over time. Based on paleobotanical studies in Northern California, the watershed was probably covered by a chaparral brush type approximately 8 to 10 thousand years ago during a warm era following the last glacial period. Since that time, the vegetation has changed to pine and oak woodland and then to the more varied coniferous forests of today (de la Fuente and Haessig, 1994).

Riparian vegetation naturally ranges in structure from an advanced, lush seral stage to a disturbed site void of any vegetation. Therefore, the natural range of variation for vegetative structure for a riparian stand, stream reach or an entire tributary, is meaningful when viewed from a watershed perspective, as compared to evaluating vegetation composition of isolated stands (USFS, 1994, pg. 21).

Introduced invasive species and dry conditions impede forest vegetation recovery of lands that have been burned and harvested (USFS, 2002). This will slow recovery of vegetation, and will therefore slow the expected rate of increasing shade.

2.8 The Riparian Corridor and Riparian Reserves

A riparian corridor includes the wetted stream channel plus an area on each side of the stream, often defined as some distance from the center or edge of the stream channel. A riparian corridor of 200 meters out from each edge of the wetted channel, as determined using USGS data and field observations, was used for purposes of riparian corridor vegetation height analysis (Figure 2.6). Analysts at the University of California, Davis, Information Center for the Environment developed this data set for the Regional Water Board.

Riparian Reserves are designated within the Salmon River watershed by the USFS. Riparian Reserves consist of lands where riparian dependent resources receive primary emphasis, and where special Standards and Guidelines apply. They include portions of a watershed required for maintaining hydrologic, geomorphic, and ecologic processes directly affecting standing and flowing water bodies (e.g., lakes and ponds, wetlands, streams, stream processes, and fish habitats). Also included are habitat needs of a variety of animals (e.g., mollusks, amphibians, lichens, fungi, bryophytes, vascular plants, American marten, red tree voles, bats, marbled murrelets and Northern spotted owls) (USFS, 1994, pg. 94).

The Klamath National Forest Final Land and Resource Management Plan (LRMP) (USDA Forest Service, 1995), introduced in Chapter 1 of this report, defines Riparian Reserves thus: Riparian Reserves generally cover an area extending out 300 feet from each side of the channel and “include the land adjacent to all permanently flowing streams, constructed ponds and reservoirs, wetlands, lakes and natural ponds, seasonally flowing or intermittent streams, floodplains, and unstable and potentially unstable land (including earthflows)” (USFS, 1994, pg. 94; USDA Forest Service, 1995: MA10-2). For the full text of the Riparian Reserves definition, as contained in the LRMP, see Table C-1, Appendix C of this report.

About twenty percent of the total length of interim Riparian Reserves has been scoured by debris torrents in the past 70 years (USFS, 1994, pg. 66&67). Intense fire or landsliding in the last 70 years has affected less than five percent of interim Riparian Reserves (USFS, 1994, pg. 66&67).

Twenty-one percent (4,955 acres) of the Riparian Reserve area in the Upper South Fork has been affected by humans, according to US Forest Service estimates (USFS, 1994, pg. 17).

The Riparian Reserves within the North Fork Salmon area occupy 37,000 acres (29%) of the total sub basin area. Of the Riparian Reserves in the analysis area 27% have forest cover greater than 70% crown closure (USFS, 1995b pg. 3-4). The North Fork Riparian Reserves have been highly impacted by channel scour from landslides, debris torrents and placer mining. Riparian vegetation has been lost, stream channels destabilized. Recovery has sometimes been very slow. Roads have also impacted the Riparian Reserves with variable impacts depending on the specific road. Fire and/or timber harvest has impacted a large acreage of Riparian Reserves through the loss of large trees, but has not had the more severe impacts of other disturbances, except where fire has increased the effects of debris flows. Grazing has occurred over large areas, but impacts to riparian areas have not been extensive. Currently the riparian vegetation consists of fewer stands of large, dense conifers than previous to European settlement, mostly due to effects of recent fires.

Riparian shade in the Upper South Fork watershed has been decreased through fire, channel scour, and influences of man such as hydraulic mining, road construction, and clearing for various purposes (USFS, 1994, pg. 62).

The riparian vegetation will continue to recover from past floods and fires, at various rates depending on site conditions. Sites continuously disturbed, such as recreational accesses, will not recover fully to site-potential vegetation. Natural disturbances such as floods and fire will continue to impact riparian areas (USFS, 1995a pg. 84).

Elk on the landscape are affecting riparian zones in certain areas (e.g., Ray's Gulch). Ground cover is removed through trampling and grazing. The elk spend lengthy periods of time congregating in riparian areas (USFS, 1994, pg. 66&67).

2.9 Impacts to the Riparian Corridor

2.9.1 Landslides

Landsliding is one of the most important geomorphic processes in the watershed (de la Fuente, 1993, pg. xi) (Figure 2.9). Large slump/earthflow deposits occupy much of the Western Paleozoic and Triassic Belt, particularly along Blue Ridge, which forms the divide between the North and South Forks of the Salmon River. Active slumps and earthflows up to 20 acres in size occur within these deposits. Debris landslides and avalanches are common in some areas, particularly in headwall areas and within the inner gorge. The information represented in Figure 2.8 is from the USFS GIS dataset called "Active Slides". This data set represents landslides inferred by the authors to have exhibited movement within the last four hundred years.

Several temporary landslide dams have formed along the Salmon River and its tributaries this century, with local influences on in-channel habitat and possibly fish passage (Elder, 2002, pg. 9). For example, two large landslides created temporary dams, blocking off the main stem of the Salmon River. The largest was the Bloomer Landslide. The second largest was the Murderers Bar landslide. These landslides created dams, blocked fish passage, and affected the river channel both upstream and downstream (de la Fuente, 1993, pg. 9-1). The Murderers Bar Landslide delivered approximately 0.59 million cubic yards of sediment to the Salmon River. The Bloomer Landslide, a large debris slide in metamorphic bedrock, delivered approximately 1.4 million cubic yards of sediment to the Salmon River.

2.9.2 Fire

There are many complex relationships between fire, timber harvest, vegetation, sedimentation, and water quality, which are not addressed in this report. The Salmon River Restoration Council Sub-basin Restoration Plan (part of the Salmon River Sub-basin Restoration Strategy) identifies fire as the number one long-term risk to the aquatic and terrestrial ecosystems within the Salmon River watershed (Elder et. al., 2002). Fire in the Salmon River watershed is fairly common and has a prominent effect on the landscape. Recent decades have seen extensive and destructive wildfire. For example, in 1977, the Hog Fire burned 57,489 acres. In 1987, a number of fires, combined, burned 102,369 acres. Areas of the watershed that have burned between 1911 and 2002 are depicted in Figure 2.9.

Suppression and exclusion of fire as a natural and human induced part of the overall vegetation regime may be resulting in a trend towards larger fires of higher severity. Fire suppression efforts on forestlands began once the Klamath Forest Reserve was established in 1905. Effective fire suppression began in the 1920s and has continued through today although this policy is changing. During the 2004 fire season, the Forest Service introduced a natural prescribed wildfire policy, first implemented during a fire in the Russian Wilderness in the upper North Fork watershed (USFS correspondence to NCRWQCB, March 21, 2005).

Disruptions in natural fire regimes by human intervention in suppression have influenced vegetation and sediment delivery patterns in the Salmon River sub basin. High fuel loading and densely stacked forest stands have increased the likelihood of frequent or extensive stand replacing wildfires. Catastrophic fires in this area are known to denude riparian and upslope areas, which increases water temperatures and sediment production (Elder, 2002). Snow pack and water retention are reduced in denuded areas.

Current efforts of fuel reduction and reintroduction of fire into the landscape, such as underburning, aim to address this problem (USFS correspondence to NCRWQCB, March 21, 2005).

2.9.3 Timber Harvest

Timber harvest represents historic, ongoing, and persistent impacts on some parts of the Salmon River watershed landscape (Figure 2.10). Landslide rates can increase with timber harvest. For example, much of the damage in Riparian Reserves in the Little North Fork resulted from road and harvest related landslides associated with road construction and timber harvest that occurred in the early 1970s (USFS, 1995b pg. 4-8). Due to riparian corridor protections outlined in the President's Forest Plan, recent timber harvest rarely extends into the riparian zone (USFS, 1994, pg. 17). Where it does occur in or near riparian corridors, timber harvesting is completed to improve and/or maintain other resource values and objectives, such as maintenance of habitat diversity to protect resources from large-scale disturbances.

Timber harvest history, expressed as acres per decade, is summarized in Table 3.4.

Table 3.4: Timber Harvest Acres Per Decade in the Salmon River Watershed (per USFS records)

Decade	Acres
Unknown	771
1940s	27
1950s	93
1960s	3587
1970s	6698
1980s	20821
1990s	15999
Total	**47995**

2.9.4 Flooding

In wet years, flooding has been associated with significant channel alteration. This includes channel migration, aggradation, scour, and widespread loss of riparian vegetation. Low gradient floodplains are stripped of riparian vegetation, and covered with fresh sediment. High gradient reaches experience both scour and aggradation (de la Fuente, 1993; USFS, 1995a pg. 80; de la Fuente and Elder, 1998). The floods of 1964, the early 1970s, and the 1997 flood produced profound scour over long reaches of stream channel in both managed and unmanaged riparian corridors (de la Fuente, 1993; USFS, 1995a pg. 80; de la Fuente and Elder, 1998). Flood features associated with the 1997 flood are shown in Figure 2.7.

2.9.5 Roads

Roads function as an extension of the stream drainage network (Figure 2.11). Roads have a significant effect on slope stability, and contribute sediment to streams through gullying and surface erosion, ditch failures, and crossing diversions. Roads affect hillslope and channel hydrology; roads affect the density, permeability, and slope gradient of the soil and colluvium; and roads affect mass balance by placing cuts and fills on hillslopes (de la Fuente and Elder, 1998, pg. 38). Roading has also impacted riparian areas. Several roads, including the primary county road through the watershed, are within riparian areas adjacent to streams. Only in a few locations do these roads impact the stream channels for long distances, but they do affect riparian conditions. The roads themselves are an impact due to loss of habitat on the road surface, but roads also allow access for additional impacts. Firewood cutting, logging, and off-road vehicle disturbance in riparian areas are made possible in places accessible by road (USFS 1997 pg. 5-5). Road impacts are detailed further in Chapter 3 of this report.

Roads have altered about 1% of the Riparian Reserves. There are about 79 miles of road within Riparian Reserves (USFS, 1995b pg. 4-10). Roads constitute a permanent disturbance to the Riparian Reserves.

2.9.6 Mining

2.9.6.1 Placer Mining/ Hydraulic and Dredger

A placer is a glacial or alluvial deposit of sand or gravel containing eroded particles of valuable minerals. In June of 1850 prospectors found rich deposits of gold in placers at the Forks of the Salmon. Historic mining activities substantially altered the watershed, as demonstrated by dramatic effects on the landscape, vegetation, soil, and river structure.

Placer mining operations typically progressed in the following manner: Placer deposits were first worked at their surface. Then material just below the surface was mined via "ground sluicing". During ground sluicing operations, riverbed deposits were mined by constructing wing dams to divert the portions of the river to be worked. Ground sluicing also required the construction of ditches and channels.

Hydraulic placer mining consisted of using a high-pressure water cannon to direct a powerful stream of water at uplands. This resulted in the washing away of huge sections of ground and cobble. Many tons of rock and soil were removed along with all of the vegetation within a disturbed area. Large tailing piles were created from these efforts. Some mines left residual vertical banks up to 60 feet in height and piles of cobbles and boulders along stream channels (de la Fuente and Haessig 1993). Mined-over floodplains and terraces remain poorly vegetated many decades after large-scale mining ended. The removal of soil down to bedrock by hydraulic mining in the Petersburg and Summerville areas created a situation where some of the mined sites are incapable of growing any vegetation except that adapted to growing on rock outcrops (USFS, 1994, pg. 20).

Historic hydraulic mining activity caused a tremendous amount of change/disturbance to the Salmon River watershed. The effects are evident almost everywhere in the watershed. The structure of the stream channel was greatly modified by mining activity. Although the effects are difficult to quantify, it is likely that wider, shallower channels, reduced pool depth, large cobble/boulder sedimentation, etc., are major contributors to reduced shade, increased insolation, and increased water temperatures.

2.9.6.2 Lode/Hardrock Mining

The Division of Mines and Geology cited that the Gilta Mine within the Knownothing Creek drainage was established in 1892. The King Solomon Mine was established in the early 1890's along Matthews Creek. The largest mine in the landscape was the Black Bear mine, which started in 1860 and became one of the most productive gold quartz mines in the area. Productions continued intermittently until the 1930s and have been mined to depths of approximately 1,000 feet. (California Geology, 1990)

The Liberty gold mining district is located near Sawyers Bar, on the north slope of the Salmon Mountains, along the North Fork of the Salmon River. According to the Division of Mines and Geology it is one of the principal pre-1970s lode gold producing districts in the Klamath Mountains geomorphic province, which is second in lode-gold production in California to the Sierra Nevada Mother Lode. Results from recent exploration activity suggest that there may be additionally economically minable gold ore reserves in the Liberty district (California Geology, 1990).

2.9.6.3 Current Status of Mining in the Watershed

Several thousand acres of public lands are currently reserved as mining claims, with mineral rights under an 1872 Mining Law provision (USFS, March 2002) (Figure 2.12). This includes more than 400 placer and lode mining claims in the Salmon River sub basin (Elder, 2002). The active gold mining occurring within the landscape is mostly placer along the South Fork and Knownothing Creeks and lode mining at the Discovery Day Mine. Recreational gold suction dredging or panning occurs at various locations along the river. Recreational placer claims have a use of two to four weeks per year during the period of July 1st through September 15th. Multiple users may use a single location in succession, for duration of use in excess of two to four weeks. There are two claimants with seasonal variances: one with six claims operates until mid-October, and the other with ten claims operates year-around. The working mines within the Knownothing drainage consist of hard rock/mill site operations upslope in the drainage while placer operations are occurring near the stream channel in the bottom 1/3 of the drainage. Several smaller placer gold mines are found along stream courses, with one or two miners working each site.

3 PROBLEM STATEMENT

3.1 Temperature

This chapter summarizes ways in which elevated water temperatures have contributed to the decline of the cold-water salmonid fishery. Stream temperature changes are affected by changes in riparian cover, increased solar heating, and changes in streamside microclimates. Stream temperatures are also affected by other factors, including sediment delivery -- through processes such as channel aggradation and pool infilling. This chapter includes a description of the water quality standards and salmonid habitat requirements related to temperature and a qualitative assessment of existing instream and watershed conditions in the Salmon River basin.

This analysis is based primarily on data that have been gathered by the Regional Water Board staff, the United States Forest Service (USFS), and the Salmon River Restoration Council. Temperature monitoring locations for the period from 1990 through 2000 are shown on Figure 3.1. The distribution of these values is plotted on Figure 3.2. Appendix A to this report, Anadromous Salmonids in the Salmon River, California: A Summary From the Literature, provides detailed information about salmonids in the watershed, which represent the beneficial uses identified as most sensitive to temperature impairment within the Salmon River watershed. Because information about habitat parameters in some areas of the watershed is not available, conservative assumptions based on professional judgment were made regarding factors that potentially limit salmonid populations in the basin.

3.1.1 Water Quality Standards - TMDL Defined

In accordance with the Clean Water Act, a TMDL is set at a level necessary to implement the applicable water quality standards. Under the Clean Water Act, water quality standards define designated uses, water quality criteria to protect those uses, and an anti-degradation policy. The State of California uses slightly different terms for its water quality standards than does the USEPA (i.e., beneficial uses, water quality objectives, and a non-degradation policy). This section describes the State water quality standards applicable to the Salmon River TMDL, using the State's terminology. The remainder of the document simply refers to water quality standards.

3.1.2 Beneficial Uses

The beneficial uses and water quality objectives for the Salmon River are contained in the *Water Quality Control Plan for the North Coast Region* (Basin Plan) as amended in 2004 (NCRWQCB, 2004). These designated existing or potential beneficial uses include:

1. Municipal and Domestic Supply (MUN)
2. Agricultural Supply (AGR)
3. Industrial Service Supply (IND)
4. Industrial Process Supply (PRO)
5. Groundwater Recharge (GWR)
6. Freshwater Replenishment (FRSH)
7. Navigation (NAV)
8. Hydropower Generation (POW)
9. Water Contact Recreation (REC-1)
10. Non-Contact Water Recreation (REC-2)
11. Commercial or Sport Fishing (COMM) *
12. Aquaculture (AQUA)
13. Cold Freshwater Habitat (COLD) *
14. Biologically Significant Area (BSA)
15. Wildlife Habitat (WILD)
16. Rare, Threatened, or Endangered Species (RARE) *

17. Migration of Aquatic Organisms (MIGR) *
18. Spawning, Reproduction, and/or Early Development (SPWN) *
19. Shellfish Harvesting (SHELL)
20. Native American Culture (CUL) *.

    * Note: Beneficial Uses with an asterisk are adversely affected by conditions that impair fish survival, such as elevated temperatures.

3.1.3 Water Quality Objectives

The Basin Plan (NCRWQCP, 2004) identifies both numeric and narrative water quality objectives for the protection of beneficial uses in Salmon River. Those pertinent to the Salmon River Temperature TMDL are listed in Table 3.1.

Table 3.1 Water quality objectives addressed in the Salmon River TMDL

Parameter	**Water Quality Objective**
Temperature	The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any COLD water be increased by more than 5° F above natural receiving water temperature.

In addition to water quality objectives, the Basin Plan (NCRWQCB, 1996) includes two prohibitions specifically applicable to logging, construction, and other associated nonpoint source activities:

The discharge of soil, silt, bark, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited; and

The placing or disposal of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature at locations where such material could pass into any stream or watercourse in the basin in quantities which could be deleterious to fish, wildlife, or other beneficial uses is prohibited.

3.1.4 Current Temperature Conditions

Figure 3.1 plots the locations of recent temperature data collection. Figure 3.2 plots the distribution of temperature data collected at those locations from 1990 through 2003 using maximum weekly average temperatures (MWATs). MWATs are discussed later in this chapter under the Salmonid Temperature Requirements heading Section 3.2. MWAT indices for salmonid rearing developed by USEPA Region 10 also are included in Figure 3.2. These metrics, also discussed in Section 3.2, reflect salmonid biological requirements with respect to temperature, and are presented to aid in interpreting available temperature data.

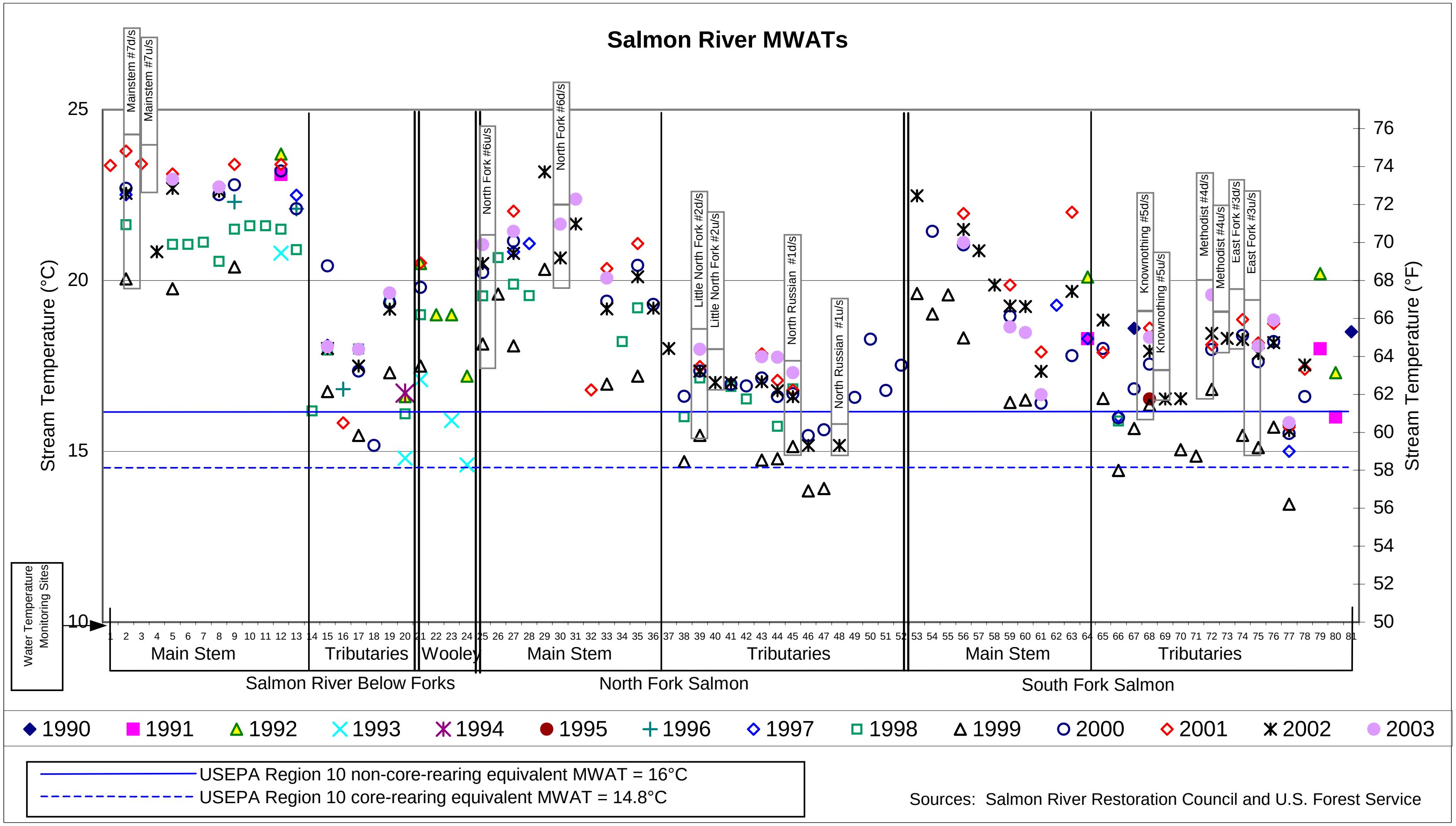


Figure 3.2: Maximum Weekly Average Temperature (MWAT) Values for Salmon River Watershed Stream Temperature Monitoring: 1990-2003

3.2 Salmonid Temperature Requirements

Temperature is one of the most important factors affecting the success of salmonids and other aquatic life. Most aquatic organisms, including salmon and steelhead, are poikilotherms, meaning the ambient temperature of water is determinate upon their temperature and metabolisms. Temperature therefore influences growth and feeding rates, metabolism, development of embryos and alevins, timing of life history events such as upstream migration, spawning, freshwater rearing, and seaward migration, and the availability of food. Temperature changes can also cause stress and lethality (Ligon et al., 1999).

Much of the information reported in the literature characterizes temperature requirements with terms such as “preferred” or “optimum” or “tolerable”. Preferred temperatures are those that fish most frequently inhabit when allowed to freely select temperatures in a thermal gradient (McCullough, 1999). An optimum range provides for feeding activity, normal physiological response, and normal behavior (without symptoms of thermal stress) (McCullough, 1999). A tolerable temperature range refers to temperatures at which an organism can survive.

Most interpretations of water temperature effects on salmonids and, by extension, water temperature standards, have been based on laboratory studies. Many studies have also looked at the relationship of high temperatures to salmonid occurrence, abundance, and distribution in the field.

Several species of anadromous fish (Table 1.1) utilize the Salmon River watershed at some point within in their life cycle, including various salmonid species. Literature reviews were conducted to determine temperature requirements for the various life stages of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*) and chinook salmon (*Oncorhynchus tschawytscha).* When possible, species-specific requirements were summarized by key life stages: migrating adults, spawning, embryo incubation and fry emergence, freshwater rearing, and adult holding. Some of the references reviewed covered salmonids as a general class of fish, while others were species specific.

3.2.1 Sensitive Life Stages of Salmon and Steelhead

Details on the history and status of anadromous salmonids in the Salmon River watershed are provided in Appendix A. Sensitive life stage associations are presented in Table 3.2.

3.2.2 Adult Migration

In addition to the needs for cold pools for juvenile rearing, salmon and trout respond to temperatures during their upstream migration (Bjornn and Reiser, 1991). Delays in migration have been observed in response to temperatures that were either too cold or too warm. Most salmonids have evolved with the temperature regime they historically used for migration and spawning, and deviations from the normal pattern can affect survival (Spence et. al., 1996). In general, upstream migration of most adult salmonids in the Salmon River occurs during a stream temperature transition period. The NCRWQCP does not provide numeric temperature objectives to protect migrating adult salmon and steelhead trout. EPA Region 10 (2001) recommends for all cold-water Pacific salmonids, including steelhead and coastal cutthroat trout in the Pacific Northwest, that the seven-day average of the daily maximum temperatures should not exceed 18°C (65°F), and the weekly mean temperature should not exceed 16°C (61°F). For the larger, lower portions of Pacific Northwest rivers, EPA (2003) recommends the seven-day average of the daily maximum (7-DADM) temperatures should not exceed 20°C (68°F) in those waters that are naturally susceptible to that temperature threshold. EPA’s criteria are derived from the analysis and synthesis of past laboratory and field research and are intended to protect the most sensitive life stages of anadromous salmonids.

Table 3.2: Listing Status and Sensitive Life Stages for Anadromous Salmonids in the Salmon River Watershed

Common Name	Run	Listing Status	Listing Authority	Sensitive Life Stage	Habitat Needs	Vulnerabilities
Coho		Threatened	State, Federal	Juveniles	Cold summer pools	Loss of riparian cover; pool infilling
Chinook	Fall	N/L		Migrating adults, Juveniles	Cold, flowing water	Reduced flows; pool infilling
Chinook	Spring	N/L		Holding adults, Juveniles	Cold summer pools	Loss of riparian cover; pool infilling
Steelhead	Fall	N/L		Juveniles	Cold summer pools	Loss of riparian cover; pool infilling
Steelhead	Spring, Summer	N/L		Juveniles, Holding adults	Cold summer pools	Loss of riparian cover; pool infilling
Steelhead	Winter	N/L		Juveniles	Cold summer pools	Loss of riparian cover; pool infilling

3.2.3 Maximum Weekly Average Temperature (MWAT)

It is useful to have measures of chronic and acute temperature exposures for assessing stream temperature data. An EPA document, *Temperature Criteria for Freshwater Fish: Protocol and Procedures* (Brungs and Jones, 1977) discusses development of criteria for assessing temperature tolerances of fish for several different life stages. Two measures of exposure are developed and applied: maximum weekly average temperature (MWAT) as a measure of chronic exposure and short-term maximum temperature as a measure of potentially lethal effects.

The Maximum Weekly Average Temperature (MWAT) is the maximum value of the mathematical mean of multiple, equally spaced, daily temperatures over a 7-day consecutive period (Brungs and Jones 1977). In different words, this is the highest value of the 7-day moving average of temperature. Simply stated, calculations of MWAT, according to Armour (1991), are the upper temperature recommended for a particular life stage. Brungs and Jones developed MWATs for the growth phase of fish life, as growth appears to be the life stage most sensitive to modified temperatures and it integrates many physiological functions. They also developed MWATs for spawning.

Sullivan and others (2000) review sub-lethal and acute temperature thresholds from a wide range of studies, incorporating information from laboratory-based research, field observations, and risk assessment approaches. The authors report calculated MWAT metrics for growth ranging from 14.3°C to 18.0°C for coho salmon, and 14.3°C to 19.0°C for steelhead trout. The risk assessment approach used by Sullivan and others (2000) suggests that an upper threshold for the MWAT of 14.8°C for coho and 17.0°C for steelhead will reduce growth 10% from optimum, and that thresholds for the MWAT of 19.0°C for both coho and steelhead will reduce growth 20% from optimum. For Chinook salmon, Sullivan, from Brungs and Jones (1977), reports an upper MWAT for growth impairment of 20°C.

While these thresholds relate to reduced growth, temperatures at sub-lethal levels also can effectively block migration, inhibit smoltification, and create disease problems (Elliot, 1981). Further, the stressful impacts of water temperatures on salmonids are cumulative and positively correlated to the duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival (Ligon *et al.* 1999).

Jobling (1981) reported that the upper lethal limit, that is, the temperature at which death occurs within minutes, ranges from 27°C to 30°C for salmonids. Sullivan *et al.* (2000) report acute threshold values, that is, temperatures causing death or total elimination of salmonids from a location, that range from 21.0°C to 25.5°C for coho, and 21.0°C to 26.0°C for steelhead. Chinook salmon, depending on acclimation temperature and life stage, have been shown to have upper lethal temperature limits from 24.0-26.7°C (McCullough, 1999). The following paragraphs assess temperature requirements for various salmonid life stages.

The MWAT is used as the primary statistical measure for interpretation of stream temperature conditions in the summary of stream temperature data in the Salmon. USEPA Region 10 has issued guidance regarding temperature criteria protective of cold water fish for various species and life-stages. These values are included here to aid with interpretation of watershed data. Because USEPA values are presented for the maximum 7-day averages of daily maxima, an MWAT equivalent value is included in Table 3.3 using a correlation equation presented in Sullivan and others (Sullivan and others, December 2000). The following values (Table 3.3) are used for comparison to measured stream temperatures to characterize the temperature quality of surface waters in the Salmon River watershed with respect to salmonid biological requirements.

Table 3.3: Recommended Uses and Criteria That Apply to Summer Maximum Temperature.

Use	Criteria	MWAT Equivalent [4]
Salmon/Trout "Core" Juvenile Rearing (*Salmon adult holding prior to spawning, may also be included in this use category*.)	16°C (61°F) 7DADM	14.8
Salmon/Trout Migration plus Non-Core Juvenile Rearing	18°C (64°F) 7DADM	16
Salmon/Trout Migration	20°C (68°F) 7DADM	17.3

Notes:
1) "7DADM" refers to the Maximum 7 Day Average of the Daily Maximums.
2) "Salmon" refers to chinook, coho, sockeye, pink, and chum salmon.
3) "Trout" refers to steelhead and coastal cutthroat trout.
4) Based on Sullivan and others (2000) p.3-10, Fig. 3.8.

Source: U. S. Environmental Protection Agency, 2003, p.25.

3.3 Natural History and Land Use Effects on Stream Temperature

Unless otherwise noted, statistics given concerning wildfires, mining, and timber harvest are referenced from various Salmon River Watershed Ecosystem Analysis reports prepared by the United States Forest Services and published in 1994, 1995, 1997, 1998, and 2002.

3.3.1 Timber Harvest

Timber Harvest represents historic, ongoing, and persistent impacts on some parts of the Salmon River watershed landscape. Extent of historic timber harvest is presented in Figure 2.10.

3.3.1.1 Effects of Timber Harvest on Stream Conditions

Landslide rates can increase with timber harvest. In granitic soils, landslides increase as much as nine to twenty times in harvest units over undisturbed areas. Also, skid trails and fuel treatments can create conditions of decreased infiltration, increased runoff, and increased sediment transport. Timber harvest in the North Fork of the Salmon River has been a more extensive activity than both mining and road construction, having occurred in almost 3,000 acres of Riparian Reserves (USFS, 1995b pg. 5-13). Much of the damage in Riparian Reserves in the Little North Fork has resulted from road and harvest related landslides associated with road construction and timber harvest that occurred in the early 1970s (USFS, 1995b pg. 4-8).

3.3.1.2 Current Timber Harvest Activities

Timber harvest extended into the riparian zone prior to implementation of the Northwest Forest Plan (USFS, 1994, pg. 17). Outside the riparian zone, much of the land base is within recent burns, wilderness, or protected Late-Successional Reserves (LSRs). LSRs are land allocations from the Forest Plan (USDA Forest Service and USDI Bureau of Land Management. 1994). The objective of the LSRs is to protect and enhance the conditions of late successional and old growth related species, including the northern spotted owl. These reserves are designed to maintain a functional, interacting, late successional and old growth forest ecosystem. Timber harvesting is completed to improve and/or maintain other resource values and objectives, such as maintenance of habitat diversity to protect resources from large-scale disturbances. Additional harvesting on matrix lands defined within the Forest Plan is allowed.

3.3.2 Roads

Roads have a significant effect on slope stability, particularly during flood events. Roads can affect hillslope and channel hydrology; the density, permeability, and slope gradient of soil and colluvium; and slope stability by placing cuts and fills on hillslopes (de la Fuente and Elder, 1998, pg. 38).

3.3.2.1 Road fills, cuts and surface drainage effects on flood processes

Road fills, cuts and surface drainage have critical effects on flood processes. Road fills are noted to have three key effects on flood processes: (a) by disrupting channel configuration at stream crossing, and causing diversions; (b) placing landslide-prone soil and rock on steep hillslopes; (c) and placing loads on the heads of slumps and earthflows (de la Fuente and Elder, 1998, pg. 39).

Road cuts affect flood processes by intercepting subsurface flow, undermining slopes, and removing weight (de la Fuente and Elder, 1998, pg. 39).

Road surface drainage including the road surface, inside ditch, and cross drains alters slope hydrology by conveying the water intercepted by road stream crossings, road cuts, and the road surface itself, and delivers it to new sites in the landscape (de la Fuente and Elder, 1998, pg. 39).

3.3.2.2 Geomorphic setting

The road components described above (fills, cuts, drainage) vary in effect among the different geomorphic settings. In the stream channel environment where roads cross or run parallel to streams, some road fills block the passage of sediment and logs; some fail, contributing sediment to streams; road cuts to inner gorge walls can initiate debris slides; ditches deliver additional water to crossings, serving as channel diversions (de la Fuente and Elder, 1998, pg. 39). In older landslide deposits, roads can undercut toe zones or load the heads of slumps and earthflows (de la Fuente and Elder, 1998, pg 39). On steep mountain slopes, fills may be placed in steep swales, while cuts undermine weak slopes (de la Fuente and Elder, 1998, pg. 39).

3.3.2.3 Quantified effects of flood processes and roads on the landscape

Following the 1997 Klamath River flood, USFS personnel analyzed the effects of roads on flood processes by determining the landslide density (landslides per square mile) in road corridors. Air photo survey results established that the overall density (number per square mile) across the landscape was 0.59. The landslide density for undisturbed land was 0.27 (de la Fuente and Elder, 1998, pg. 40). 182 landslides were identified within the 50-foot wide road corridor and calculated to represent a landslide density of 7.34 (de la Fuente and Elder, 1998, pg. 40). While this calculation yields a landslide density in the road corridor 27 times that in undisturbed lands, the calculation does not take into account differences in effects between different landslides (de la Fuente and Elder, 1998). It is also notable that the presence of a landslide in the road corridor does not necessarily mean it was caused by the road (de la Fuente and Elder, 1998).

3.3.3 Effects of Channel Scour on Stream Temperature

Channel scour resulting in loss of riparian vegetation and associated shade can affect stream temperature. USFS was able to document effects of scour on stream temperature in Elk Creek, a watershed near the Salmon River. Elk Creek, tributary to the Klamath River, discharges into the Klamath River upstream of the Salmon River. Elk Creek has wilderness areas in the Upper Elk Creek sub-watershed, and harvested lands with associated roads in the Lower and East Fork Elk Creek sub-watersheds. In Elk Creek, the 1997 flood resulted in loss of riparian vegetation and stream habitat, filling of pools, and decreases in total length and number of pools. In the Phase I Final Report of the Flood of 1997, USFS staff describe the changes to Elk Creek that were propagated by the 1997 flood (de la Fuente and Elder, 1998, Appendix G, pg. 8). "The 1997 flood caused widening and shallowing of the active stream channel and loss of riparian vegetation. This was observed along the entire length of surveyed segments, although much more pronounced in alluvial reaches. Increased heating of the stream in summer is likely because there is less vegetative canopy to shade the streams and because water flowing in wider and shallower stream channels is more prone to heating from solar radiation and increased surface area in contact with warm air." In fact, an analysis of measured temperatures in Elk Creek confirms this. Elk Creek water temperatures for the period 1990 through 1995 were compared with 1997 water temperatures (Table 3.5). Similar events appear to have happened in the Salmon River watershed, and may happen again in the future.

Table 3.5: Elk Creek Water Temperature: Comparison of 1990 – 1995 with 1997

Year	Begin Hottest 31 days	Average °F	Instant. Max. °F	7-Day Max. Average °F	31-Day Max. Average °F	Diurnal Variation °F	Low Flow cfs	Average Air Temp °F
1990	July 22	63.9	72.3	71.2	69.1	8.1	no data	74.1
1991	July 11	65.5	71.4	70.3	69.1	8.3	28	73.8
1992	Aug 1	64.8	72.7	71.2	68.0	7.4	17.4	69.4
1993	July 18	59.9	67.3	65.7	62.8	7.0	44.0	69.6
1994	July5	65.8	72.3	71.2	69.1	8.1	16.1	76.0
1995	July 16	60.9	68.2	66.4	63.9	7.0	no data	71.4
Mean	1990-95	63.5	70.7	69.4	67.0	7.6	26.4	72.4
1997	Aug 2	64.0	74.5	73.0	69.6	12.5	49.3	74.6

From de la Fuente and Elder, 1998, Appendix G, page 21.

3.3.4 Fire

3.3.4.1 Impacts of Fire

Riparian areas along perennial streams typically have the most continuous stands of large trees. Riparian trees are most effective in providing shade for streams. Thus, fire impacts to riparian corridors can have direct effects on stream temperature by reducing streamside shade. Fire can also lead to increased soil erosion, and increased sediment delivery that in turn can result in stream aggradation, pool filling, and in extreme cases landsliding, debris torrents, or other forms of mass movement. Increased sediment loads can affect stream temperatures by increasing active wetted channel widths, and thus increasing solar radiation inputs, and reducing the depths of stratified pools.

Since the early 1900s, about 16% (3,810 acres) of the Riparian Reserve in the Upper South Fork has been burned by fire of varying intensity; 658 acres (3% of the Riparian Reserves) have experienced stand-replacing fires (USFS, 1994, pg. 17). During the same period, about 39% of Riparian Reserves (14, 406 acres) in the North Fork sub basin burned. The Hog Fire of 1977 combined with the Yellow Fire of 1987 burned approximately 7 % (2,600 acres) of Riparian Reserves in the North Fork sub basin (USFS, 1995b, pg. 4-9).

The greatest disturbance apparent along the tributary streams in the lower South Fork sub basin is wildfire, specifically from the 1987 fires on the north side of the river. Riparian areas along Negro and Indian

Creeks, and adjacent smaller streams, were set back to an early seral stage. West side tributaries to Black Bear Creek and all of Murphy Gulch burned hot. Large portions of South Fork Riparian Reserves of Knownothing Creek, Methodist Creek, and Hotelling Gulch sub basins underwent stand-replacing fire in 1987, with Hotelling Gulch losing the greatest proportion of riparian vegetation and Knownothing Creek losing relatively little (USFS, 1997, pg. 3-6). On the main Salmon, catastrophic fires in recent decades left an imprint on Crapo and Nordheimer Creeks by decreasing riparian vegetation, and increasing surface erosion and sediment delivery to the channels (USFS, 1995a, pg. 80). Riparian vegetation recovery can vary greatly, depending on site conditions. For example, in largely granitic terranes, recovery is a slow process, taking approximately 80 years for the establishment of large conifers within the Riparian Reserves. In ultramafic terranes, particularly along smaller streams, herbaceous plants, shrubs, and hardwoods come in quickly and do provide effective shade (USFS correspondence to NCRWQCB, March 21, 2005).

Fires greatly increase the potential for landsliding and soil erosion in the ensuing years after fires (de la Fuente, 1993). Sediment derived from soil and surface erosion immediately after the 1987 fires was estimated at 106,190 cubic yards/year. Prior to the fire, it was estimated at 14,906 cubic yards/year.

3.3.4.2 Effects of Fire on Stream Condition and Water Quality

The 1977 and 1987 fires adversely impacted riparian areas in the watershed, particularly along streams north of the South Fork Salmon between Forks and Black Bear Creek (USFS, 1997, pg. 2-1). The greatest disturbance apparent along the tributary streams in the lower South Fork sub basin is wildfire, specifically from the 1987 fires on the north side of the river. With the greatly increased landslide potential, the threat of catastrophic scouring in flood events is also increased.

3.3.5 Mining

Historic mining activities substantially altered the watershed, as demonstrated by dramatic effects on the landscape, vegetation, soil, and river structure. Although mined areas have disturbed a small percentage of the Riparian Reserves, the disturbances are long lasting and usually occur along reaches of fish-bearing streams (USFS, 1995b pg. 4-10). Riparian vegetation was severely impacted in places by hydraulic mining and also by mining camps and other settlements. The impacts are significant, long lasting alterations of the riparian area (USFS, 1994, pg. 17). Lack of vegetation allows for greater amounts of solar radiation to reach the stream, raising stream temperatures.

3.3.6 Grazing

There are currently all or portions of four grazing allotments within the boundary of the watershed. They are: Big Flat, Carter Meadows, Garden Gulch, and South Russian Creek. Little evidence exists to provide a direct linkage between existing grazing management and stream temperatures in the Salmon River watershed.

3.3.7 Water Use

The Salmon River watershed has less than three hundred residents. Uses of water include domestic service, fire suppression, residential gardens, and livestock water. There are nine water transmissions under special-use permits, and two dams in White’s Gulch, one in Crapo Creek. Water is transmitted for private use by both pipe and ditch. There are approximately ten miles of ditch within the watershed. Little North Fork has a diversion ditch in current use. Knownothing Creek has a non-operational ditch, which in the past provided water to a dozen households. The Knownothing Creek ditch may be put into service again. The following creeks are used for water sources: Cecil Creek, Crawford Creek, Ketchum Gulch, Rush Creek, Taylor Creek, Long Gulch, Henry’s Gulch, and East Fork Salmon River (USFS, 1994). No linkage has been made between existing water use and temperature conditions in the watershed. Future applications for increased use (i.e..: Forks of Salmon Community Service District) should consider potential impacts to water temperature.

3.4 Summary of Effects of Historic Land Use

Historic land use has had a profound and lasting effect upon the landscape of the Salmon River watershed. Within the channel, a new dynamic equilibrium exists around the alterations that include scoured channels filled with boulders. Other degradation, such as from fire or timber harvesting, may be in various stages of regeneration.

4 TEMPERATURE TMDL

4.1 Sources of Increased Stream Temperature

The water bodies in the Salmon River watershed are included on the 303(d) list as impaired for temperature. Increased surface water temperatures can result from point and non-point sources. Because there are no known point sources of heat input to the streams of the Salmon River watershed, temperature loads from point sources are not considered further in this document. Full details of the analysis on which the conclusions presented in this chapter are based may be reviewed in **Appendix B** of this report.

Water temperature is a measure of the total heat energy contained in a volume of water. Stream temperature is the product of a complex interaction of heat exchange processes. These processes include heat gain from direct solar (short–wave) radiation; both gain and loss of heat through long-wave radiation, convection, conduction, and advection; and heat loss from evaporation (Brown 1980; Beschta et al. 1987; Sinokrot and Stefan 1993; Theurer et al., 1984).

- Net direct solar radiation reaching a stream surface is the difference between incoming radiation and reflected radiation, reduced by the fraction of radiation that is blocked by topography and stream bank vegetation (Sinokrot and Stefan, 1993). At a given location, incoming solar radiation is a function of the suns position, which in turn is determined by latitude, day of the year, and time of day. During the summer months, when solar radiation levels are highest and streamflows are low, shade from streamside forests and vegetation can be a significant control on direct solar radiation reaching streams (Beschta et al., 1987).

- Long-wave radiation emitted from the water surface can cool streams. Heat exchange via long-wave radiation at a stream surface is a function of the difference between air temperature and water surface temperature (Sinokrot and Stefan, 1993; ODEQ, 2000). During the course of a 24-hour period, heat leaving and heat entering a stream via long-wave radiation generally balance (Beschta, 1997; ODEQ, 2000).

- Evaporative heat losses are a function of the vapor pressure gradient above the stream surface and wind conditions (Sinokrot and Stefan, 1993). Evaporation tends to dissipate energy from water and thus tends to lower temperatures. The rate of evaporation increases with increasing stream temperature. Air movement (wind) and low vapor pressures (dry air) increase the rate of evaporation and accelerate stream cooling (ODEQ, 2000).

- Convection describes heat transferred between the air and water via molecular and turbulent motion. Heat is transferred from areas of warmer temperature to areas of cooler temperature. The amount of heat transferred by this mechanism is generally considered low (Brown 1980; Sinokrot and Stefan, 1993).

- Conduction is the means of heat transfer between the stream and its bed. In shallow streams, solar radiation may be able to warm the streambed (Brown, 1980). Bedrock or cobbles on the streambed may store heat and conduct heat back to the water if the bed is warmer than the water (ODEQ, 2000). Likewise, water can lose or gain heat as it passes through subsurface sediments during intra-gravel flow through gravel bars and meanders. Bed conduction is a function of the thermal conductivity of the bed and the temperature gradient within the bed (Sinokrot and Stefan, 1993). A streambed that has absorbed radiant energy during the day will conduct that energy back to the stream at night.

- Advection is heat transfer through the lateral movement of water as stream flow or groundwater. Advection accounts for heat added to a stream by tributaries or groundwater. This process may warm or cool a stream depending on whether a tributary or groundwater entering the stream is warmer or cooler than the stream.

Each of the heat fluxes discussed above can be represented by mathematical equations. By adding the values of the fluxes for a particular location, the net of the heat fluxes associated with all of these processes can be calculated (Theurer et al., 1984). The net heat flux represents the change in the water body's heat storage. The net change in storage may be positive, leading to higher stream temperatures, negative, leading to lower stream temperatures, or zero such that stream temperature does not change.

4.2 Analytical Methods and Results

4.2.1 Overview

The modeling objective was to evaluate effects of changes in vegetation, channel geometry, and flow on stream temperature. With respect to seasonal variations in stream temperatures, the analysis used summertime conditions as constituting a limiting condition for salmonid survival with respect to temperature.

The approach taken to develop this technical TMDL for stream temperature in the Salmon River watershed involved the use of a computer simulation model to investigate stream heating processes. The USGS SSTEMP model was used to evaluate the relative importance of the various factors that combine to produce the observed stream temperatures, and to evaluate what impact changes in streamside vegetation, channel geometry, and flow may have on the stream temperature regime. The SSTEMP model is intended for application to a segment or reach of a stream or river (Bartholow, 2002). Figure 4.1 shows a schematic of a stream reach with some of the input variables required. In this figure, Q refers to flow, and T refers to stream temperature.

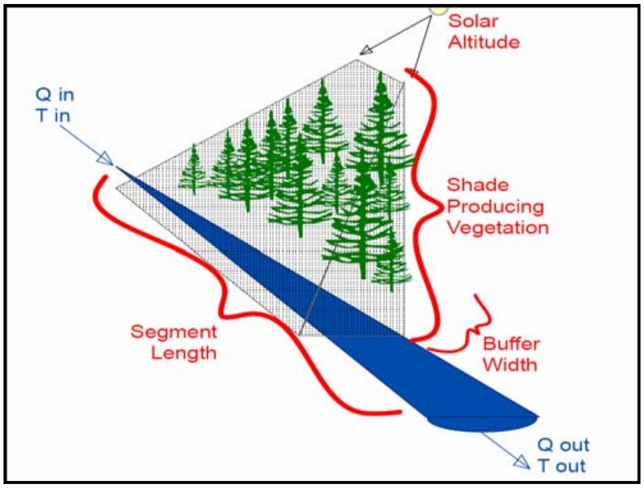


Figure 4.1: Stream Reach Characteristics

Segments were chosen to address the modeling objectives, and included segments with temperature data available at both upstream and downstream ends of a reach. Locations of each segment are shown in Figure 4.2.

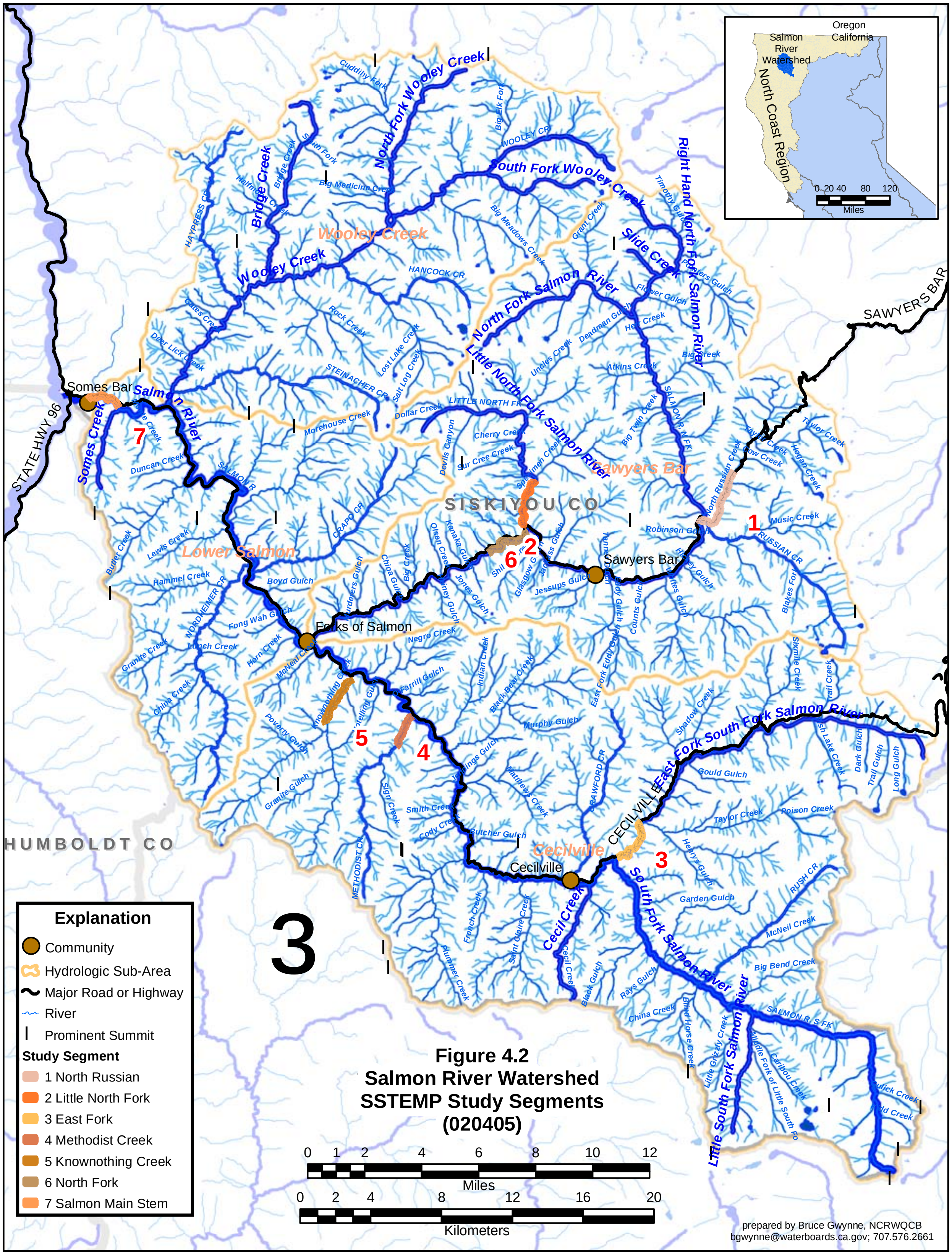


Figure 4.2
Salmon River Watershed
SSTEMP Study Segments
(020405)

prepared by Bruce Gwynne, NCRWQCB
bgwynne@waterboards.ca.gov; 707.576.2661

Reach-level models were first calibrated to measured stream temperatures. Two different dates were modeled in preparing this report. Calibration results for these two modeled periods are presented in Table 4.1 and Table 4.2. Temperatures predicted by the model for current conditions for all locations are within 0.7°C of the measured temperatures. Then, simulations were run with SSTEMP by adjusting specific parameters to simulate the upper end of reach-level increases in shade-producing vegetation, active and wetted channel widths, and flow, all of which can be affected by management. See Appendix B for details of analytical methods.

4.2.2 Increased Streamside Vegetation

The impact of changes in effective shade on stream temperatures was evaluated for seven reaches of streams in the Salmon River watershed using the SSTEMP model. The reaches and results are listed in Table 4.1. Stream temperatures were simulated for current shade conditions, as well as mature riparian conditions, as adjusted potential effective shade.

Table 4.1: Measured and Modeled Daily Average Stream Temperatures of Modeled Segments for the MWAT of Each Segment (Model Date 1)

Reach	Current Effective Shade (%)	Adjusted Potential Effective Shade (%)	Measured Temperature (°C) (°F)	Simulated Current Temperature (°C) (°F)	Simulated Potential Temperature (°C) (°F)
North Russian	73.0	84.7	16.4 61.5	17.1 62.8	16.4 61.5
Little North Fork	70.2	82.2	17.2 63.0	17.4 63.3	17.1 62.8
East Fork	51.6	75.0	17.8 64.0	17.9 64.2	17.2 63.0
Methodist Creek	71.1	85.9	18.4 65.1	17.7 63.9	16.7 62.1
Knownothing Creek	71.5	85.9	17.6 63.7	17.4 63.3	16.7 62.1
North Fork	36.4	66.0	20.6 69.1	20.9 69.6	20.5 68.9
Salmon Mainstem	1.1	8.3	22.3 72.1	22.7 72.9	22.6 72.7
Numeric Target (mean of Adjusted Potential Effective Shade)	-	**69.7**	-	-	-

The results of the stream temperature simulations demonstrate the impact that changes in streamside vegetation conditions have on stream temperatures. The simulations show that an increase in effective shade from current to adjusted potential shade condition results in a decrease in stream temperatures. Temperature reductions for the segments simulated ranged from 0.1 to 1.0°C. These results suggest that shade has a greater effect on stream temperatures on tributary segments than on mainstem segments.

Table 4.2 Measured and Modeled Daily Average Stream Temperatures of Modeled Segments (Model Date 2)

Reach	Current Effective Shade (%)	Adjusted Potential Effective Shade (%)	Measured Temperature (°C) (°F)	Simulated Current Temperature (°C) (°F)	Simulated Potential Temperature (°C) (°F)
North Russian	74.6	87.3	15.5 59.9	15.6 60.1	14.7 58.4
Little North Fork	71.4	81.4	15.5 60.0	16.0 60.7	15.5 59.9
East Fork	51.3	74.8	17.8 64.1	18.1 64.6	17.5 63.5
Methodist Creek	73.6	88.1	16.3 61.4	16.4 61.5	15.4 59.7
Knownothing Creek	73.8	88.0	15.9 60.7	16.1 60.9	15.3 59.6
North Fork	51.4	76.6	18.3 65.0	17.9 64.3	17.6 63.6
Salmon Mainstem	16.2	50.6	20.7 69.3	20.9 69.7	20.4 68.7

Changes in the rate of heating from current conditions to the model's adjusted potential shade conditions were investigated for an alternate date, generally in late August. Results in Figure 4.3 show that increasing riparian trees to adjusted potential heights can produce a reduction in the rate of stream heating of 0.12 °C to 0.51°C per stream kilometer, and in some cases can change a warming segment into a cooling segment.

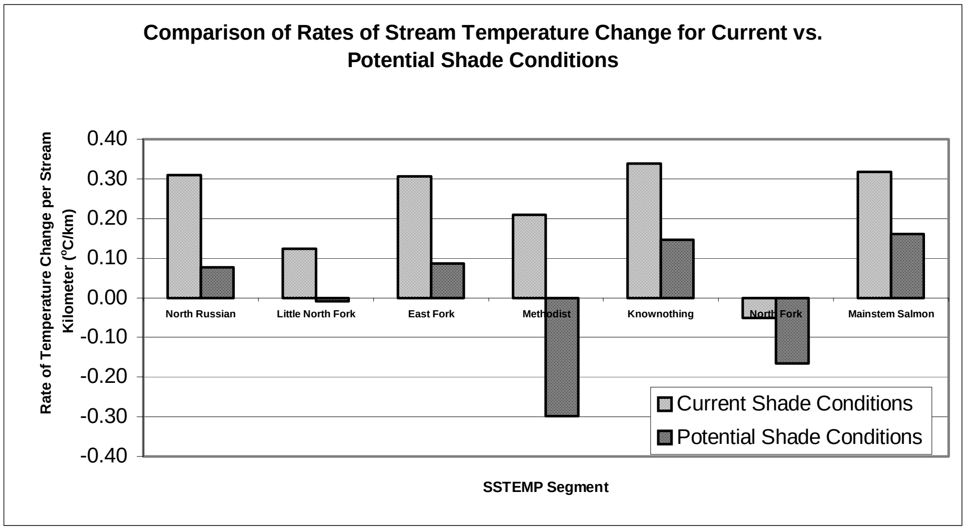


Figure 4.3 Comparisons of Rates of Stream Temperature Change for Current vs. Potential Shade Conditions for Flow Measurement Dates.

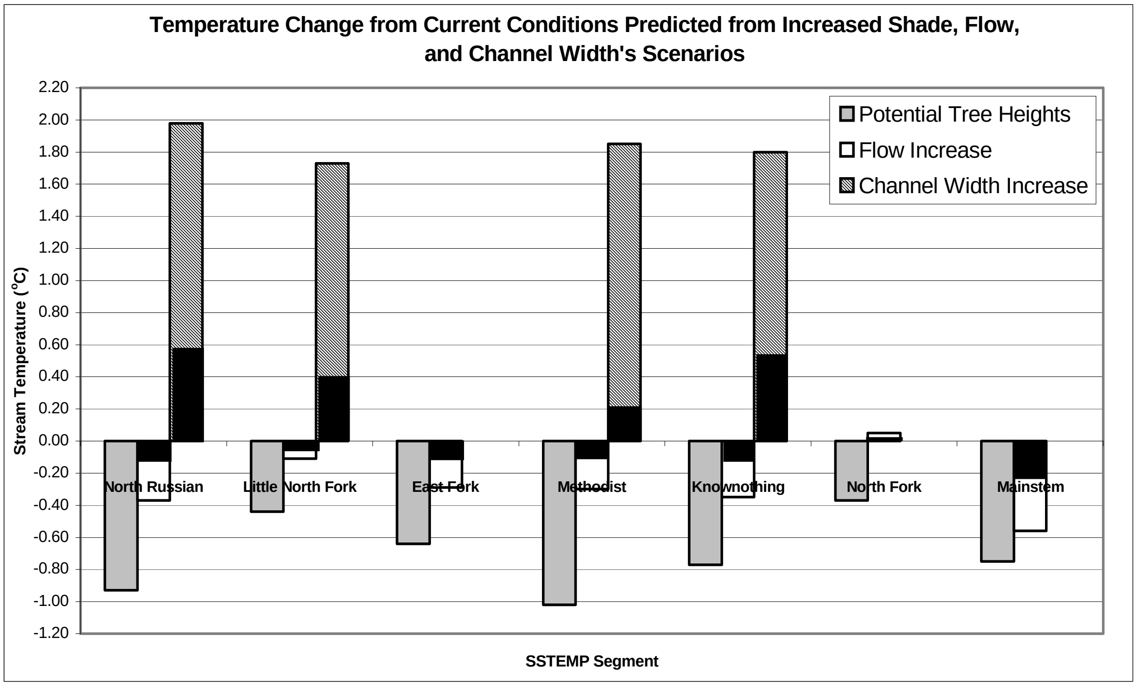
The Basin Plan's water quality objective for temperature states that temperatures of intrastate waters shall not be altered unless it can be shown that such an alteration does not impact beneficial uses. Our analysis in the Salmon River watershed shows that increased streamside shade can lead to reduced stream temperatures, and suggests the corollary, that reduced stream shade can cause increases in stream temperature.

4.2.3 Increased Stream Width

SSTEMP was used to simulate aggradation events (e.g., debris torrents). These simulations were run for tributary stream segments where a debris torrent could produce significant scouring that could significantly widen the active channel and wetted widths, as happened in areas within and adjacent to the Salmon River watershed during the 1997 flood events (de la Fuente 1998). To simulate these effects, the model's input data for riparian vegetation placement and wetted width geometry were adjusted. In order to simulate a debris torrent, vegetation was placed further from the stream, producing a hypothetical reduction in effective shade. Wetted width was also increased to simulate the effects of a debris torrent. SSTEMP was then used to predict stream temperatures for the combination of increased wetted widths and reduced effective shade associated with channel widening.

4.2.4 Increased Flow

To represent the effects of fire, timber harvest, or changes in management at a landscape scale, the model's flow values were increased incrementally to double that used for the current condition scenarios. Increases in flow following a fire or logging event have been well documented in similar watersheds.



Note: For flow and channel width columns, solid portion represents the temperature change from a 25% increase, while the full column length represents the change in temperature from a 100% increase

Figure 4.4 Temperature Change from Current Conditions Predicted for Increased Shade, Flow, and Channel Widths Scenarios for Flow Measurement Dates.

Temperature changes from simulated current conditions (for Flow Measurement Dates) resulting from changes in shade, channel geometry, and flow are presented in Figure 4.4.

4.3 Conclusions

The results of the stream temperature modeling analysis show that changes in channel geometry, riparian vegetation conditions, and stream flow characteristics can change stream temperatures. Specifically, for increased riparian vegetation heights, the resulting reductions in solar inputs would lead to reduced stream temperatures. For increased active and wetted channel widths, increased solar radiation inputs to streams would result in elevated stream temperatures. For flow, increases over current conditions generally result in small decreases in predicted stream temperatures. For this variable, slight increases in solar radiation input associated with increased stream surface area are more than balanced by the increased resistance of higher flows to temperature change, and reduced travel times. The analysis uses a 0.25°C difference as a threshold of significance.

Shade is of great concern for this TMDL because management can affect it by changing the nature and extent of the vegetative component, and changes in shade can alter stream temperatures from natural levels. Total shade can be directly related to solar radiation inputs that affect stream temperatures.

Stream temperatures also are sensitive to air temperature, and in some circumstances relative humidity and wind speed (see Appendix B sensitivity analysis), which in turn are subject to change as a result of management of streamside vegetation. Changes in microclimate associated with removal of riparian vegetation and changes to these factors can also lead to increased stream temperatures. However, the degree of microclimate alteration due to changes in riparian vegetation is not readily predictable, although the phenomenon has been well documented.

The stream temperature modeling analysis demonstrates that changes in solar radiation inputs alone can lead to significant changes in stream temperatures, especially in small streams. Furthermore, the modeling analysis demonstrates that an increase in stream shade from current vegetation conditions to those that could be expected for mature vegetation conditions would lead to improved stream temperatures. Such changes can be expected to occur on a landscape scale. This reach-level analysis predicts that changes to current channel geometry that might result from large inputs of sediment would increase stream temperatures. Such large changes are often observed in some reaches of a watershed in response to extreme events (such as the 1997 flood), while minimally affecting other reaches in the same or nearby watersheds (de la Fuente 1998).

From a management standpoint, the analysis leads to these conclusions:

1. Where human activity has caused loss of riparian shade that has resulted in elevation of stream temperatures above natural receiving water temperatures, the Basin Plan’s water quality objective for temperature is not being achieved.
2. The recovery of riparian vegetation height and extent from past disturbances is expected to be the most important factor at a landscape scale in lowering stream temperatures toward natural levels where they would meet Basin Plan objectives.
3. Increased sediment delivery, resulting from upslope disturbance, which subsequently leads to changes in channel geometry, can increase stream temperatures. Where this situation is occurring or is at risk of occurring as a result of management activities, the Basin Plan objective for temperature might not be met.
4. The effects of increased flow on temperature appear to be minor in this watershed and are not considered significant for this TMDL.

4.4 Salmon River Temperature TMDL

4.4.1 Temperature TMDL and Allocations

This section presents the temperature TMDL and load allocations. The starting point for the analysis is the equation that describes the Total Maximum Daily Load or loading capacity:

$$\textbf{TMDL} = \Sigma\textbf{WLAs} + \Sigma\textbf{LAs} + \textbf{Natural Background}$$

where Σ = the sum, **WLAs** = waste load allocations, and **LAs** = load allocations. Waste load allocations are contributions of a pollutant from point sources while load allocations are contributions from management-related non-point sources.

4.4.1.1 Development of Pollutant Load Capacity and Surrogate Measures

To use the loading capacity and to be able to compare it to current conditions, a surrogate measure of loading capacity is proposed. EPA regulations (40 CFR §130.2(i)) allow for the use of other appropriate measures (surrogate measures) to allocate loads for conditions "when the impairment is tied to a pollutant for which a numeric criterion is not possible…" (EPA 1998c). There are no numeric criteria for radiant heat loads. However, it is possible to relate heat load to effective shade (that shade resulting from topography and vegetation that reduces the heat load reaching a stream) and to relate effective shade to temperature conditions. Effective shade can be readily measured in the field and also can be calculated using mathematical equations.

In this analysis, natural effective shade is estimated as potential effective shade (based on fully mature trees growing along the bankfull channel of the streams) reduced by 10 percent to account for natural effects such as fire, windthrow, and earth movements that would reduce the actual riparian area vegetation below the site potential. This modified condition is taken to represent an approximation of natural vegetation, and is referred to in this document as adjusted potential vegetation. The target water temperatures are those that result from achieving or maintaining adjusted potential effective shade in the watershed. All significant sources of stream temperature increase are accounted for as potential effective shade. The estimation includes both natural stream geometry and natural riparian vegetation.

There are no point sources of temperature within the Salmon River watershed, meaning the WLA is zero. Therefore, the TMDL loading capacity is equal to adjusted potential effective shade conditions and the associated solar loading that results in natural receiving water temperatures. The TMDL equation becomes:

$$\text{TMDL} = \text{Loading Capacity} = \text{Adjusted Potential Effective Shade}$$

The adjusted potential effective shade for the watershed is approximated by the mean of adjusted potential effective shade values calculated for use in the SSTEMP reach simulations. The TMDL is set equal to 69.7%, the mean adjusted potential effective shade value calculated for the week that the MWAT occurred on these reaches in 2002. This calculation is an estimation of the average adjusted potential effective shade on all stream reaches.

4.4.1.2 Load Allocations

In accordance with EPA regulations, the TMDL (i.e., loading capacity) for a water body is to be allocated among the various sources of the targeted pollutant, with a margin of safety. The sum of the load allocations for individual locations in the watershed is equivalent to the loading capacity for the watershed as a whole. Allocations for point sources are known as wasteload allocations. Those for non-point sources are known as load allocations. There are no known point sources of heat into the Salmon River and its tributaries, thus the wasteload allocation for point sources is set at zero. The TMDL for temperature for the Salmon River and its tributaries is distributed among the non-point sources of heat in the watershed, with a margin of safety. In this case, with the natural background non-point sources being sunlight at the various streamside locations in the watershed, and with effective shade being used as a surrogate for solar energy, the establishment of load allocations equates to the identification of the effective shade requirement for any specific streamside location. Site-specific adjusted potential shade is set as the legally required load allocation for the Salmon River temperature TMDL. The loads for this TMDL are the shade provided by topography and natural mature vegetation conditions along the bankfull channel at a site, approximated as adjusted potential shade conditions. Meeting this loading capacity and the associated load allocations is expected to result in meeting the Basin Plan narrative objective for temperature. These site-specific adjusted shade levels are estimated by Table 4.1. Table 4.1 shows the load allocations for reaches representing all stream reaches in the watershed.

4.5 Temperature and Temperature Related Indicators and Numeric Targets

4.5.1 Temperature

Stream temperature is a directly measurable water quality parameter and requires no indicator for interpretation of the water quality standard related to temperature.

4.5.2 Effective Shade

Target: Adjusted Potential Shade Conditions from Riparian Vegetation

The target shade conditions are those that result from achieving the natural mature vegetation conditions along bankfull stream channels in the watershed. This is approximated as adjusted potential shade conditions as described in Section 4.4.1.

Approximations for effective shade targets for the vegetation classes occurring in the watershed are set at 90% of the maximum potential vegetation height for the class. Appendix B of this report provides details about vegetation data. Modeled riparian vegetation widths are assumed to be at least 30m out from each side of the wetted channel.

4.6 Margins of Safety

The Clean Water Act Section 303(d) and the associated regulations at 40 CFR §130.7 require that TMDLs include a margin of safety that takes into account any lack of knowledge concerning the relationship between the pollutant loads and the desired receiving water quality. The margin of safety is often implicitly incorporated into conservative assumptions used in calculating loading capacities, waste load allocations, and load allocations (EPA 1991). The margin of safety may also be incorporated explicitly as a separate component in the TMDL equation. For this analysis, conservative assumptions were made that account for uncertainties in the analysis.

- This report analyzes temperature. Some improvements in stream temperature that may result from reduced sedimentation are not calculated explicitly. The US Forest Service and California Department of Fish and Game have combined funds for a multi-year commitment to reduce sediment loads from controllable sources, on a prioritized basis. Reduced sediment loads could lead to increased frequency and depth of pools, independent of changes in solar radiation input. These changes tend to result in lower stream temperatures overall and in more lower temperature pool habitat. These types of changes are not directly accounted for in the TMDL. Reductions in sediment loads from ongoing efforts that lead to improved pool conditions, or reduced risk of catastrophic failure (e.g., at road crossings) provide a margin of safety for the TMDL.

- The potential shade conditions associated with the loading capacity assume that the occurrence of potential vegetation at a site extends to the bankfull channel width. This does not account for additional channel narrowing that may occur as a result of reduced sediment loads. These effects constitute a margin of safety.

- The effects of changes to streamside riparian areas toward mature trees will tend to create microclimates that will lead to improvements in stream temperatures. These effects were not accounted for in the temperature analysis and provide a margin of safety.

- Changes in streamside vegetation toward larger, mature trees will increase the potential for contributions of large woody debris to the streams. Increases in large woody debris benefit stream temperatures and associated cool water habitat by increasing channel complexity, including the number and depth of pools, and hyporheic flows (USEPA, 2003, p.6. Fris). These changes were not accounted for in the analysis and provide a margin of safety.

4.7 Seasonal Variation and Critical Conditions

With respect to seasonal variations in stream temperatures, the analysis used summertime conditions as constituting a limiting condition for salmonid survival with respect to temperature. Sensitive life stages exist in Salmon River watershed throughout the year, but summer water temperatures represent the most critical conditions with respect to temperature and the most sensitive beneficial uses.

4.8 Public Participation

Regional Water Board staff conducted outreach and public participation efforts beginning in 2002, with a presentation to Salmon River stakeholders on July 24, 2002, and a presentation to the Siskiyou County Board of Supervisors on October 1, 2002 Coordination with stakeholders including the Salmon River Restoration Council and the USFS has continued since then. Both groups have been generous in sharing available data and knowledge about conditions in the watershed. Regional Water Board staff and staff of USEPA Region 9 also have been engaged in informal consultation with the US Fish and Wildlife Service and NOAA Fisheries on endangered species issues in the Klamath River, which have included consideration of tributaries to the Klamath. Similar discussions have occurred with representatives of the tribal governments in the Klamath Basin in California. Outreach and public participation is expected to continue through the MOU/WDR enactment and subsequent monitoring. A Regional Water Board Workshop, Staff Workshop, and Regional Water Board Hearing have been scheduled for purposes of introducing the proposed TMDL, soliciting comments, and pursuing Regional Water Board approval of this TMDL report and Implementation Strategy.

5 IMPLEMENTATION STRATEGY

United States Forest Service controls 98.7% of the Salmon River watershed, and has designated this watershed as high priority for mitigating identified problems under a long range plan and restoration strategy. At least 70% of this watershed has been designated Wilderness or Late Successional Reserve (Figure 5.1). It is expected that actions that the USFS has already identified, and to which the USFS is currently committed will achieve the improvements required for attainment of this TMDL. The Salmon River TMDL for temperature relies on a Memorandum of Understanding (MOU), the terms of which link existing USFS analysis and commitments to TMDL objectives and load allocations, and ultimately to Clean Water Act and Basin Plan compliance. The MOU would be consistent with the Klamath River Basin Restoration Plans and the Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program of the State (SWRCB CALEPA, 2004). The US Forest Service documents introduced in Chapter 1 of this report (Table 5.1) provide the basis, plan, and strategy for this approach.

Table 5.1: Documents Relied Upon for Implementation Strategy

Documents Containing Implementation of Riparian Recovery		
Abbreviation	Title	Date
LRMP	Land and Resource Management Plan Klamath National Forest, 1995 (Including all amendments as of 11/21/01) Siskiyou County, CA and Jackson County, OR “Klamath National Forest Plan Chapter 4, Management Area 10 – Riparian Reserves	1995 Et seq. 11/21/01
SRSRS	Salmon River Sub-basin Restoration Strategy: Steps to Recovery and Conservation of Aquatic Resources Don Elder, Brenda Olson, Alan Olson Klamath National Forest, Yreka, CA, and Jim Villeponteaux, Peter Brucker Salmon River Restoration Council Sawyers Bar, CA Report Prepared for: The Klamath River Basin Fisheries Restoration Task Force Interagency Agreement 14-48-11333-98-h019	June 14, 2002

Riparian Reserve Standards and Guidelines from the LRMP are included here as part of Appendix C (Table C-1). While all of these Standards and Guidelines are important to achieving the Riparian Reserve Desired Future Condition, some will prove to be of particular importance to achieving temperature water quality objectives. These include: Interim Widths for fish-bearing streams (MA10-2 & 3); Watershed Habitat Restoration (MA10-10 & 12); and Fisheries and Wildlife (MA10-13, 18, & 19). For example, MA10-2, Interim Widths for fish-bearing streams, provides for a Riparian Reserve management area including “...the stream and area on each side of the stream extending from the edges of the active channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distances equal to the height of two site-potential trees, or 300’ slope distance, ... whichever is greatest”. This Riparian Reserve management area is a wider area than was used for the SSTEMP model, adding to the Margin of Safety. Refer to Appendix C for details on management area Standards and Guidelines, and specific schedules for implementation within the Salmon River watershed (Table C-5).

Regional Water Board staff will meet with Klamath National Forest staff to draft and execute a Memorandum of Understanding (MOU), affirming the understanding and commitment expressed in the LRMP and SRSRS. Ability of the USFS to meet LRMP and SRSRS goals will be enhanced by ongoing

USFS partnering with other organizations including Native American people, California Department of Fish and Game, U.S. Fish and Wildlife Service, NOAA Fisheries, Siskiyou County, and the Salmon River Restoration Council. The development of the MOU will entail linking an understanding of shade improvement in the Salmon River watershed with USFS policies and programs.

The TMDL, based on the analysis provided, requires a definitive trend of increasing vegetation cover and increasing vegetation height within the defined riparian zone. The MOU will be designed to document a commitment to meet the TMDL target, which is adjusted potential effective shade.

The Regional Water Board will enter into an MOU with the USFS that will identify those elements of existing USFS plans and commitments that will support achieving TMDL loading capacities and would be expected to lead to meeting Basin Plan water quality standards for temperature. All appropriate protections of Riparian Reserves, as detailed in Appendix C of this report, shall be considered appropriate for inclusion in the MOU.

6 MONITORING PLAN

A monitoring plan will be developed as part of the Implementation Plan for this TMDL. Existing monitoring plans (Elder et. al., 2002) cover a wider array of factors than would be practical for inclusion in this temperature TMDL report. Appropriate monitoring, for assurance of improved riparian shade and resultant reduction in solar radiation inputs and instream temperatures will be pursued. The USFS and Salomon River Restoration Council have monitored temperature conditions in the watershed in past years and plan to continue this effort. Additional monitoring would be intended to increase understanding of thermal conditions and thermal refugia in the Salmon River by expanding monitoring locations to include additional stream channel conditions not fully represented in the stream reach segments used for the model analysis presented in Appendix B of this report. This will include areas not supporting vegetation due to extensive historic impacts from mining, designated wilderness areas heavily impacted by fire, and areas thought to display accruing or hyporheic flows.

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8 APPENDICES

Appendix A: Anadromous Salmonids in the Salmon River, California: A Summary From the Literature.

Appendix B: Temperature Analysis

Appendix D: Data

Appendix E: Comments on April 15, 2005 Proposal

Appendix F: Staff Response to Comments on April 15, 2005 Proposal