U.S. Environmental Protection Agency
Region IX

FINAL

Middle Fork Eel River Total Maximum Daily Loads for Temperature and Sediment

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CHAPTER 1: INTRODUCTION

Overview of the TMDL program

The primary purpose of the Total Maximum Daily Load (TMDL) program for California's Eel River is to assure that beneficial uses of water (such as salmonid habitat) are protected from detrimental increases in sediment and temperature. The TMDLs set the maximum levels of pollutants that the waterbody can receive without exceeding water quality standards, an important step in achieving water quality standards for the Middle Fork Eel River and tributaries (including the Black Butte River) in Northern California.

The major water quality problems in the Middle Fork Eel River and tributaries addressed in this report are reflected in the decline of salmon and steelhead populations. While many factors have been implicated in the decline of west coast salmon and steelhead, we are concerned here with two inland water quality considerations - increases to natural sediment and temperature patterns. The Middle Fork Eel (along with many other watersheds in California and throughout the nation) has been put on a list of "impaired" or polluted waters. In this watershed, the listing leads to the TMDL, which determines the "allowable" amount of sediment and temperature for the watershed. Development of measures to implement the TMDL is the responsibility of the State of California.

Background

The Middle Fork Eel River Total Maximum Daily Loads (TMDLs) for sediment and temperature are being established in accordance with Section 303(d) of the Clean Water Act, because the State of California has determined that the water quality standards for the Middle Fork Eel River are not met due to excessive sediment and temperature. In accordance with Section 303(d), the State of California periodically identifies "those waters within its boundaries for which the effluent limitations... are not stringent enough to implement any water quality standard applicable to such waters." In 1992, EPA added the Middle Fork Eel River to California's 303(d) impaired water list due to elevated sedimentation and temperature, as part of listing the entire Eel River basin. The North Coast Regional Water Quality Control Board (Regional Board) has continued to identify the Middle Fork Eel River as impaired in subsequent listing cycles, the latest in 2002.

In accordance with a consent decree (Pacific Coast Federation of Fishermen's Associations, et al. v. Marcus, No. 95-4474 MHP, 11 March 1997), December 2003 is the deadline for establishment of these TMDLs. Because the State of California will not complete adoption of TMDLs for the Middle Fork Eel River by this deadline, EPA is establishing these TMDLs.

The purpose of the Middle Fork Eel River TMDLs is to identify the total amount (or load) of sediment and heat that can be delivered to the Middle Fork Eel River and tributaries without exceeding water quality standards, and then to allocate the total amount among the sources of sediment or heat in the watershed. Although factors other than excessive sediment and heat in the watershed may be affecting salmonid populations (e.g., ocean conditions), these TMDLs focus on sediment and heat, the pollutants for which the Middle Fork Eel River is listed under Section 303(d). EPA expects the Regional Board to develop an implementation strategy that will result in implementing the TMDLs in accordance with the requirements of 40 CFR 130.6. The allocations, when implemented, are expected to result in achieving the applicable water quality standards for sediment and temperature for the Middle Fork Eel River and its tributaries.

These TMDLs apply to the portions of the Middle Fork Eel River watershed governed by California water quality standards. They do not apply to lands under tribal jurisdiction, which include substantial areas around the Round Valley area. This is because tribal lands, as independent jurisdictions, are not subject to the State of California's water quality standards.

1.1 WATERSHED CHARACTERISTICS

The Middle Fork Eel River watershed area is located primarily in northeast Mendocino County with smaller amounts in southern Trinity and Glenn Counties. It is east of Highway 101, approximately 150 miles northeast from San Francisco, and includes the town of Covelo. The Middle Fork Eel watershed, as defined by this TMDL, is 753 square miles in area (approx. 482,000 acres). Local use of watershed names within the Eel River area often is not consistent. This analysis includes all of the major tributaries of the Middle Fork Eel, including the Black Butte River watershed. The Upper Middle Fork Eel has also been called the Wilderness or the Middle Fork; this area is also included in the analysis. It includes the Yolla Bolly-Middle Eel Wilderness, of which about 75,000 acres (about 16% of the basin area) are within the Middle Fork Eel watershed (R. Faust, pers. comm.). Ownership of the basin is approximately 51% federally managed (Mendocino National Forest and Bureau of Land Management), 4% Round Valley Tribe and 45% private. Large ranches, smaller private lands and some industrial timber company lands in the Black Butte watershed form the mosaic of private landownership (See Figure 1).

Several distinct subareas characterize the watershed. The Round Valley area is the main population center, with approximately 2,000 residents in the town of Covelo and the surrounding areas of the Round Valley tribal lands. Relatively hidden and untraveled, this beautiful, open valley is surrounded by mountains. The Round Valley area leads via dirt road into the Mendocino National Forest areas of the Yolla Bolly/Upper Middle Fork Eel Wilderness area, including parts of the Yolla Bolly Wilderness. The Black Butte River is a major tributary and lies within the Mendocino National Forest. The Elk and Thatcher Creek areas are a mix of BLM, Mendocino National Forest and private lands with a more noticeable grass, brush and oak woodlands landscape. The State hydrologic area is 111.70 (Middle Fork Eel), which is composed of Eden Valley HSA, Round Valley HSA (which approximates the USFS Elk Creek, Williams/Thatcher and Round Valley subareas), Black Butte River HSA and Wilderness HSA (which is the same as the USFS Upper Middle Fork area.)

Many previous studies have characterized the Middle Fork Eel, especially for geology and sediment. The California Department of Water Resources extensively studied the basin for possible use as a dam and reservoir site during the 1960s. USFS watershed analyses have been completed for the Upper Middle Fork Eel (USFS 1994) and Black Butte River (USFS 1996) subwatersheds. In addition, the USGS studied sedimentation of the Eel during and after the 1964 flood.

The area’s geology is underlain by the Franciscan terrane that dominates most of California’s North Coast. Naturally unstable, this type of geology is sensitive to human disturbance. The Middle Fork Eel watershed is relatively dry and warm, away from the influence of coastal fog. The mean maximum temperature in July in Covelo is in the mid 90's. Almost all of the estimated 40 inches of annual rainfall, with significantly more rainfall at the higher elevations, occurs between November and April. Many smaller tributaries dry up in late summer. In the winter, there is often snow at the higher elevations.

Land use activities in the Middle Fork Eel include grazing and other agriculture, timber harvest, recreation and residences. Many reports have noted severe overgrazing in the past, particularly during the late 1800's and early 1900's, which led to permanent soil loss and vegetation changes (DWR, 1982; Supernowicz, 1995.) The grazing pressure at present is fairly light. The Round Valley area has been used for agriculture and grazing, although intensive, high-value row crops are also a relatively small proportion of the landscape. Small-scale logging began around 1862 near Covelo, continuing until after World War II, when private lands were extensively cut and burned. The harvest of public lands of Mendocino National Forest began in 1958. It is estimated that 46 percent of the timbered land in the basin (23 percent of the overall land) was logged by either clear cut or partial cut from 1950 - 1981 (DWR, 1982).

Changes in vegetation due to fire management are noted in many documents on the Middle Fork Eel (USDA, 1996 WA, Supernowicz, DWR, 1982.) Before the 1850s, Native Americans used fire to keep the landscape open. Early ranchers used fire for similar purposes. In addition, large natural catastrophic fires in 1865 and 1910 following several years of drought resulted in total replacement of timber stands.

1.2. ENDANGERED SPECIES ACT CONSULTATION

EPA has initiated informal consultation with the National Marine Fisheries and the U.S. Fish and Wildlife Services on this action, under Section 7(a)(2) of the Endangered Species Act. Section 7(a)(2) states that each federal agency shall ensure that its actions are not likely to jeopardize the continued existence of any federally-listed endangered or threatened species.

EPA’s consultation with the Services has not yet been completed. EPA believes it is unlikely that the Services will conclude that the TMDLs that EPA is establishing violate Section (7)(a)(2) since the TMDLs and allocations are calculated in order to meet water quality standards, and water quality standards are expressly designed to “protect the public health or welfare, enhance the quality of water and serve the purposes” of the Clean Water Act, which are “to restore and maintain the physical, chemical, and biological integrity of the Nation’s water.” Additionally, this action will improve existing conditions. However, EPA retains the discretion to revise this action if the consultation identifies deficiencies in the TMDLs or allocations.

1.3 ORGANIZATION

This report is divided into 6 chapters. Chapter 2 (Problem Statement) describes the nature of the environmental problems addressed by the TMDLs. Chapter 3 (Temperature TMDL) describes results of a model used to evaluate temperature conditions in the watershed, identifies targets for stream temperatures, identifies the total load of heat that can be delivered to the Middle Fork Eel River and tributaries without exceeding water quality standards, and describes how EPA is apportioning the total load of heat. Chapter 4 (Sediment TMDL) identifies stream and watershed characteristics to be used to evaluate whether the Middle Fork Eel River is attaining water quality standards for sediment, describes what is currently understood about the sources of sediment in the watershed, identifies the total load of sediment that can be delivered to the Middle Fork Eel and its tributaries without exceeding water quality standards, and describes how EPA is apportioning the total load among the sediment sources. Chapter 5 (Implementation and Monitoring Recommendations) contains recommendations to the State regarding implementation and monitoring of the TMDLs. Chapter 6 (Public Participation) describes public participation in the development of the TMDLs.

CHAPTER 2: PROBLEM STATEMENT

This chapter summarizes what is known about how temperature and sediment are affecting the beneficial uses associated with the decline of the cold water salmonid fishery in the Middle Fork Eel River and tributaries. It includes a description of the water quality standards and salmonid habitat requirements related to temperature and sediment.

2.1. FISH POPULATION PROBLEMS

Historically, the Middle Fork Eel had populations of fall-run steelhead, which enter the watershed shortly before spawning in the fall, and spring chinook and summer steelhead, which enter the watershed in the spring and summer, waiting until fall to spawn. Prior to 1955, the mainstem Middle Fork Eel provided summer habitat for spring chinook and summer steelhead, but following the 1955 and 1964 floods the spring chinook were extirpated, and summer steelhead habitat has been confined to the uppermost reaches of the mainstem and tributaries (B. McFadin, pers comm., Oct. 2003, and R. Gill, memo to J. Parish *(sic)*, Oct. 9, 2003, citing Jones 2000, CDFG 1965, and Harris 1992). Population trends have been documented only for summer steelhead; population information is limited for fall-run steelhead and chinook. The available sources of information provide a picture of the decline of summer steelhead populations. Anecdotal information for chinook populations also indicates a decline. Fall steelhead distribution appears to have been stable for the last few decades, but extensive population estimates over time are not available. Below is a summary of the available information by species and subbasin.

Many different habitat conditions are crucial for the survival of salmon and steelhead. Salmonid populations are affected by a number of factors, including commercial and sport harvest, adequate food, adequate cover and ocean conditions. These TMDLs focus only on the achievement of water quality standards related to sediment and temperature which will facilitate, but not guarantee, population recovery.

Spring chinook - entire basin

Spring chinook salmon (also known as king salmon) spawned historically in the lower Middle Fork Eel and at least as far upstream as the confluence of the Black Butte River. Stream surveys indicated that historically, lower reaches of Mill, Short, Williams and Elk Creeks were important chinook spawning tributaries (DWR, 1966). In 1972-1973, angler surveys in the Dos Rios area reported 21 king salmon caught (CDFG, 1972). Professional fisheries staff estimated that in 1998, the chinook population possibly numbered 40 adults in Elk Creek, 20 in Thatcher Creek, 40 in Mill Creek, and 20 in Williams Creek. This is down from anecdotal reports of thousands in the first half of the century. The same pattern is thought to have occurred in the Black Butte and Wilderness/Upper Middle Fork watersheds: only small populations (about 100 adults) were thought to exist in 1998, whereas thousands were thought to have existed historically (NMFS, 2003). As late as 1963, the California Department of Fish and Game estimated approximately 13,000 chinook spawned each year in the Middle Fork Eel River watershed (CDFG, 1965).

The Round Valley Tribe may have more historical and current information on chinook populations; however, the data were not available to EPA for these TMDLs. The streams around Round Valley may have had 5,000 chinook migrants in the early 1960s (USFS, 1994). However, chinook are rarely found in the area today.

Summer Steelhead -Upper Middle Fork/Wilderness

The Wilderness/Upper Middle Fork Eel subarea contains one of the only populations of summer steelhead in California's coast range. Population trend information has been collected by California Department of Fish and Game from 1966 to the present (Figure 2). A recent draft statistical analysis of the data from 1966-2002 (NMFS, 2003) found that the population trend is downward in both the long and the short term. This downward trend does not include the possibly far greater numbers of adult summer steelhead that existed before the 1964 flood, which were thought to exceed 3,500 adults (CDFG, 1980). DFG has also estimated that juvenile standing crops at two sites in the summer steelhead area in the upper (Fern Point) and lower (Osborne) areas from 1980-present are low compared to the recent past.

Electroshocking of juvenile steelhead populations in the North Fork of the Middle Fork and its tributaries of Rock, Morrison and Willow Creeks conducted by Brown (1976) estimated that biomass averaged 21 g/m^3 on Rock Creek to 12.3 g/m^3 on the North Fork of the Middle Fork. In 1986-88, Brown & Moyle (1988) concluded that trout were abundant in the upper part of the drainage; but in the lower portion of the drainage, trout were only present in cool tributary streams, in areas below the confluence of a cool tributary, or in well-shaded streams. This type of break in salmonid abundance occurred below Osborne Roughs on the Middle Fork Eel River.

Fall Steelhead - Black Butte

During the early 1960's, DWR observed that "steelhead spawn in virtually all of the tributaries of the Middle Fork upstream to at least Haynes Delight which was the upstream limit of the stream surveys (DWR, 1966)." In 1986-88, steelhead were abundant in cool, well-shaded sites in the upper reaches. Downstream sites were progressively more open and water temperatures higher. Near Baldy Creek, steelhead began utilizing cool tributary water and shady areas. Trout became more restricted to such areas and declined in abundance at sites that were further downstream (Brown & Moyle, 1988.) The California Department of Fish and Game estimated approximately 23,000 steelhead spawned each year in the Middle Fork Eel River watershed in 1963, but they did not distinguish between the summer and fall runs (CDFG, 1965).

2.2. STREAM TEMPERATURE PROBLEMS

This section presents the available information on stream temperature problems for salmonids in the Middle Fork Eel and tributaries. Stream temperature directly governs almost every aspect of the survival of Pacific Salmon (Berman, 1998). Temperature is such an important requirement that coho, steelhead, chinook and rainbow trout are known as "cold water fish." Metabolism, food requirements, growth rates, timing of adult migration upstream, timing of juvenile migration downstream, sensitivity to disease and direct lethal effects are affected by stream temperatures (Spence et al, 1996.)

Stream temperatures are generally marginal to inadequate for summer rearing salmonids in the Middle Fork Eel River and tributaries, although a few tributaries have adequate conditions. Much of the length of the exposed main channels are close to lethal during the hottest part of the summer. The most sensitive period is summer, when young salmonids are growing before migrating to the ocean and stream temperatures are hottest. Thus, this is the period analyzed in the temperature TMDL. The criteria evaluated in the TMDL is the MWAT, or Maximum Weekly Average Temperature, unless otherwise indicated.

MWAT is calculated here as the maximum value of the 7-day running average of all recorded temperatures (monitors often make hourly measurements). This widely used temperature parameter helps to summarize the general trend of stream temperatures, which fluctuate daily and seasonally. The term MWAT is not always used consistently. For example, the State of Oregon defines MWAT as the maximum week of the daily maximum. In addition, the term MWAT is occasionally used to denote a threshold of concern.

EPA evaluated the condition of stream temperatures based on extensive scientific literature on salmonids and stream temperatures. Stream temperature data were collected by EPA and others from field measurements for modeled tributaries. The literature on which this evaluation is based has tested salmonid response in both the laboratory and the field. (For a thorough review of the scientific literature please see information from scientific panels in the States of Oregon and Washington in ODEQ, 1995; WDOE, 2000; EPA Region 10, 2001a&b; Sullivan et al., 2000.)

This TMDL uses five temperature ranges based on steelhead temperature tolerances derived from the literature to categorize the quality of summer stream habitat in regard to temperature (see Table 1). This TMDL focuses on steelhead temperature tolerances because chinook are not present in the summer and coho are not found in the watershed. Human activities in the watershed, such as harvesting trees in riparian areas, are likely factors contributing to the high temperatures in the stream. Temperatures that are consistently too hot for salmonids may have contributed, along with other factors, to population declines. The MWAT is used to determine the hottest period of the year. These temperature ranges are not perfectly precise in the stream, because salmonids are affected by several factors, including fluctuations in temperature, mean temperatures, food supplies and access to cool water areas (refugia). In addition, steelhead may likely respond gradually to sublethal temperatures with effects such as reduced growth; they are not likely to have clear thresholds in the natural environment.

Table 1
Summer Stream Temperatures (in MWAT) to Evaluate Steelhead Rearing Conditions

GOOD CONDITIONS	<15° C (59° F)
ADEQUATE	15-16.99° C (59-63° F)
MARGINAL	17-18.99° C (63-66° F)
INADEQUATE	19-23.99° C (63-75° F)
LETHAL	≥ 24° C (75° F)

Current stream temperatures

Measurements of summer stream temperature conditions for steelhead are available for approximately 40 locations throughout the Middle Fork Eel, particularly in 1996 - 1998 and 2002 from the CDFG and USEPA. Figure 3 shows the results of the monitoring. Many locations in the Middle Fork Eel basin are known to have variable temperature conditions for summering juveniles. Most of the larger stream channels that were monitored had inadequate conditions, while a few have lethal conditions. By contrast, the upper areas of many tributaries provide adequate (15-17° C) to marginal (17-19° C) conditions. There were a few locations that provide good conditions. This indicates that current conditions for salmonids are less than ideal, but the basin is not among the worst for temperature conditions in the North Coast. Salmonids could certainly benefit from refugia such as large pools in the main channels, and adequate access to tributaries to use as refugia during the hottest months.

Historical Trends

Evaluating historical trends can give us a better idea of how much human activities may have influenced high summer temperatures, or whether high temperatures are also to be expected under natural conditions in the stream. Long-term trends in stream temperatures can only be evaluated for the main channels of the Middle Fork Eel**;** historic temperatures are not known for tributaries. However, even the data available for the main channels are limited. Only a general picture of stream temperatures over time can be presented here; marginal changes cannot be examined due to differences in yearly weather patterns, placement of monitors, and data reporting. Two major historical records exist in the Middle Fork Eel: the 1959 stream temperature information described by Smith & Elwell and the 1973 stream temperatures by Kubicek (1977). In general, the current temperature patterns in the basin (1996-1998 and 2002) are similar to historical patterns (1961 and 1973); that is, adequate in the summer only in the uppermost headwaters, some tributaries, and the mainstem area upstream of Osborn Station. Lethal conditions were found currently and historically in lower Black Butte River and the entire Middle Fork Eel downstream of Buck Creek. In addition, most tributaries in the Round Valley and Elk/Thatcher areas are dry except in their uppermost portions. Since some lethal temperatures in the larger main channels were also found historically when fish populations appeared stable, EPA concludes that lethal conditions on most of the mainstem did not significantly affect salmonid populations; however, it is possible that tributaries, as well as shaded pools along the mainstem, provided adequate refugia in the summer. However, even the historic data that are available are not extensive. Details of the historical and current stream temperature monitoring follow.

The area of the Middle Fork River 0.5 miles upstream of the Black Butte River had maximum temperatures that were lethal (28° C) during 1958 and 1959; similar maximum temperatures existed in 1973 (Kubicek, 1977) and 1996 as well. The MWAT was 25° C. This area appears to have been consistently too hot for salmonids during the summer, both historically and currently.

One stream temperature measurement taken at 2:30 p.m. during the summer of 1973 in lower Black Butte was lethal (27° C). Similar daily maximum temperatures during 2002 were noted: the daily maximum temperature was above 26° C for the entire month of July, and was occasionally above 28° C (although the 2:30 PM temperature was often less than the daily maximum). The diurnal swing in temperatures in July was approximately 4-5° C. The MWAT at this site was 25° C during 2002. Jumpoff Creek in 1973 was measured at 17° C, and in 2002 in Jumpoff Creek upstream of this location, maximum temperature was rarely above 17° C. This location was interesting in that the diurnal swing was only 2° C, and the MWAT was 16° C (adequate for steelhead). Jumpoff Creek was noted in 1973 to have abundant juveniles up to 10 inches in length.

The area of the main channel of the Middle Fork Eel below Black Butte River historically had lethal summer temperatures; researchers noted that "until the end of June, salmonids were observed throughout the lower portion of the stream (Middle Fork Eel), and nongame fish appeared to be absent. As stream temperatures rose to lethal levels in July, salmonids disappeared. As temperatures decreased in September, salmonids were found to be distributed again throughout the lower portion of the Middle Fork, and nongame fish again became scarce" (Smith & Elwel as cited in Kubicek, 1977). These lethal historical conditions are consistent with more recently monitored temperatures; in 1996, the Middle Fork Eel above Thatcher had an MWAT of 26-27° C.

Thus, temperatures in the exposed main channels appear to have been fairly stable and generally lethal over time in the hottest summer months. This is not necessarily true of smaller channels, where shade is a more important variable. The smaller channels probably provided cooler conditions for the fish to escape to during the warmest periods. It is likely that because the mainstem channels were always almost completely exposed, shade was a less important factor in these channels than in tributaries. Riparian vegetation can have a greater effect on smaller channels than on mainstem channels; however, we have little historical information on the temperatures in these types of channels. The main channels were also noted historically to have areas of cooler water known as refugia (from pools, groundwater seeps and intergravel flow) that provided habitat. These areas may have helped to preserve natural groundwater temperatures. We do not have information about the temperatures or characteristics of such pools. Although we do not have historical data for the tributaries, we consider it likely that, over time and with increased human disturbance to the riparian zone, the tributary areas have been subject to increased temperatures, which likely contributed to salmonid population declines. (See discussion of temperature modeling in Section 3.2 below.)

Refugia

Pools can provide important thermal refugia for salmonids. Stratified pools can provide a much-needed refuge in hot periods of the day and during the hottest times of the year. Nielsen & Lisle (1994) noted that cold pockets "were consistently about 3.5° C cooler than surface water and as great as 7.8° C cooler" in the Middle Fork Eel.

The Department of Fish and Game's temperature monitoring also illustrates the importance of pools as temperature refugia. For example, the pool in the Middle Fork Eel at Rattlesnake Creek was generally between 4-8° C cooler than the riffle at the same location. In addition, the pool was rarely above 19° C, whereas the riffle was almost always above 19° C, which is in the inadequate range. A similar but much less pronounced pattern was found at Fern Point pool and riffle. There was a much smaller difference between the pool and riffle at Osborne roughs.

In addition, there appear to be several groundwater-dominated tributaries where stream temperatures are consistently low. Monitoring locations in Shield Creek (MWAT of 14° C) and both Jumpoff and Smokehouse Creeks (MWAT 16° C) appear to provide cool conditions, possibly because of the existence of springs in the area.

These cooler-water areas probably contributed historically, and may contribute even more significantly today, since temperatures appear to be warmer, to conditions that support salmonids despite lethal temperatures in the mainstem reaches.

USFS Watershed Analyses

USFS Watershed Analyses for the Middle Fork Eel River (USFS 1994) and Black Butte River (USFS 1996) subwatersheds conclude that human activities contributed to conditions that resulted in increased erosion and sedimentation, direct removal of riparian vegetation, and secondary impacts resulting from bank erosion and decreased vegetation in the watershed. This began with sheep and cattle grazing in the late 19th and early 20th centuries causing significant damage, with limited recovery many decades later, even following the cessation of sheep grazing and reduced intensity of cattle grazing. Past timber harvest practices that would not meet current standards were also used on intermittent and perennial streams. This resulted in direct and indirect increases in stream temperatures. The primary cause of today's higher sedimentation rates and stream temperatures appears to be the 1964 flood; although the rainfall associated with that event was natural, the effects resulting from it were exacerbated by management activities in the basin. Furthermore, some of the problems continue today, including unauthorized cattle grazing and roads contributing to sedimentation. Thus, the Regional Board has determined that elevated stream temperatures in the Middle Fork Eel River basin are the result of both natural and anthropogenic factors. (R. Gill, letter to J. Parrish, Nov. 10, 2003).

2.3. SEDIMENT PROBLEMS

Salmon requirements related to stream sediment

This section presents available information related to sediment problems in streams in the Middle Fork Eel and tributaries. Salmonids have a variety of requirements related to sediment. Salmonids have different water quality and habitat requirements at different life stages (spawning, egg development, juveniles, adults). Sediment of appropriate quality and quantity is needed for redd (i.e., salmon nest) construction, spawning, and embryo development. Excessive amounts of sediment or changes in size distribution (e.g., increased fine sediment) can adversely affect salmonid development and habitat.

Excessive fine sediment can reduce egg and embryo survival and juvenile salmonid development. Tappel and Bjornn (1983) found that embryo survival decreases as the amount of fine sediment increases. Excess fine sediment can prevent adequate water flow through salmon redds, which is critical for maintaining adequate oxygen levels and removing metabolic wastes. Deposits of these finer sediments can also prevent the hatching fry from emerging from the redd, resulting in smothering. Excess fine sediment can cause gravels in the water body to become embedded (i.e., the fine sediment surrounds and packs in against the gravels), which effectively cements them into the channel bottom. Embeddedness can also prevent the spawning salmon from building redds.

An imbalance between fine or coarse sediment supply and transport can also adversely affect the quality and availability of salmonid habitat by changing the morphology of the stream. It can reduce overall stream depth and the availability of shelter, and it can reduce the frequency, volume, and depth of pools. Pools provide salmon a resting location and protection from predators. In the Middle Fork Eel, pools are often the only place juvenile steelhead are found in the summer, as steelhead leave areas with high temperatures.

Excessive sediment can affect other factors important to salmonids. Stream temperatures can increase as a result of stream widening and pool filling. The abundance of invertebrates, a primary food source for juvenile salmonids, can be reduced by excessive fine sediment. Large woody debris, which provides shelter and supports food sources, can be buried. Increased sediment delivery can also result in elevated turbidity, which is highly correlated with increased suspended sediment concentrations. Increases in turbidity or suspended sediment can impair growth by reducing availability or visibility of food sources, and the suspended sediment can cause direct damage to the fish by clogging gills.

Sediment conditions in the Middle Fork Eel

Historical trends

Local residents and fisheries investigations report large changes to stream channels, particularly after the 1964 flood. Human activities in the watershed may have increased the severity of that flood on sediment conditions in the streams. USFS Watershed Analyses for the Middle Fork Eel River (USFS 1994) and Black Butte River (USFS 1996) subwatersheds conclude that human activities did contribute to conditions that resulted in increased erosion and sedimentation, direct removal of riparian vegetation, and secondary impacts resulting from bank erosion and decreased vegetation in the watershed. The primary cause of today's higher sedimentation rates appears to be the 1964 flood, which was a natural event with effects that were exacerbated by management activities in the basin. CDFG personnel (Jones, 1992) reported that after the 1964 flood, the area used by summer steelhead – the Upper Middle Fork/Wilderness area – was filled with rock, gravel, and sand to a depth of 3-12 meters (10-40 feet). Pools previously used for summer holding areas (for summer steelhead) were almost entirely obliterated. Information on fine sediment conditions was not available.

Current conditions & evaluation of stream recovery

EPA reviewed information documenting the recovery of the channel after the 1964 flood. The findings are summarized below.

Upper Middle Fork/Wilderness

Recovery of the channel in the summer steelhead area (the Upper Middle Fork Eel) was noted by Mendocino National Forest staff as early as the mid-1970's in photos of the area. These professional assessments did not include measurements. In addition, Mendocino National Forest did a cursory review of the historic (1961) and current (1993) photos, noting that the Middle Fork near Buck Creek appears to look nearly the same in 1993 as in 1961. Department of Fish and Game personnel (as cited in DWR, 1982), noted that after the 1964 flood, the area from the Eel River Work Station to the Balm of Gilead had filled with sediment "so deep and evenly deposited that it was possible to drive a truck up most of the stream channel... By 1972, the channel had scoured through most of these deposits, and the river flowed at pre-flood channel elevations. Some of the flood deposits remain as terraces" (DWR, 1982).

A general picture of sediment substrate conditions by Mendocino National Forest staff during stream surveys also shows a channel that has a low percentage of the stream length with fine sediment deposits, based on visual observations. In the area stretching from the Upper Middle Fork down to the confluence with the North Fork, 10% of the stream length had sand or fine sediment deposits; the rest of the length was in bedrock, boulder or cobble bottom. The area downstream to the confluence had about 15% in sand and fines. While this assessment is limited in value since it is based on visual observations, it does suggest that fine sediment deposition in the stream does not appear to dominate the stream system. In addition, while a visual evaluation cannot eliminate fine sediment as a problem for egg and embryo survival, it may be reasonable to assume that fine sediment is not a problem in pool filling or channel morphology changes; thus, it is unlikely to be compounding the temperature problems in the basin. Portions of this area are managed as wilderness, meaning that there would be no activities that contribute to sediment production at a rate higher than would exist under natural conditions. Much of this area appears to have recovered from the adverse effects of the 1964 flood.

Black Butte River

The Black Butte River was greatly affected by the 1964 flood as well. The 1964 flood caused the Black Butte River to become braided downstream of Butte Creek. At the gaging station, one-half mile above the mouth, the channel aggraded 8 feet. A measurement in 1975 showed that 6 feet of this sediment had been washed out (Lisle, 1981). A follow-up measurement in 1986 found that 4.5 feet of new sediment had been deposited at the gaging station since 1974. The 1986 sediment level is 6.5 feet above the 1963 level (Nolan et al., in USDA Forest Service, 1996). A more recent look at aerial photos shows that the recovery from the 1964 flood is still not complete; the Black Butte Creek near Nebo Creek shows wider gravel bars, more meandering due to less channel gradient, and less riparian vegetation in 1993 than 1961.

The Department of Fish and Game conducted extensive surveys of the streams in the Middle Fork Eel and tributaries during the summer of 2002. Most of these results are not yet available.

The USFS, as part of its Aquatic and Riparian Effectiveness Monitoring Program, sampled 6 randomly selected stream reaches in the Black Butte watershed using stream substrate bulk core samplers. The resulting D50 and percent fines data show variable results: two sites with good conditions, one site with poor conditions and three sites in the middle range. This type of random selection monitoring is designed to portray overall conditions. Given that some areas of Black Butte River appear to remain degraded from 1964 flood conditions, it is reasonable to assume that sediment continues to adversely affect beneficial uses in this subwatershed; it is also possible that sediment has filled some of the pools that could provide refugia in the summer.

In summary, data regarding historical or current conditions for many streams in the Middle Fork Eel are not readily available. The information that does exist indicates that the Upper Middle Fork Eel has recovered somewhat from the drastic effects of the 1964 flood. The response reaches of the Black Butte do not appear to have recovered fully. Conditions in most other areas are unknown, although CDFG stream inventory reports that will be available in the future may provide information on current conditions. However, it is likely that the widespread sedimentation and channel changes that occurred following the 1964 flood provided difficult conditions for salmonid survival (e.g., higher proportions of fine sediment, filling of pools, etc.). It is also possible that other areas of the watershed have sufficiently recovered, particularly considering that in some parts of the watershed, little management activity is taking place and anecdotal information suggests that water quality conditions relative to sediment are probably good.

2.4. WATER QUALITY STANDARDS

In accordance with the Clean Water Act, TMDLs are set at levels necessary to achieve the applicable water quality standards. Under the federal Clean Water Act, water quality standards consist of designated uses, water quality criteria to protect the uses, and an antidegradation policy. The State of California uses slightly different language (i.e., beneficial uses, water quality objectives, and a non-degradation policy). This section describes the State water quality standards applicable to the Middle Fork Eel River TMDL using the State's terminology. The remainder of this document simply refers to water quality standards.

The beneficial uses and water quality objectives for the Middle Fork Eel River are contained in the Water Quality Control Plan for the North Coast Region (Basin Plan), as amended (NCRWQCB 2001). The Basin Plan identifies many beneficial uses for the Middle Fork Eel River, specifically: Municipal and Domestic Supply; Agricultural Supply; Industrial Process Supply; Groundwater Recharge; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Cold Freshwater Habitat; Rare, Threatened or Endangered Species; Migration of Aquatic Organisms; and Spawning, Reproduction and/or Early Development.

The water quality objectives pertinent to the Middle Fork Eel River temperature and sediment TMDLs are listed in Table 2.

Table 2. Water Quality Objectives

Parameter	**Water Quality Objectives**
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
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 an alteration in temperature does not adversely affect beneficial uses.
	At no time or place shall the temperature of any COLD (water with a beneficial use of cold freshwater habitat) water be increased by more than 5 ˚F above natural receiving water temperature .
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.

In addition to water quality objectives, the Basin Plan includes two prohibitions specifically applicable to logging, construction, and other associated sediment producing 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.

CHAPTER 3: TEMPERATURE TMDL

Summary

The analysis conducted for the TMDL (see Appendix A) concludes that shade is important for the protection of summer stream temperatures in the Middle Fork Eel basin, particularly in the tributaries. Water quality standards for temperature require that there be no alteration to natural temperatures. Therefore, EPA concludes that meeting the water quality standard of not altering natural stream temperatures requires that there be no human-caused changes to "natural" shade. EPA's analysis, which is summarized in this section and described in more detail in Appendix A, determined the conditions required to meet water quality standards by modeling two representative tributary watersheds. It found that changes in the sizes of conifers (and thus shade) affect the stream temperatures and thus quality of fish habitat, and are important to assuring that salmonids (the most sensitive beneficial use in the basin) are not adversely affected by changes in natural stream temperatures in the Middle Fork Eel and tributaries.

This chapter presents information pertinent to the temperature TMDL for the Middle Fork Eel in several sections. Section 3.1 provides EPA's interpretation of the water quality standards for the temperature TMDL. Section 3.2 describes the modeling that was conducted to examine the role streamside vegetation plays in stream temperature changes. Section 3.3 describes water quality targets. Section 3.4 presents the TMDL and allocations.

3.1. INTERPRETING THE EXISTING WATER QUALITY STANDARDS FOR TEMPERATURE

This temperature TMDL is set to attain the applicable water quality standards. The Basin Plan identifies the following two temperature objectives for surface water:

> "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 an alteration in temperature does not adversely affect beneficial uses."

> "At no time or place shall the temperature of any COLD <i.e. water with a beneficial use of cold freshwater habitat> water be increased by more than 5 degree F above natural receiving water temperature."

EPA interpreted the above standards for the TMDL as follows. In considering the first objective, EPA examined whether alterations from natural temperature conditions would adversely affect the most sensitive beneficial use - that is, cold water fish during the summer rearing period.

EPA modeled natural stream temperatures (based on assumptions regarding the sizes of conifers if they were allowed to grow fully), current stream temperatures (based on existing vegetation mapping and assumptions of size distributions of trees), and stream temperatures under two different management scenarios (based on assumptions of sizes under Forest Practice Rules), then compared the distribution of habitat available under these different conditions. The temperature conditions for salmon (by stream miles) varied from adequate to marginal to inadequate (see Table 1 for an explanation of temperature ranges). In this way, EPA interpreted whether changes to shade conditions, and thus changes to water temperature, have the potential to adversely affect beneficial uses as specified in the State's water quality standard.

EPA's conclusion, as described further in the next section, is that decreased shade, and associated increases in water temperature, would adversely affect the cold water fishery beneficial use. Thus, EPA concluded that the TMDL should be set at the level necessary to attain natural temperature conditions. Attaining the water quality standard for temperature would require attainment of natural temperature conditions, particularly considering that summer temperatures in most locations in the Middle Fork Eel basin are far from ideal for salmonids, even, apparently, under natural conditions. Accordingly, achieving the water quality standard, as interpreted in this TMDL, requires that there be no alterations to natural stream temperatures. Because meeting this first objective will also result in meeting the second objective (i.e., not increasing the stream temperature more than 5 degrees F), this TMDL is designed to meet the first objective.

Examining the Role of Shade on Summer Stream Temperatures

Factors that could affect stream temperature include solar radiation, shading, weather conditions, air temperature, stream flow and depth, spring inflow, snowmelt, etc. Although stream temperatures could be affected by any of these factors, shade is the factor in the Middle Fork Eel basin that is most likely to be altered by human activities from natural conditions; thus, the TMDL focuses on shade. The Middle Fork Eel does not have discharges of cooling water from industries, large water diversions, agricultural return flows nor dams. Only smaller diversions are present and, given the low population density, these are assumed to be insignificant.

Alterations to shade in the Middle Fork Eel basin occur primarily through changes in streamside vegetation (i.e., riparian vegetation) or through stream widening. The modeling done in support of TMDL development examines the effects of changes in the size of riparian vegetation, especially conifers. The model uses existing stream widths, because information from photos shows that, except for areas of lower Black Butte, many streams areas have returned to pre-1964 conditions. In other cases, no information was available.

3.2. TEMPERATURE AND SHADE MODELING

Investigating the Influences of Shade with QUAL2E/Shade Model

EPA funded Tetra Tech to model the influences of shade in the Middle Fork Eel basin. Appendix A is a more detailed and technical discussion of the model and data used. Stream temperature modeling is a well-developed area of inquiry and has been used throughout the Pacific Northwest. QUAL2E, which has been peer reviewed and is publicly available, was refined with a shade element to investigate shade influences on stream temperatures in the Middle Fork Eel.

Two tributaries were modeled–the North Fork of the Middle Fork and the Uppermost Black Butte/Jumpoff Creek areas–to determine whether changes in shade are affecting stream temperatures and whether the extent of these changes adversely affects beneficial uses. Data were sufficient to model these areas completely. These two subareas are representative of most of the streams that do not dry out in the summer in the watershed, in terms of vegetation distribution, land use and ownership, so they can serve as a surrogate for tributaries throughout the entire watershed. Mainstem reaches were not specifically modeled, and they require a different analysis, as is discussed below in Section 3.3.

Inputs to the model include watershed location (e.g., latitude and longitude), global solar radiation (essentially, the radiation above the treetops and topography for the duration of the simulation, which is the source of heat), stream coordinates of all sampling points, wetted stream width, average depth, topographic shading characteristics (angles from 12 standard azimuth directions), and vegetation shading characteristics (distance from edge of stream to riparian buffer, average absolute height of vegetation canopy, average height of the vegetation canopy with respect to the stream surface, and average canopy density).

Modeling Heat and Translating Heat to Shade

The model uses heat (the pollutant addressed in the TMDL) expressed in langleys/day (ly/day), and translates the heat load to temperature and shade, which are measurements that can be made directly by land managers. Heat is determined by estimating global solar radiation and estimating reductions to global solar radiation from factors such as topography and vegetation shading characteristics. This reduction of heat from global solar radiation to heat at the stream surface can be expressed approximately as a percentage shade over the stream: With no shade, heat would equal global solar radiation. With 50% shade, half of the global solar radiation would reach the stream. Heat that thus reaches the stream is translated to temperature using factors such as width and depth of the stream and temperature of incoming water. The model routes the temperatures through the stream network, to account for cumulative effects of upstream temperatures.

Five scenarios were modeled to determine the changes to stream temperatures and beneficial uses of summer rearing habitat quality. The only factor that was varied was vegetation size, the size of conifers being the most influential factor. Size of vegetation in the dataset is given a diameter at breast height (dbh), as the model uses height (computed from dbh) to calculate shade characteristics over the stream surface. Appendix A describes the equations used to convert dbh to height. The existing vegetation dataset was recently completed by the USFS and has not yet undergone a planned review. However, this data was more recently developed than the CALVEG dataset and USFS determined that it is more accurate. The scenarios that were modeled are as follows:

1 - Current condition. This scenario uses the current size of vegetation as provided by the USFS data. For USFS lands, the current condition in these streams is the result of a decade under the Northwest Forest Plan (NWFP), which has "no cut" buffers surrounding the streams.

2 - No trees- topographical shading only. This scenario was chosen to illustrate the importance that shade has in this watershed; it is not meant to reflect current or future conditions. In this scenario, the only shade over the stream is from unvegetated topography such as adjacent hillslopes. All existing trees were eliminated from the model for the purposes of this scenario.

3 - 18 inch dbh conifer-maximum likely private timber management. Silvicultural management styles vary amongst different ownerships. There is a wide variety of harvesting cycles and techniques in the Mendocino County area, even within the Eel area (Hope, Feiler, personal communications). Management practices under the State's Forest Practice rules result in a variety of sizes of trees left in the riparian zone after harvesting, so it is difficult to generalize with any precision about the projected future condition based on the State's Forest Practice rules. Theoretically, an owner can harvest all trees as small as 12 inch dbh under the Forest Practice Rules, but generally it is not economical to do so. This scenario represents the likely maximum harvest in the subbasin if all lands were under private timber management (Feiler, Hope, personal communications). Thus, EPA looked at this case to represent the likely most extreme results if timber harvest were privately managed.

4 - 24 inch dbh conifer-alternative timber management. Given the variety of private timberland management styles, EPA also modeled a stand of 24 inch dbh conifers as another possible representation of future conditions under basinwide private timber management.

5 - 48 inch dbh conifer - natural full growth conditions. While it is difficult to generalize on the natural size of conifers, given the range of site conditions, elevation and species, 48 inch dbh conifers adequately represent "natural" growth for the purposes of determining shade. EPA reviewed available information from the USFS files and personnel, which suggests that a 48 inch dbh reasonably represents old growth.

In the model, cumulative effects are taken into account by routing stream temperatures downstream through the system, accounting for local conditions (upstream temperature, shade conditions, topographical conditions, solar radiation) along the way. Table 3 displays the number of stream miles in each of the temperature categories, the shade-adjusted solar radiation, and the % shade for each of the scenarios for the two subbasins. (% shade is calculated as a proportion of the solar radiation that is blocked from global solar radiation.) Figures 4 and 5 show the number of stream miles in each category visually for the two subbasins. Appendix C includes maps with these results shown along the stream networks.

The modeling results indicate that current conditions in the tributaries are primarily either adequate (15-17° C) or marginal(17-19° C); neither good conditions (<15° C) nor lethal conditions (≥24° C) were found in the modeling results (which is also supported by limited observation data). The effects of cooler springs on local conditions would not have been shown in modeling results. The monitoring data did show that a few streams, which were thought to have abundant springs, had good conditions. These streams were not in the watersheds modeled. Current conditions do appear to have increased stream temperatures over natural conditions. On average, the model indicates that current conditions have degraded slightly from natural conditions, with an increase of about 3 miles of stream length in adequate and marginal categories, and an increase of about 3 miles in the inadequate category (Table 3). This is not a huge alteration of natural conditions: it is slightly more than 5% of the total length of stream with degraded habitat.

The topographical shading scenario illustrates the changes from current conditions that would result if shading from trees was absent entirely. This models the extreme case, if all vegetation were completely removed from the watershed. Without vegetation shade, salmonid conditions would be far worse than current conditions: in the North Fork Middle Fork, stream miles in the inadequate category would nearly triple over current conditions, from 7.8 to 21.4 miles, while those in the marginal category would decrease by about 75%, from 16.5 miles to 3.7 miles. In Upper Black Butte, stream length in the adequate category would decrease by 75%, from nearly 20 miles to less than five miles, without vegetative shading. Stream lengths in the inadequate category (19-24° C) would increase from less than 4 miles to over 55 miles. What this shows is that vegetation shade is critical for protecting cool temperatures in the tributaries. Interestingly, the model does not predict lethal temperatures in tributaries in either subbasin, even with no vegetation present. This may be the result of a combination of factors such as the existing stream orientation, steep topography and amount of sky openness. The basin topography is generally steep enough near these types of tributary streams so that some shading is available during the day.

Increased sizes of conifers in the tributaries over the topographic shading only scenario provides improvements in conditions for salmonids. For example, in the Upper Black Butte subarea, going from topographic shading to an 18" dbh tree would increase the stream length in adequate conditions nearly four-fold, and eliminate all but about 10% of the total stream length in the inadequate category. Improvements in the North Fork Middle Fork subarea are not as dramatic, but still noteworthy. Small, incremental improvements (e.g., a mile or two from the inadequate category into the adequate category) are seen when the tree size is increased from 18" dbh to 24" dbh.

Current conditions are somewhat better than conditions under the 18-24" dbh scenarios, which suggests that current management is somewhat better than what would be expected if the entire basin were privately owned and managed for timber production under the current Forest Practice Rules. It is likely that Forest Service management under the NWFP is largely responsible for this result.

Table 3. Temperature Modeling Results

Upper Black Butte Subbasin

Temperature Category	Current Conditions	% of Total	No Trees /Shading	18" dbh	24" dbh	Full Growth 48"dbh	% of Total
	Number of Stream Miles in Each Temperature Category						
Good (MWAT < 15° C)	0.0	0%	0.0	0.0	0.0	0.0	0%
Adequate (15° C < MWAT < 17° C)	19.9	24%	4.7	18.0	19.3	23.3	28%
Marginal (17° C < MWAT < 19° C)	59.7	72%	22.7	56.9	56.5	58.7	71%
Inadequate (19° C < MWAT < 24° C)	3.7	4%	55.9	8.4	7.5	1.2	1%
Lethal (MWAT ≥ 24° C)	0.0	0%	0.0	0.0	0.0	0.0	0%
TOTAL	83.3	100%	83.3	83.3	83.3	83.2	100%
Solar Radiation (ly/day)	109.5		231.6	117.8	112.4	100.3	
% Shade	72%		40%	69%	71%	74%	

North Fork Middle Fork Subbasin

Temperature Category	Current Conditions	% of Total	No Trees /Shading	18" dbh	24" dbh	Full Growth 48"dbh	% of Total
	Number of Stream Miles in Each Temperature Category						
Good (MWAT < 15° C)	0.0	0%	0.0	0.0	0.0	0.0	0%
Adequate (15° C < MWAT < 17° C)	0.9	4%	0.0	0.9	0.9	1.6	6%
Marginal (17° C < MWAT < 19° C)	16.5	65%	3.7	12.1	14.0	19.6	78%
Inadequate (19° C < MWAT < 24° C)	7.8	31%	21.4	12.1	10.3	4.0	16%
Lethal (MWAT ≥ 24° C)	0.0	0%	0.0	0.0	0.0	0.0	0%
TOTAL	25.2	100%	25.1	25.1	25.2	25.2	100%
Solar Radiation (ly/day)	128.6		240.0	139.7	133.5	117.5	
% Shade	67%		38%	64%	65%	69%	

Average of Modeled Subbasins

Temperature Category	Current Conditions	% of Total	No Trees /Shading	18" dbh	24" dbh	Full Growth 48"dbh	% of Total
	Number of Stream Miles in Each Temperature Category						
Good (MWAT < 15° C)	0.0	0%	0.0	0.0	0.0	0.0	0%
Adequate (15° C < MWAT < 17° C)	10.4	19%	2.4	9.5	10.1	12.5	23%
Marginal (17° C < MWAT < 19° C)	38.1	70%	13.2	34.5	35.3	39.2	72%
Inadequate (19° C < MWAT < 24° C)	5.8	11%	38.7	10.3	8.9	2.6	5%
Lethal (MWAT ≥ 24° C)	0.0	0%	0.0	0.0	0.0	0.0	0%
TOTAL	54.3	100%	54.2	54.2	54.3	54.2	100%
Solar Radiation (ly/day)	119.1		235.8	128.8	123.0	108.9	
% Shade	69%		39%	67%	68%	72%	

When the trees are allowed to increase to the natural full growth scenario of 48" dbh, the model shows significant improvements: in Black Butte, only 1 mile of stream length is in the inadequate category, and the rest is in the marginal or adequate categories. The adequate category improves by about 17% over baseline conditions, and by about a third over the 18" dbh scenario. In the North Fork Middle Fork subarea, the improvements are similar, with about half the stream length in the inadequate category over baseline conditions, and smaller increases in the stream lengths that would fall into the marginal and adequate categories. What this shows is that allowing the trees to increase in size to their natural full growth potential provides noteworthy improvements in temperature conditions for salmonids. It is important to note, however, that even under this scenario, the model does not predict that every mile of stream will fall into the marginal or better categories; and none of the stream length is predicted in these tributaries to fall into the good or lethal categories.

Selection of Scenario Corresponding to Water Quality Standards

The narrative water quality standard states "the natural...water temperature...shall not be altered unless it can be demonstrated...that such an alteration in temperature does not adversely affect beneficial uses." The modeling of the Upper Black Butte and North Fork Middle Fork subareas illustrates that stream temperatures in the tributaries of the Middle Fork Eel watershed are expected to provide primarily adequate (15-17° C) to marginal (17-19° C) conditions under natural full growth vegetation conditions. Reducing the amount of shade from conifers (largely from reducing the tree size in the riparian zone) increases the amount of inadequate habitat and decreases the amount of adequate habitat, which "adversely affects beneficial uses" and alters the natural water temperature. Therefore, EPA has concluded that, particularly given the small amount of adequate and good habitat, any alteration in stream temperatures from natural conditions would adversely affect beneficial uses. Therefore, EPA is selecting the natural full growth scenario (48" dbh Douglas fir) to calculate the TMDL and allocations needed to attain the water quality standard. As discussed, the natural vegetation allows for natural shade and thus natural stream temperatures.

The natural full growth scenario thus corresponds to "natural potential" shade, or the shade that would result from natural full growth and the corresponding natural temperatures. Accordingly, EPA concludes that attaining the water quality standards requires that there be no human-caused changes to "natural potential" shade. However, this is not the same as expecting adequate or good stream temperatures for summer rearing steelhead in every mile of every stream in the basin. The public and land managers can expect that even when water quality standards are attained, there will be a wide range of stream temperature conditions for steelhead from good stream temperatures (particularly in the spring-fed tributaries) to lethal stream temperatures (particularly in the main channels). However, achieving conditions that reflect natural full potential shade will result in conditions that are better for rearing salmonids than those achieved under some current forestry management styles. This is particularly true for privately managed timber lands. Currently, the US Forest Service lands are managed under the Northwest Forest Plan, which have resulted in no cut for about 15 years; thus, it is likely to be closer to the natural condition than any of the privately managed areas. In addition, land managers who examine their site-specific management practices will be able to determine if they protect natural potential shade, rather than relying solely on the generalizations in the modeled results.

3.3. WATER QUALITY INDICATORS AND TARGETS

EPA has modeled estimates of the distribution of stream temperatures that would occur under full natural growth as an indicator of the conditions that would adequately represent meeting applicable water quality standards. Thus, temperature conditions under full natural shade serve as the indicator for meeting water quality standards. The minimum target value is the distribution of stream lengths that fall into the adequate and marginal temperature categories under the full growth scenario, as shown in Table 3 (column labeled full growth 48" dbh). For the tributaries in the watershed as a whole, this means that at least 23% of total stream length should fall into the good or adequate categories (< 17° C) and at least 95% of total stream length should fall into the good, adequate or marginal categories (< 15° C).

For the two subareas that were fully modeled, EPA has identified a more specific distribution of temperature range distributions, reflecting what is known about the subarea from the modeling effort and what its potential would be. Thus, as shown in Table 3, in the Black Butte subarea, at least 28% of total stream length should fall into the good or adequate categories (< 17° C) and at least 99% of total stream length should fall into the good, adequate or marginal categories (< 15° C). For the North Fork Middle Fork, at least 6% of total stream length should fall into the good or adequate categories (< 17° C) and at least 84% of total stream length should fall into the good, adequate or marginal categories (< 15° C). The differences between these two reflect topographical and channel geometry differences in the subareas. In the future, if additional subareas are modeled, it would be appropriate to also develop more refined models if the watershed-wide average appeared not to represent achievable conditions in the subarea–for example, if an area has significantly less natural growth of conifers.

These targets illustrate that the public and land managers should expect to see instream temperatures that vary from adequate to marginal to inadequate in those tributaries, even with attainment of water quality standards. However, as shade is allowed to reach its full natural potential, the stream reaches with adequate conditions will be improved and the stream reaches with inadequate conditions will be minimized. For the main channels, EPA expects that near lethal conditions would still be expected in many areas during the hottest periods of the summer, consistent with historical conditions. We do not have monitoring data nor modeling to more specifically define natural temperature conditions in the main channels. As noted above, however, anecdotal evidence indicates that refugia were more numerous historically than under current conditions. Therefore, as a temperature indicator for the mainstem channels, we are including an increasing trend in refugia. For the main channels, full natural shade is also the target condition, although EPA did not model main channels. This will be particularly important in areas where deeper pools exist alongside the channel. It will be possible to estimate full natural growth conditions and determine on a case-by-case basis in the field whether those conditions have potential to shade the stream and protect natural temperatures. This assessment should also be made considering whether there are local conditions that could provide refugia (e.g., a deep pool, upwelling groundwater or greater topographic shading) as well as whether incoming water from upstream areas and tributaries reflects natural water temperatures.

In addition, EPA is including as a target an increase in the number and depths of refugia pools along the main channels. These conditions likely contributed to salmonid survival historically, and may have decreased in number and depths without full recovery since the 1964 flood.

Again, it should be noted that EPA is selecting the natural full growth scenario as the scenario that corresponds to the applicable water quality standards, because we believe it is most representative of natural conditions, even though the resulting water temperatures will probably remain quite warm for steelhead in some areas during the hottest period of the year.

3.4. TMDL AND ALLOCATIONS

3.4.1 Loading Capacity and TMDL

The loading capacity (i.e., the TMDL) is the total loading of the pollutant that the river can assimilate and still attain water quality standards for temperature. In this TMDL, the pollutant is heat, measured in langleys/day (ly/day). It is a measure of energy per unit area, and can be converted to metric units such as joules (1 ly = 41,850 joules/m^2).

In the model, "global solar radiation" over each stream segment–i.e., the solar radiation that exists above the vegetation (385 ly/day)–is reduced by topography and vegetation characteristics, resulting in a smaller amount of heat reaching the stream for each segment. As explained in Section 3.2, the heat that actually reaches the streams varies, depending upon the hillslopes, orientation and other factors, including, most importantly for the tributaries, the shade provided by the vegetation.

Tributaries

The TMDL is the maximum amount of heat from solar radiation that can be added to streams in the Middle Fork Eel River watershed and not exceed water quality standards. For the two modeled subareas, this equates to the amount of heat that would result from the full natural growth scenario; i.e., 100 ly/day for Upper Black Butte and 118 ly/day for North Fork Middle Fork (see Table 3). This is calculated in the model by subtracting the heat that would be blocked by vegetation and topography from the global solar radiation. For unmodeled tributaries, the allowable load is the average for the two subbasins, or 109 ly/day. The two subareas are representative of tributaries in the basin with perennial flow, and thus the average of the two is appropriate to use for the basin as a whole.

The TMDL for the Middle Fork Eel basin tributaries, other than the two modeled subareas, is set equal to 109 ly/day.

The TMDL for the two subareas is determined with greater specificity by the modeling, reflecting the greater information available for those subareas, allowing a specific refinement to the basin-wide average:

The TMDL for the Upper Black Butte subarea is set at 100 ly/day;
The TMDL for the North Fork Middle Fork subarea is set at 118 ly/day.

Future modeling of additional subareas, if undertaken, can be used to refine these TMDLs. Otherwise, the loading for the basin shall apply.

The mathematical expression of the basin-wide TMDL is the result of the average of all the stream segments in the 2 modeled subareas, given an assumption of natural full growth vegetation (i.e., 48 inch conifers). This is the loading capacity of the stream, and will allow water quality standards for temperature to be achieved. This can also be expressed as equivalent to the heat reaching the streams in the watershed when every stream segment has "natural" (unaltered) shade. This represents about a 9% reduction in heat over current conditions: 119 ly/day on average for the basin as a whole, 110 ly/day for the Upper Black Butte subarea, and 129 ly/day for the North Fork Middle Fork subarea.

Mainstem Reaches

The Public Review Draft TMDL proposed two alternative temperature approaches for the mainstem reaches. Alternative 1 was to make a determination that no TMDL for temperature was needed for the mainstem reaches based on the theory that water quality standards for temperature were being met because any temperature elevation was due to natural causes. Alternative 2 was to set a TMDL of 9% reduction of heat input in the mainstem channels, which is the same reduction required for the tributary reaches to attain water quality standards. EPA reviewed public comments on the alternatives and selected Alternative 2. The information available to EPA indicates that the main cause of the temperature increase in the basin, according to Regional Board staff, was the increase in sediment following the 1955 and 1964 floods, which filled in refugia pools, destroyed the riparian vegetation, and aggraded the stream channel to the degree that riparian recovery has not occurred. All these factors have apparently combined to result in the loss of cold water habitat. While there has been some debate about the floods, it appears that human activities in the basin exacerbated the natural effects of those floods, resulting in greater sediment deposition and pool filling and loss of more riparian vegetation than would have occurred without human influences. Thus, temperatures have been elevated above natural levels to some degree. Therefore, we are selecting Alternative 2 and setting the TMDL and allocations for the mainstem reaches as discussed below.

As noted above, the Regional Board has indicated that beneficial uses are not being supported in the mainstem reaches, due at least in part to elevated temperatures. The modeling performed for this TMDL in the tributaries indicates that approximately a 9% decrease in heat input is needed in order to achieve water quality standards for temperature in the basin as a whole. This is based on the basinwide maximum allowable heat input of 109 ly/day, reduced from current conditions of about 119 ly/day. The main channels differ significantly in important heat- and shade- related characteristics from the modeled tributaries; in particular, mainstem reaches are generally wider and deeper, with faster streamflow and greater volume, and heat is influenced less by shading factors, so they are generally hotter than the tributaries. Accordingly, we do not consider it appropriate to apply the 109 ly/day loading capacity to the main channels. Instead, we are expressing the TMDL in terms of a 9% decrease from current heat loading for the main channel. This is based on the assumption that even though conditions are different, there is likely a similar extent of temperature impairment in the main channels as exists in the tributaries. Thus,

The TMDL for mainstem reaches is set at 9% heat reduction on average.

Based on input from the Regional Board and our analysis of conditions in the mainstem channels, we recommend that most of the necessary decrease be achieved through protection of natural potential shade and an increase in protection of refugia pools along the channels.

3.4.2 Allocations

In accordance with EPA regulations, the loading capacity (i.e. TMDL) is allocated to the various sources of heat in the watershed, with a margin of safety. The margin of safety in this TMDL is not added as a separate component of the TMDL, but rather is incorporated into conservative assumptions used to develop the TMDL, as discussed below.

The measure of heat reaching the stream is several steps removed from actions which can be taken by land managers. Thus, for the tributary load allocations, we have translated the TMDL of heat (langleys/day) into an average % shade requirement for the watershed. As described above, “shade” is not precisely the same as the amount of stream in shadow or the amount of the stream surface shaded from direct sunlight. Shade is the reduction in solar radiation, i.e., the reduction of light and heat, from global solar radiation, or the heat that exists globally in the basin (i.e., above the trees and topography, prior to any shading), less the filtering and buffering of heat and light by vegetation and topography, which translates to the heat input at the water surface.

Using this translation, shade was calculated as the reduction in solar radiation from the global solar radiation to that which is filtered through the vegetation and topography. It is expressed as a percentage of shade, which is equivalent to a percentage reduction in radiation. For example, the reduction from 385 ly/day (global solar radiation) to 109 ly/day (the basinwide TMDL) is a 72% reduction in solar radiation, or the equivalent of a minimum 72% shade; this is the basinwide allocation. We are expressing the reduction of solar radiation in % shade because, while solar radiation and heat cannot be measured directly, shade can be measured more directly and simply throughout the basin–for example, by using a solar pathfinder, which is a simple tool that is frequently employed by land managers to determine shade. Likewise, changes in shade can be measured over time. Thus, this expression of the TMDL is more useful to land managers and regulators because they can measure their progress using simple, established methods that are readily available, rather than needing to measure heat in langleys per day.

For the two modeled subbasins with more data available, we have added detail by translating the TMDL into % shade allocations along different stream segments. These are very close to the basinwide allocation. For the Upper Black Butte area, the allocations (minimum 74% shade on average) are shown in Figure 6. North Fork Middle Fork allocations (minimum 69% shade on average) are illustrated in Figure 7. These two figures add more detail to the shade allocations by specifying allocations along different stream segments.

For the remainder of the watershed (excluding the mainstem reaches), the allocation is derived from the TMDL of 109 langleys per day. As discussed, this is equivalent to 72% shade, on average. This indicates that about 2-3% more shade is needed, on average, than what exists under current conditions.

For the mainstem reaches, the allocations are the same as the TMDL: a 9% reduction in the heat input over current conditions. As noted above, the main concern for the mainstem is to achieve natural conditions, both for shade and channel conditions, with regard to refugia. An increase in shaded pools, and increased depth and frequency of primary pools should result in natural heat loading and corresponding natural temperatures.

In summary:

The load allocation for Upper Black Butte subarea = average blocked solar radiation for the subarea represented by the full natural growth scenario, which = (385-100)/385 ly/day, or 285/385 ly/day, which = 74% reduction in solar radiation, or 74% shade.

The load allocation for North Fork Middle Fork subarea = average blocked solar radiation for the subarea represented by the full natural growth scenario, which = (385-118)/385 ly/day, or 267/385 ly/day, which = 69% reduction in solar radiation, or 69% shade.

The load allocation for the remainder of the watershed (excluding the mainstem reaches) = average blocked solar radiation for the two subareas represented by the full natural growth scenario, or (385-109)/385 ly/day, or 276/385 ly/day, which = 72% reduction in solar radiation, or 72% shade.

Current conditions in Upper Black Butte suggest 72% shade (see Table 3). In North Fork Middle Fork, current conditions reflect 67% shade. The overall average is assumed to be about 69% shade, based on the two subareas. Thus, only a small improvement is needed to meet water quality standards for temperature, to add 2-3% more shade overall. Given that little timber harvesting has taken place in the basin, it is understandable that the basin is nearly meeting standards at present.

For the mainstem reaches, a 9% reduction in the heat input over current conditions is necessary.

There is some uncertainty in the modeling, as discussed below. In practice, the Regional Board has indicated that they intend to protect and facilitate shade from site-potential tree height, on a site-by-site basis. In other words, the Regional Board will work to attain natural shade conditions, which will eventually result in attainment of natural temperature conditions. EPA does not expect that every tree in the riparian zone will reach the full 48" diameter or corresponding height as modeled. In practice, there will be some areas where trees may not attain the modeled size, and there may be other areas where trees grow even larger than the modeled size. The primary purpose of the modeling is to characterize current conditions and estimate the extent of heat reductions needed to attain water quality standards. Because appropriate heat loads, water temperatures and tree heights cannot be generalized on a basinwide scale, this reduction is best achieved by allowing trees to grow so as to provide the equivalent amount of shade that would be provided under natural conditions. In addition, measures to reduce sediment discharge and promote establishment or protection of additional refugia pool areas will facilitate attainment of water quality standards. In this sense, the temperature and sediment TMDLs overlap to some degree.

3.4.3 Margin of Safety

An implicit margin of safety is included using conservative assumptions to account for uncertainties concerning the relationship between pollutant loads and instream water quality and other uncertainties in the analysis. It is likely, given both anecdotal information and results of the temperature monitoring and modeling, that current temperatures in the basin are close to meeting water quality standards and may be adequately supportive of the cold water fishery. Due to uncertainty in existing natural temperature conditions throughout the basin, it is appropriate to develop this TMDL to identify loadings that EPA has confidence will support beneficial uses. Using 48" dbh to reflect full natural growth may in fact be more protective than would be achieved under natural conditions, considering what would likely be achieved with natural fire regimes. In addition, management under the Northwest Forest Plan may already be resulting in attainment of water quality standards for some USFS and BLM lands. The TMDL allocations provide an additional layer of protection for both public and private lands. In addition, protections provided by controlling sediment (Chapter 4) will also protect water temperatures.

Implementing the temperature TMDL will result in larger riparian vegetation, which will increase the potential for contributions of large woody debris to 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, which can provide areas of cooler water for fish. These changes were not accounted for in the analysis, but provide an implicit margin of safety. Refugia from existing stratified pools or streams dominated by springs provide cooler temperatures than were accounted for in the TMDL. As this provides additional benefits to the resource, it provides an implicit margin of safety. Finally, implementing the temperature TMDL will result in larger riparian vegetation. Larger vegetation will tend to create microclimates that will lead to improvements in stream temperatures. These effects were not accounted for in the temperature analysis, but provide an implicit margin of safety.

There is some uncertainty in the use of models to determine current stream temperatures and to predict temperatures under various growth scenarios. The data used were the best data available to EPA. The diameter-height relationship curve was developed using data for southern Oregon Douglas fir forests, which grow taller than trees in the Middle Fork Eel basin. However, the only other data, made available to EPA for the Middle Fork Eel basin, covered less than one percent of the basin, and was for riparian areas that have been uncut for only about 10 years. This may not have been adequately representative of the conditions in the Middle Fork Eel.

EPA tested the data, which was provided by the USFS, to determine how it would affect the analysis. If these data are representative, then it is likely that the model predicts tree heights in all scenarios (i.e., both in the current conditions and in the full growth scenario) that are taller than existing conditions or likely full growth conditions, on an average basis for the basin. In testing the data, EPA developed an alternative diameter-height relationship using the data and ran the model for the Upper Black Butte subbasin. Using this alternative data would have yielded a TMDL that calls for slightly less shade overall, by about 2-3%, and it would have suggested a slightly higher temperature threshold for the tributaries. Given the uncertainties, EPA used the more protective diameter-height relationship developed from the original data that was available. In practice, the Regional Board has indicated that it intends to protect riparian vegetation on a site-by-site basis, which will result in protection of natural shade and the eventual attainment of natural water temperatures.

3.4.4 Seasonal Variation and Critical Conditions

The TMDL must account for seasonal variation and critical conditions. In the Middle Fork Eel watershed, the summer period defines the critical period when stream temperatures are most likely to have adverse impacts on beneficial uses (young salmonids growing in the streams before migrating to the ocean). To account for seasonal variations and critical conditions, the analysis is based on the MWAT (i.e., the maximum weekly average of the 7 day running average of all monitored temperatures). Temperatures are not limiting to beneficial uses during the winter period.

CHAPTER 4: SEDIMENT TMDL

Summary

This chapter presents information specific to the sediment TMDL for the Middle Fork Eel River. The first section identifies water quality indicators, which serve as interpretations of the water quality standards. The second section of this chapter presents the results of the USFS sediment source analysis, along with new information that was provided from the USFS and Regional Board to improve the analysis. These indicators can also be used to evaluate stream and watershed conditions and progress toward or achievement of the TMDL. The third section presents the calculations used to set the TMDL, which is the total loading of sediment that the Middle Fork Eel River and its tributaries can receive without exceeding water quality standards, and apportions the total among the major categories of sediment sources, on a subwatershed basis.

The sediment source analysis for the Middle Fork Eel conducted by the United States Forest Service, with additional information provided by Regional Board staff, concluded that the majority of sediment delivered to streams is naturally caused, and most of the sediment is from landslides. The results suggest that, overall, the Middle Fork Eel is less disturbed by human-caused sediment than most other watersheds studied in the North Coast. This is probably because little management activity is currently occurring in the basin. Some of the subwatersheds appear to be in better condition than others. Sediment production from human disturbance in the basin appears to be associated primarily with road conditions in some of the subwatershed areas. It also appears, based on current information, that some USFS lands in the Middle Fork Eel may be meeting water quality standards for sediment. For example, the Yolla Bolly Wilderness is left in natural (unmanaged) condition. This occupies a large portion of the Upper Middle Fork subwatershed. Additionally, some management under the Northwest Forest Plan may be generating little sediment above that which would be generated under natural conditions. Therefore, the USFS may be able to meet TMDL limits without changing its current practices or current intensity of use. However, little information was available for instream conditions, and confidence in some portions of the sediment source analysis that was conducted for this TMDL was limited. Furthermore, the available information on management and sediment production on private lands was less complete and more uncertain. Thus, EPA cannot at this time conclude that water quality standards are being met. The final TMDL provides more specificity than the draft TMDL, addresses sources of uncertainty in the sediment source analysis, and sets the TMDL and allocations on a subwatershed basis in order to better address those areas where sediment reduction is clearly needed to meet water quality standards.

4.1. WATER QUALITY INDICATORS AND TARGETS

This section identifies water quality indicators and targets that are more specific to the Middle Fork Eel River and generally more quantifiable than the water quality standards for sediment contained in the Basin Plan. They are interpretations of the water quality standards expressed in terms of instream and watershed conditions. For each indicator, a numeric or qualitative target value is identified to define the desired condition for that indicator. The indicators are not directly enforceable by EPA; however, one indicator, for turbidity, uses similar language to the Basin Plan turbidity water quality objective, which is enforceable by the NCRWQCB.

No single indicator adequately describes water quality related to sediment, so a suite of instream and watershed indicators is identified. Because of the inherent variability associated with stream channel conditions, and because no single indicator applies at all points in the stream system, attainment of the targets is intended to be evaluated using a weight-of-evidence approach. That is, when considered together, the indicators are expected to provide good evidence of the condition of the stream and attainment of water quality standards.

Instream indicators reflect sediment conditions that support salmonids. They relate to instream sediment supply and are important because they are direct measures of stream "health." In addition to instream indicators, we are including watershed indicators in this TMDL because watershed indicators focus on imminent threats to water quality that can be detected and corrected before the sediment is actually delivered to the stream, and because watershed indicators are often easier to measure than instream indicators. These watershed indicators are established to identify conditions in the watershed needed to protect water quality. They are set at levels associated with well functioning watersheds.

Watershed indicators assist with the identification of threats to water quality for both temporal and spatial reasons. Watershed indicators reflect conditions in the watershed at the time of measurement, whereas instream indicators can take years or decades to respond to changes in the watershed, because linkages between hillslope sediment production and instream sediment delivery are complicated by time lags from production to delivery, instream storage, and transport through the system. Also, watershed indicators tend to reflect local conditions, whereas instream indicators often reflect upstream watershed conditions as well as local conditions. Thus, watershed indicators help to identify more prospectively conditions in the watershed needed to protect water quality. Both instream and watershed indicators are appropriate to use in describing attainment of water quality standards.

4.1.1 Summary of Indicators and Targets

This section describes several sediment indicators for the Middle Fork Eel River TMDL. Table 5 summarizes the indicators, targets, description and purpose. Very little information is available on current values of the indicators in the watershed; however, anecdotal information suggests that the watershed is in relatively good condition relative to other North Coast basins, although some subwatersheds may have greater sediment problems (D. Leland, pers. comm., 2003). In this watershed, much of the Forest Service land may be currently meeting these target values; as noted, however, monitoring or observational data concerning specific indicators is generally not available. Regional Water Board staff has also developed additional information and detail on each of these indicators in developing implementation plans for other North Coast TMDLs (NCRWQCB, 2002). EPA expects that future monitoring of these indicators will provide additional information to assess whether the water quality standards are being attained and whether the TMDL is effective in meeting water quality standards.

Table 5. Sediment Indicators and Targets

INDICATOR	TARGET	DESCRIPTION	PURPOSE
Instream			
Spawning Gravel Quality	<14% < 0.85 mm ≤30% < 6.4 mm;	Bulk samples during low-flow period, at riffles heads in potential spawning reaches. Discussion of indicators and targets by Kondolf (2000), Chapman (1988).	Indirect measure of fine sediment content relative to incubation and fry emergence from the redd Indirect measure of ability of salmonids to construct redds
Turbidity and Suspended Sediment	Turbidity ≤ 20% above naturally occurring background (also included in Basin Plan)	Measured upstream and downstream of sediment discharging activity or between “paired” watersheds or reference streams.	Indirect measure of fish feeding/growth ability related to sediment, and impacts from management activities
Riffle Embeddedness	≤25% or improving (decreasing) trend toward 25%	Estimated visually at riffle heads where spawning is likely, during low-flow period (Flosi et al 1998)	Indirect measure of spawning support; improved quality & size distribution of spawning gravel
V*	≤0.21	Residual pool volume. Measure during low-flow period. (Lisle and Hilton 1992)	Estimate of sediment filling of pools from disturbance
Macroinvertabrate community composition	Improving trends	EPT, Richness & % Dominant Taxa indices. Methods should follow CDFG-WPCL (1996) or refined methods currently under development.	Estimate of salmonid food availability, indirect estimate of sediment quality.
Thalweg profile	Increasing variation from the mean	Measured in deposition reaches during low-flow period.	Estimate of improving habitat complexity & availability
pool/riffle distribution & depth of pools	increasing trend toward >40% in primary pools	Trend or greater than % (by length), measured low-flow period.	Estimates improving habitat availability
Watershed Indicators			
Diversion potential & stream crossing failure potential	≤1% crossings in 100 yr storm	Conduct road inventory to identify and fix stream crossing problems (Weaver and Hagans 1994). See USDA (1999) Roads Analysis for assessing road network.	Estimates potential for reduced risk of sediment delivery from hillslope sources to the watercourse
Hydrologic connectivity of roads	Decreasing length of road	Conduct road inventory to identify and fix road drainage problems (Weaver and Hagans 1994).	Estimates potential for reduced risk of sediment delivery from hillslope sources to the watercourse
Annual road inspection & correction	Increased mileage inspected and corrected	Roads inspected and maintained, or decommissioned or hydrologically closed prior to winter- No migration barriers.	Estimates potential for reduced risk of sediment delivery from hillslope sources to the watercourse
Road location, sidecast	Reduce density next to stream, increased % outsloped	see text	minimize sediment delivery
Activities in unstable areas	avoid and/or /eliminate	Subject to geological/geotechnical assessment to minimize delivery and/or show that no increased delivery would result	minimize sediment delivery from management activities

4.1.2 Instream Indicators

Spawning Gravel Quality: Percent Fines < 0.85 mm: ≤14%; Percent Fines <6.4 mm ≤ 30%
Streambed gravels naturally consist of a range of particle sizes from finer clay and sand to coarser cobbles and boulders. Kondolf (2000) described how various gravel sizes and mixtures can influence different salmonid life stages including redd construction, egg incubation and alevin emergence. In addition, spaces between clean cobbles provide important cover for salmonid and other fry at a critical and vulnerable time in their life history. The percent fines <0.85 mm is defined as the percentage of subsurface fine material in pool tail-outs < 0.85 mm in diameter. These indicators and targets represent adequate spawning, incubation, and emergence conditions relative to substrate composition. Excess fine sediment can decrease water flow through salmon redds. Sufficient water flow is critical for maintaining adequate oxygen levels and removing metabolic wastes. Deposits of these finer sediments can also prevent the recently hatched fry from emerging from the redds, resulting in entrapment. Monitoring should be conducted by bulk sampling during low-flow periods at the heads of riffles, in potential spawning reaches. The target of ≤30% for particles less than 6.4mm sizes is based on literature relating size classes survival to emergence (summarized in Chapman 1988, and Kondolf 2000). No data for this indicator was available to EPA during development of this TMDL.

Turbidity and Suspended Sediment: <20% above naturally occurring background levels
Turbidity is a measure of the ability of light to shine through water (with greater turbidity indicating more material in the water blocking the light). Although turbidity levels can be elevated by both sediment and organic material, in California's North Coast, stream turbidity levels tend to be highly correlated with suspended sediment. High turbidity in the stream affects fish by reducing visibility, which may result in reduced feeding and growth. The deleterious effects on salmonids were found not only to be a function of concentration of fine particles but also a function of duration of exposure. Sigler et al (1984) found that as little as 25 NTUs of turbidity caused a reduction in fish growth. The North Coast Basin Plan presently stipulates that turbidity shall not be increased more than 20 percent above naturally occurring background levels by an individual activity. This indicator should be measured during and following winter storm flows, and upstream and downstream of a management activity to compare changes in the turbidity levels that are likely attributable to that activity. Information should include both magnitude and duration of elevated turbidity levels.

Although some data are available, turbidity data correlated to flows is not available for the Middle Fork Eel basin. Many measurements taken during the winter of 1981 - 1982 (DWR, 1982, at 24 sites) and in 1959 - 1964 show extremely high turbidities during peak storm discharges. Seven sites had measurements over 1000 NTUs during a November storm and then returned to less than 40 NTU 5 days later. USGS and DWR also reported extremely high turbidity measurements during the 1964 flood (as reported in DWR, 1982) - 5800 NTU for Williams Creek, 3600 NTU for Black Butte River and 3100 NTU at the ranger station. These measurements are thought to be among the highest ever reported. This suggests that the results of the 1964 flood were significant in this basin. However, these limited data points do not provide any indication of background turbidity, nor do they provide an indication of current conditions.

Riffle Embeddedness: <u><25% or improving (decreasing) trend</u>
Embeddedness is a measure of fine sediment that surrounds and packs-in gravels. A heavily embedded riffle section may limit the ability of an adult female to construct a redd. When constructing its redd, generally at a pool tail-out (or the head of the riffle), the spawning fish essentially slaps its tail against the channel bottom, which lifts unembedded gravels and removes some of the fine sediment. This process results in a pile of cleaner and more permeable gravel, which is more suited to nurturing of the eggs. Embedded gravels do not generally lift easily, which prevents spawning fish from building their redds. Flosi et al. (1998) suggest that gravels that are less than 25% embedded are preferred for spawning. This target should be estimated during the low-flow period, generally at riffle heads, in potential spawning reaches.

Embeddedness is measured as part of the CDFG stream inventory program. Results from summer 2002 estimates are not yet available.

V* <u><0.21 (Franciscan geology)</u>
V* is a measure of the fraction of a pool's volume that is filled by fine sediment, and represents the in-channel supply of mobile bedload sediment (Lisle and Hilton 1992). It reflects the quality of pool habitat, because when less of the pool is filled (a lower pool volume) it reflects deeper, cooler pools offering protection from predators, a food source, and resting location. Lisle and Hilton (1992) also describe methods for monitoring, which should be conducted in low-flow periods. V* is not appropriate for large rivers, but in large river systems it is appropriate for tributaries. The target of V* values less than .21 (Franciscan geology) is based on Knopp (1993). The only V* value available for this basin,0.08 for Balm of Gilead Creek, is well within the target range.

Macroinvertebrate Community Composition: <u>Improving trends in EPT, % dominant taxa and species richness indices</u>
Benthic macroinvertebrate populations are greatly influenced by water quality and are often adversely affected by excess fine sediment. This TMDL recommends several indices be calculated, following the CDFG Water Pollution Control Laboratory Stream Bioassessment Procedures (1996), until refined indices are available. Alternatively, methods that are generally consistent with those methods, such as those employed by USFS (<u>http://www.usu.edu/buglab/</u>) may be utilized.

1. EPT Index. The EPT Index is the number of species within the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT), more commonly known as mayflies, stoneflies and caddisflies. These organisms require higher levels of water quality and respond rapidly to improving or degrading conditions.
2. Percent Dominant Taxa. This index is calculated by dividing the number of organisms in the most abundant taxa by the total number of organisms in the sample. Collections dominated by one taxa generally represent a disturbed ecosystem.
3. Richness Index. This is the total number of taxa represented in the sample. Higher diversity can indicate better water quality.

Thalweg Profile: <u>Increasing variation of elevation around the mean slope</u>
Variety and complexity in habitat is needed to support fish at different times in the year or in their life cycle. Both pools and riffles are used through spawning, incubation of eggs, and emergence

of the fry. Deeper pools, overhanging banks, or logs provide cover from predators. Measuring the thalweg profile is an indicator of habitat complexity. The thalweg is the deepest part of the stream channel at a given cross section. The thalweg profile is a plot of the elevation of the thalweg as surveyed in a series of cross sections. Harrelson et al. (1994) provide a practical guide for performing thalweg profiles and cross sections. The profile appears as a jagged but descending line, relatively flat at pool areas, and descending sharply at cascades. The comparison between the mean slope (i.e., the overall trend of the descending stream) and the details of the slope is a measure of the complexity of stream habitats. More variability in the profile indicates more complexity in stream habitat. Inadequate availability of pool-forming features, such as bedrock or large woody debris, can be revealed by this indicator of channel structure. Because the change in the profile will occur relatively slowly, and because not enough is yet known about channel structure to establish a specific number that reflects a satisfactory degree of variation, the target is simply an increasing trend in variation from the mean thalweg profile slope. This indicator should be measured during the low-flow period every 5-10 years, after large storm seasons.

Primary Pool Distribution and Depth: Increasing inventory of reaches which are >40% pools; increasing primary pool depth

Pools generally account for more than 40% of stream length in streams with good salmonid habitat (Flosi et al. 1998). Frequent pools are important for providing feeding stations and shelter, and may also serve locally as temperature refugia. Primary pools are defined by Flosi et al. (1998) as follows: For 1st and 2nd order streams, they have a maximum residual depth (the maximum depth of a pool minus the maximum depth of its downstream riffle crest, or the depth of the pool at the point of zero flow) of at least two feet, occupy at least half the width of the low flow channel, and are as long as the low flow channel width. For 3rd and 4th order streams, they have a maximum residual depth of at least three feet, occupy at least half the width of the low flow channel, and are as long as the low flow channel width. (Small, un-branched, perennial tributaries that terminate at an outer point are designated 1st order; the junction of two 1st-order streams is designated 2nd order, and the junction of two 2nd-order streams is designated 3rd order, etc.). This indicator should be measured during the low-flow period every 5-10 years, after large storm seasons. Information in this watershed should especially include the depth of pools because in this watershed deeper pools may also be important as temperature refugia. Backwater pools are used by salmonids as overwintering habitats (Flosi et al. 1998). In particular, they provide shelter from high storm flows. Lateral scour pools (i.e., pools formed near either bank) tend to be heavily used by fish for cover and refugia.

4.1.3. Watershed Indicators

Stream Crossings with Diversion Potential or Significant Failure Potential: <1% of all stream crossings divert or fail as a result of a 100-year or smaller flood

Most roads, including skid roads and railroads, cross ephemeral or perennial streams. Crossings are built to capture the stream flow and safely convey it through, under, or around the roadbed. However, stream crossings can fail, adding sediment from the crossing structure (i.e., fill) or from the road bed directly into the stream. Stream crossings with diversion potential or significant failure potential are high risks for sediment delivery to streams. Stream crossing failures are generally related to undersized, poorly placed, plugged, or partially plugged culverts. When a crossing fails, the total sediment volume delivered to the stream usually includes both the volume of road fill associated with the crossing and sediment from collateral failures such as debris torrents that scour the channel and stream banks. An important problem is water draining down the road away from the stream crossing. This can result in water creating a new channel. Diversion potential is the potential for a road to divert water from its intended drainage system across or through the road fill, thereby delivering road-related sediment to a watercourse. The potential to deliver sediment to the stream can be eliminated from almost all stream crossings by eliminating inboard ditches, outsloping roads, or installing rolling dips (US EPA 1998). Less than 1% of stream crossings have conditions where modification is inappropriate because it would endanger travelers or where modification is impractical because of physical constraints.

Hydrologic Connectivity: Decreasing length
A road is hydrologically connected to a stream when the road drains water directly to the stream. A hydrologically connected road increases the intensity, frequency, and magnitude of flood flows and suspended sediment loads in the adjacent stream, which can result in destabilization of the stream channel. This can have a devastating effect on salmonid redds and growing embryos (Lisle 1989). The connectivity can be reduced by outsloping roads, creating road drainage that mimics natural drainage as much as possible, and other factors (USDA 1999, Weaver and Hagans 1994).

Annual Road Inspection and Correction:
EPA's analysis indicates that in watersheds with road networks that do not have excessively road-related sedimentation, roads are either (1) regularly inspected and maintained; (2) hydrologically maintenance free (i.e., they do not alter the natural hydrology of the stream); or (3) decommissioned or hydrologically closed (i.e., fills and culverts have been removed and the natural hydrology of the hillslope has largely been restored).

Road Location and Sidecast: Prevent sediment delivery
This indicator is intended to address the highest risk sediment delivery from roads not covered in other indicators. Roads located in inner gorges and headwall areas are more likely to fail than roads located in other topographic locations. Roads should be removed from inner gorge and potentially unstable headwall areas, except where alternative road locations are unavailable and the road is clearly needed. Sidecast soil on steep slopes can trigger earth movements, potentially resulting in sediment delivery to watercourses. These factors reflect the highest risk of sediment delivery from roads, and should be the highest priorities for correction (C. Cook, M. Furniss, M. Madej, R. Klein, G. Bundros, pers. comm., 1998, in EPA 1998).

This target calls for: (1) all roads alongside inner gorge areas or in potentially unstable headwall areas should be removed unless alternative road locations are unavailable and the need for the road is clearly justified; and (2) sidecast or fill on steep (i.e., greater than 50%) or potentially unstable slopes, that could delivery sediment to a watercourse, should be pulled back or stabilized.

Activity in Unstable Areas: Target: avoid or eliminate, unless detailed geologic assessment by a certified engineering geologist concludes there is no additional potential for increased sediment loading
Unstable areas are those areas that have a high risk of landsliding, including steep slopes, inner gorges, headwall swales, stream banks, existing landslides, and other locations identified in the

field. Any activity that might trigger a landslide in these areas (e.g., road building, harvesting, yarding, terracing for vineyards) should be avoided, unless a detailed geologic assessment by a certified engineering geologist concludes there is no additional potential for increased sediment loading. An analysis of chronic landsliding in the Noyo River basin indicated that landslides observed on aerial photographs largely coincide with predicted chronic risk areas, including steep slopes, inner gorges and headwall swales (Dietrich et al., 1998). Several other studies have shown that landslides are larger or more common in some harvest areas, particularly in inner gorges (US EPA, 2000). Weaver and Hagans (1994) also suggest methods for eliminating or decreasing the potential for road-related sediment delivery.

4.2. SEDIMENT SOURCE ANALYSIS

This section summarizes the results of the sediment source analysis conducted by the US Forest Service for this TMDL, as well as USFS and Regional Water Board staff review and revisions to the original sediment source analysis. The purpose of the sediment source analysis was to identify and estimate the relative amounts of sediment from the various sediment delivery processes and sources in the watershed. Appendix B contains the original USFS sediment source analysis; this section is a summary of Appendix B, along with the updates and revisions to it, and an explanation of EPA's use of this information in developing the TMDL.

USFS Sediment Source analysis methodology

The original sediment source analysis for the Middle Fork Eel River and tributaries (including Black Butte River) was conducted by the USFS for EPA. The sediment source analysis was composed of two parts - 1) a landslide assessment based on aerial photos with some field checking, and 2) a small sediment source survey largely based on field work and rate estimates from other studies. The landslide air photo assessment was conducted for all land in the watershed, including both the USFS lands of the Mendocino National Forest and private lands. Some information, particularly for small sources, was not available for private lands, as explained below. Lands belonging to the Round Valley Indian Tribe are not subject to State water quality standards, so the TMDL does not apply to them, although some information from some tribal lands is included, where it was available.

The landslide component utilized a basin-wide air photo inventory that mapped all visible landslides from available air photo sets, estimated sediment volume delivered to the stream system from those landslides, and assigned a management association (road-related, harvest-related) to slides when there was a management activity visible in the photo above the landslide in the photo; landslides with no management association were assumed to be due to natural causes.

In the original source analysis, landslides were placed into three periods: 1940-1969, 1970-1984 and 1985-2000. The latest period was used to determine current rates. Unfortunately, air photo availability was limited, and the air photos do not accurately bracket these time periods. For example, the 1940-1969 rates are determined from air photos dated 1952 and 1969 for the Upper Middle Eel, Elk Creek and Black Butte River subareas, and 1965 photos for the western portion of the basin (Round Valley and Williams Creek). The 1970-1984 rates were determined from 1981 photos for Upper Middle Eel and Elk Creek, 1979 photos for Black Butte River, and 1984 photos for Round Valley and Williams Creek. The current period is based on 1998 air photos for Upper Middle Eel and Elk Creek, 1993 and 1998 photos for Black Butte River, and 2000 photos for Round Valley and Williams Creek. Thus, the periods are not strictly comparable, but they were chosen to include the major storms of the periods: 1955, 1964, 1974, 1986 and 1997. In addition, delineating these periods separated the earlier periods from the most recent period, during which modern logging practices, USFS Best Management Practices, and standards of the Northwest Forest Plan have been used. The revisions to the source analysis include minor corrections in the landslide analysis.

The small source component of the USFS study addressed sources that would not be visible on air photos, such as surface erosion from roads, timber harvest units, gullies related to human activity, and streambank erosion. Field work was conducted on USFS lands only; USFS data (e.g., from emergency road repair work) as well as sediment delivery rates determined from other studies were extrapolated for basinwide rates. Regional Board staff worked independently and with the USFS and EPA following issuance of the Draft TMDL to provide greater accuracy in the small source component of the USFS source analysis. This included revisions to the road surface erosion and road-related gully portions of the analysis for private lands in the Round Valley, Elk Creek and Williams/Thatcher subwatersheds, revisions to the bank erosion calculations for the entire watershed, and some revisions to the landslide analysis as well. We have concluded that these revisions improve the accuracy and clarity of the source analysis, and we used the revised sediment source analysis in development of the final TMDL. (See pers. communications with B. McFadin, NCRWQCB, R. Faust, Mendocino National Forest, and J. de la Fuente, Klamath National Forest).

For USFS lands, the small sediment source survey assessed the road prism (road surface, cutbanks, inside ditches and cut & fill slope); road failures (such as cutbank and fill failures, small landslides and washed out culverts); timber harvest erosion from skid trails and landings; and gullies from roads in grassland areas. Sites were randomly selected from a weighted average of road lengths and harvest areas in the subwatersheds, and were stratified by USFS road maintenance level. Field crews measured the road surface, cutbanks, inside ditches and cut and fill slopes. This information was used in a model to generate sediment estimates. The sediment estimates were then extrapolated to the entire USFS road network. Additional information on road failures was obtained from Mendocino National Forest records and engineering personnel. Road-related gullies were also field surveyed in USFS grassland and hardwood stands. Bank erosion estimates were revised by the Regional Board staff.

Revisions to the Sediment Source Analysis

Regional Board staff revised the bank erosion estimates for the watershed downward from the original source analysis, to 250 t/mi^2/yr. To develop revised estimates for the road surface erosion in the Elk Creek, Round Valley and Williams/Thatcher subwatersheds, Regional Board staff revised estimates of road lengths on private lands in those watersheds and categorized them by use type, and corresponding sediment delivery rates, then surveying a portion of the roads to determine hydrologic connectivity and corresponding sediment delivery rates. Similarly, Regional Board staff surveyed road-related gullies along a portion of roads in the predominantly privately-owned subwatersheds to develop gully delivery rates (B. McFadin, letter to J. Parrish, Dec. 10, 2003).

In addition, USFS reviewed their estimates of landslide delivery rates and management associations, and corrected the database, resulting in some revised landslide associations and periods. Thus, bank erosion estimates for the basin were developed by Regional Board staff; road surface erosion and road-related gully estimates for the Elk Creek, Round Valley and Williams/Thatcher subwatersheds were also developed by Regional Board staff. Landslide estimates (both natural and management-related) were developed by USFS. Road surface erosion and road-related gully estimates for the Black Butte and Upper Middle Fork subwatersheds were developed by USFS. USFS also developed estimates for timber-related surface erosion; these values were less than 1 t/mi^2/yr, and were not used for the final source analysis summary. No estimates of harvest-related surface erosion were developed for private lands and, because it was assumed that this category would be quite small, it was not included in the source analysis summary.

Results

The USFS landslide assessment identified over 4,000 landslides in the 61-year period from 1940 to 2000, with 77% of the number and 81% of the volume occurring prior to 1969. Most of the sediment was probably generated from the 1964 flood, which is known to have caused significant changes in the watershed. The sediment generated in the 1940-1969 period averaged 1,352 t/mi^2/yr. In 1970-1984, the rate was only 276 t/mi^2/yr, probably in part because everything that could have been triggered was triggered during the 1964 flood. The basinwide current rate (1985-2002) is estimated to be 330 t/mi^2/yr, including both natural landslides (324 t/mi^2/yr) and management-related landslides (6 t/mi^2/yr).

The Black Butte River and Williams/Thatcher subwatersheds accounted for 44% of the sediment volume over the 1940-2002 period, with rates of 1,461 and 1,236 t/mi^2/yr, respectively, for the 63-year period, compared with 790 t/mi^2/yr for the basin as a whole, and only 272 t/mi^2/yr for the Upper Middle Fork. Elk/Dos Rios and Round Valley subwatersheds produced an average of 428 and 415 t/mi^2/yr, respectively, during the study period.

The toes of large, deep-seated landslides comprise the bulk of the volume of sediment delivered to the stream. Most of these landslides were not associated with any management activity. The relative lack of management associations with landslides has not changed significantly over the entire study period, although the period that includes the 1964 flood yielded significantly higher volumes of both natural landslides and road-related landslides.

The summary of estimates for the most recent period is shown in Table 6. Natural landslides account for 324t/mi^2/yr on a basinwide average, and bank erosion is estimated to be 250 t/mi^2/yr . Landslides associated with roads and harvest areas totaled 6 t/mi^2/yr. Estimates for sources associated with roads, gullies, and harvest areas totaled about 76 t/mi^2/yr.

Table 6: Current Sediment Loading 1985-2002 (t/mi^2/yr)

Source	Black Butte	Elk Ck	Round Valley	Upper MF	Williams/ Thatcher	BASINWIDE Load
Natural Landslides	474	809	124	160	167	324
Bank Erosion	250	250	250	250	250	250
TOTAL Natural	**724**	**1,059**	**374**	**410**	**417**	**574**
Road-Related Landslides	3	10	10	1	2	4
Harvest-Related Landslides	6	3	0	1	0	2
Subtotal Landslides	**9**	**13**	**10**	**2**	**2**	**6**
Surface/Other Road Sources	6	20	80	8	40	26
Road-Related Gullies	1	40	110	0	130	50
Subtotal Small Mgmt Sources	**7**	**60**	**190**	**8**	**170**	**76**
TOTAL Management-Related	**16**	**73**	**200**	**10**	**172**	**82**
TOTAL ALL SOURCES	**740**	**1,132**	**574**	**420**	**589**	**656**
% Natural	98%	94%	65%	98%	71%	88%
% Management	2%	6%	35%	2%	29%	13%

Sources:
USFS for all landslide data. NCRWQCB for bank erosion. NCRWQCB for road surface erosion and road-related gullies in predominantly privately-owned subwatersheds of Elk Ck, Round Valley and Williams/Thatcher; USFS for USFS lands. USFS also analyzed data for harvest-related surface erosion (primarily from landings) for USFS lands. The values, which totaled less than one t/mi^2/yr, are not included here. The values for private lands are unknown but also expected to be miinor, and no estimates are included for that category. There are some differences in USFS and NCRWQCB subwatershed delineations that would affect the values in each of the subwatersheds slightly. These are considered to be relatively minor.

Elk Creek subwatershed has the highest rate of sediment production, at 1,132 t/mi^2/yr. Most of this is associated with natural landslides (809 t/mi^2/yr), which is nearly double the rate of natural landsliding in Black Butte subwatershed and five to six times the rates in the other three subwatersheds. Road-related and harvest-related landsliding rates are highest in Black Butte, Elk Creek and Round Valley subwatersheds (9-13 t/mi^2/yr), and are minimal in Upper Middle Fork and Williams/Thatcher subwatersheds (2 t/mi^2/yr). Road-related surface erosion and road-related gully erosion rates are relatively small in the Black Butte and Upper Middle Fork subwatersheds (7-8 t/mi^2/yr), which probably reflects USFS road maintenance policies and minimal management activity: the Yolla Bolly-Middle Eel Wilderness Area is located partly within the Upper Middle

Fork subwatersheds, and implementation of the Northwest Forest Plan has also resulted in reduced harvest activity in both subwatersheds. By contrast, the greatest rates of road-related erosion (surface erosion and gullies) are in the predominantly privately-owned subwatersheds, with rates from 60 t/mi^2/yr (Elk Creek) to 170 t/mi^2/yr (Williams/Thatcher) and 190 t/mi^2/yr (Round Valley). This reflects both the greater volume and density of roads in these subwatersheds and the variations in road maintenance and road construction standards. In the basin as a whole, management-related sediment delivery averages 82 t/mi^2/yr, and natural sources average 574 t/mi^2/yr.

Discussion

The sediment source analysis represents a significant amount of work by USFS and Regional Board staff, and provides useful information regarding sediment sources in this basin. EPA's initial concerns about the sediment source analysis (discussed in the Draft TMDL), particularly related to the assignment of management associations to sources, have been tempered by the revisions to the analysis. Some of the remaining uncertainties in the data are outlined below. These uncertainties are considered to be relatively minor.

For the landslide analysis, the air photo periods selected were assumed to include all of the landslides for that period, even though the air photos were not bracketed by the periods selected. The assessment also combined several different air photo years into a single period in order to simplify the analysis. In doing so, the major storm periods were kept together, and an assumption was made that little sediment was generated in the smaller storm years. However, it is possible that some landslides occurred in different time periods than those to which they were assigned. Errors also could have been made in assigning management associations to landslides. Estimating landslide sizes and delivery is difficult and likely resulted in some errors. The sizes of the possible errors are not known. Landslides were assigned a timber harvest association only in clearcuts; smaller landslides associated with non clearcuts or other management associations could have been overlooked. Landslides that were associated with fire or uncharacterized as to association were deemed to be natural; some of these could be mischaracterized (Some corrections were made to the source analysis for the final TMDL). Over the 63 year study period, landslides characterized as fire-associated accounted for 15 t/mi^2/yr, so this is not a large factor in the overall quantity generated. Road-related or other small landslides may have been smaller than the threshold size that could be seen in aerial photos. This probably resulted in an underestimate of road-related landslides. The extent of the error is not known, but could possibly be large. However, because the TMDL and allocations are based on the amount of natural sediment delivery, errors in the amount of management-related landslides , even if large, do not affect the TMDL calculation.

Estimates for small sources on both USFS and private lands is probably low (B. McFadin, letter to J. Parrish, Dec. 10, 2003). Gully estimates include only estimates from road-caused gullies. Erosion from roads, timber harvest and gullies may have been underestimated, since erosion generated prior to the 2003 field estimates may not have been visible. Time periods associated with these estimates cannot be estimated accurately, and may range from one to more than 10 years. In addition, some of the bank erosion is likely due to management causes, though it is not possible to clearly determine how much is due to management versus non management causes.

4.3. TMDL AND ALLOCATIONS

4.3.1. Loading Capacity and TMDL

This TMDL is set equal to the loading capacity of the Middle Fork Eel River. The TMDL is the estimate of the total amount of sediment, from both natural and human-caused sources, that can be delivered to streams in the Middle Fork Eel River watershed without exceeding applicable water quality standards. The approach taken focuses on sediment delivery, rather than a more direct measure of salmonid habitat (i.e. instream conditions.) Sediment delivery can be subject to direct management by landowners (for example, roads can be well maintained), whereas instream conditions (pool depth, percent fines) are subject to upstream management that may not be under the control of local landowners. While it would be desirable to be able to mathematically model the relationship between salmon habitat and sediment delivery, these tools are not available for watersheds with landslides and road failure hazards. Sediment movement is complex both spatially and temporally. Sediment found in some downstream locations can be the result of sediment sources far upstream. Instream sedimentation can also be the result of land management from decades past. Nevertheless, management activities can clearly increase sediment delivery, and instream habitat can be adversely affected by increased sediment inputs. Therefore, it is reasonable to link increases in sediment delivery to decreased stream habitat quality. The approach also assumes that salmon can be supported in streams even with the yearly variation of natural rates of erosion observed in the 20th century. Although the sediment delivered to the streams has varied over time, salmon have adjusted to the natural variability by using the habitat complexity created by the stream's adjustments to the naturally varying sediment loads. In addition, we are assuming that the natural amount of sediment can generally be increased to some extent and not adversely affect fish. We postulate this because historically, fish populations were thriving throughout the North Coast, even though there was human caused sediment from ranching, the tanbark industry and some logging.

During the public comment period on the draft TMDL, EPA solicited comments on two alternative methods of setting the TMDL. Alternative 1 was based on loading capacities and allocations from neighboring basins, whereas Alternative 2 was based on the sediment source analysis for this basin. Based on both public comments and EPA's determination that the revised sediment source analysis improves the accuracy of the estimates, EPA has chosen Alternative 2, using the revised numbers provided by the cooperating agencies.

EPA is using a method of setting the TMDL and allocations similar to that employed in other basins (e.g., North Fork Eel, Noyo, Big and Albion Rivers, USEPA, 2003, 1999, 2001 and 2001). It is based on the assumption that a certain amount of loading greater than what is natural is acceptable, and will still result in meeting water quality standards. Most of the basins in the North Coast historically had some management activity taking place in the basin, while fish populations remained stable. We are basing the loading capacity and TMDL for the Middle Fork Eel basin on a calculation of 105% of natural loading, with some adjustment for certain subbasins, as discussed below.

This is more conservative than the calculation we have used for some other basins, which, when using this method to determine loading capacity, have frequently been based on 125% of natural loading, or higher where it was clear that water quality standards would still be met, or the sediment source analysis underestimated natural loading. Such considerations do not apply in this basin. In this basin, EPA considers 105% to be appropriate based on consideration of several factors. Recovery from the 1955 and 1964 floods in parts of the basin has been extraordinarily slow and beneficial uses are in some cases still not supported. While the conditions in the Middle Fork Eel are not as bad as in many North Coast watersheds, it is not clear that additional capacity to carry new sediment loads exists. Furthermore, it is apparent that reducing sediment will also assist in achieving water quality standards for temperature and achieving the heat load established in for the Temperature TMDL. Moreover, we do not expect that calling for a lower percentage of management loading than in other basins would be burdensome to landowners. Management activity is not high in the basin relative to other watersheds on the North Coast, and USFS management may have already resulted in extremely low management-related sediment loading. In addition, parts of the USFS lands are managed as wilderness and are not producing management-associated sediment, so basing the overall loading capacity on 105% of natural loading is also not a burden on other landowners.

Subwatershed Loading Capacities and TMDLs

In order to assist the Regional Board in identifying which subwatersheds require the greatest sediment load reductions, EPA set a loading capacity and TMDL for each of the subwatersheds (Table 7). In general, these subwatershed TMDLs are set at 105% of natural loading; however, in no case is the loading capacity set at greater than the existing sediment delivery rate. This is because there are high natural loads in some subwatersheds relative to management loads, and there is no indication that the watersheds can support additional sediment loads.

TMDL = Loading Capacity = 105% of natural load or existing load, whichever is less.

Thus, in the Upper Middle Fork, where the management load is already very small due primarily to the management of the wilderness area, the TMDL is set at 420 tons/mi^2/yr, which is the existing load. In this subwatershed, setting the TMDL at 105% of natural would have allowed an increase of the current management-related sediment load by almost 50%. Instead, in order to be consistent with the management of the wilderness area, and to protect the only run of summer steelhead in the state, the TMDL is set at existing loading.

Similarly, the Black Butte subwatershed has a high natural load relative to current management loading, and setting the TMDL at 105% of natural loading would have allowed an increase in management-related loading. Therefore, the TMDL is set at the existing loading, or 740 tons/mi^2/yr. EPA considers this appropriate because the Black Butte subwatershed was significantly affected by the 1964 flood, and has not sufficiently recovered even during the last four decades (D. Leland, B. McFadin, pers. comm., 2003).

The TMDL and Loading Capacity are set at 105% of natural loading in Elk Creek, Round Valley and Williams/Thatcher subwatersheds (see Table 7), which results in reductions in management-related loading in all three subwatersheds.

Table 7: Sediment TMDLs and Allocations (t/mi^2/yr)

Source	Black Butte	Elk Ck	Round Valley	Upper MF	Williams/ Thatcher	BASINWIDE Load
TOTAL Natural	**724**	**1,059**	**374**	**410**	**417**	**574**
% Reduction over current	0%	0%	0%	0%	0%	0%
Subtotal Landslides	**9**	**12**	**10**	**2**	**2**	**6**
% Reduction over current	0%	5%	5%	0%	5%	5%
Subtotal Small Mgmt Sources	**7**	**41**	**9**	**8**	**19**	**23**
% Reduction over current	0%	32%	95%	0%	89%	70%
TOTAL Management-Related	**16**	**53**	**19**	**10**	**21**	**29**
% Reduction over current	0%	27%	91%	0%	88%	65%
TMDL – ALL SOURCES	**740**	**1,112**	**393**	**420**	**438**	**603**
% Reduction over current	0%	2%	32%	0%	26%	8%
% Natural	98%	95%	95%	98%	95%	95%
% Management	2%	5%	5%	2%	5%	5%

TMDL is set at 105% of natural sediment, or current sediment production, whichever is less. Amount of sediment above natural production is allocated 95% to landslides and the remainder to small sources, based on the assumption that sediment from landslides is difficult to control. Any apparent inconsistencies are due to rounding.

4.3.2. Allocations

In accordance with EPA regulations, the loading capacity (i.e. TMDL) is allocated to the various sources of sediment in the watershed, with a margin of safety. That is:

TMDL = sum of "wasteload allocations" for individual point sources,
+ sum of the "load allocations" for nonpoint sources, and
+ sum of the "load allocations" for background sources

Although nonpoint sources are responsible for most sediment loading in the watershed, limited point sources may also discharge some sediment in the watershed. Current and prospective future point sources that may discharge in the watershed and are therefore at issue in this TMDL include:

-CalTrans facilities (e.g., State Highway 162) that discharge pursuant to the CalTrans statewide NPDES permit issued by the State Water Resources Control Board, and
-Construction sites that discharge pursuant to California's NPDES general permit for construction site runoff.

Because the discharge from these point sources cannot be readily determined, and because possible loading from point sources is not distinguished from general management-related loading in the source analysis, EPA considers the rates set as load allocations (i.e., for nonpoint sources) to also represent wasteload allocations (i.e., for those point sources that would be covered by general NPDES permits). There are no other wasteload allocations, as there are no other individual point sources of sediment in the basin.

The load allocations for the Middle Fork Eel River Sediment TMDL are presented in Table 7. The allocations clarify the relative emphasis and magnitude of erosion control programs that need to be developed during implementation The load allocations are expressed in terms of yearly averages (tons/mi^2/yr). They could be divided by 365 to derive daily loading rates (tons/mi^2/day), but EPA is expressing them as yearly averages, because sediment delivery to streams is naturally highly variable on a daily basis. In fact, EPA expects the load allocations to be evaluated on a ten-year rolling average basis, because of the natural variability in sediment delivery rates. In addition, EPA does not expect each square mile within a particular source category throughout the subwatershed to necessarily meet the load allocation; rather, EPA expects the subwatershed average for the entire source category to meet the load allocation for that category**.**

The allocations shown in Table 7 are based on the revised sediment source analysis. Allocations for the subwatersheds are set as follows: where the TMDL is set equal to current loading (Black Butte and Upper Middle Fork subwatersheds), the allocations are set the same as current loading. For Elk Creek, Round Valley and Williams/Thatcher, 95% of the management load (which is the TMDL less the natural load) is allocated to management-related landslides, and 5% is allocated to smaller sources. This is because sediment delivery from landslides is more difficult to control, whereas considerable reductions can be obtained for the smaller sources, which are primarily road-related. Consequently, in the remaining subwatersheds, needed sediment reductions from road-related small sources are 32% for Elk Creek, 89% for Williams/Thatcher and 95% for Round Valley. The latter two subwatersheds currently contain very high road densities and a great deal of road-related sediment production.

As is apparent from Table7, these allocations require a reduction from the current overall management-related loading (65% reduction on average through the basin, with greatest reductions to be addressed in the Round Valley and Williams/Thatcher subwatersheds (91% and 88% management-related sediment reductions, respectively), followed by Elk Creek (27% management reduction needed).

4.3.3. Margin of Safety

The margin of safety (MOS) must be included in a TMDL to account for uncertainties concerning the relationship between pollutant loads and instream water quality and other uncertainties in the analysis. The margin of safety can be incorporated into conservative assumptions used to develop the TMDL, or added as an explicit separate component of the TMDL.

This TMDL includes an implicit margin of safety based on EPA's conservative assumptions regarding the uncertainty associated with the sediment source analysis, as well as with the need to protect the resource. An implicit MOS is also included by setting the loading capacity conservatively, at 105% of natural loading or current loading, whichever is less.

4.3.4. Seasonal Variation and Critical Conditions

The TMDL must describe how seasonal variations were considered. Sediment delivery in the Middle Fork Eel River watershed inherently has considerable annual and seasonal variability. The magnitudes, timing, duration, and frequencies of sediment delivery fluctuate naturally depending on intra- and inter-annual storm patterns. Since the storm events and mechanisms of sediment delivery are largely unpredictable year to year, the TMDL and load allocations are designed to apply to the sources of sediment, not the movement of sediment across the landscape, and to be evaluated on a ten-year rolling average basis. EPA assumes that by controlling the sources to the extent specified in the load allocations, sediment delivery will occur within an acceptable range for supporting aquatic habitat, regardless of the variability of storm events. EPA also intends that the allocations be determined on a 10-year rolling average, to account for inherent inter-annual variation.

The TMDL must also account for critical conditions for stream flow, loading, and water quality parameters. Rather than explicitly estimating critical flow conditions, this TMDL uses indicators which reflect net long term effects of sediment loading and transport for two reasons. First, sediment impacts may occur long after sediment is discharged, often at locations far downstream of the sediment source. Second, it is impractical to accurately measure sediment loading and transport, and the resulting short term effects, during the high magnitude flow events that produce most sediment loading and channel modifications.

CHAPTER 5: IMPLEMENTATION AND MONITORING MEASURES

The main responsibility for water quality management and monitoring resides with the State. EPA fully expects the State to develop and submit implementation measures to EPA as part of revisions to the State water quality management plan, as provided by EPA regulations at 40 C.F.R. Sec. 130.6.

The State implementation measures should contain provisions for ensuring that the allocations in the TMDL will in fact be achieved. These provisions may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs, including the State's recently upgraded nonpoint source control program.

For the Temperature TMDL, the State may want to consider using the management scenarios developed for the model (18-24" dbh) to assist in considering the effects of more intensive management than what is occurring at present, and determine appropriate measures to prevent additional management-related heat load from raising stream temperatures further.

EPA recommends that implementation programs be developed using site specific information for protection or achievement of "natural potential" shade. Regional Board staff have indicated that this is how they intend to implement the TMDL. The data, analysis and model used for the TMDL provide justification for the protection or achievement of natural potential shade, as well as the required TMDL loading capacity and allocations calculations. But actual protection or changes toward achievement of natural potential shade may best be determined, not by modeled levels, but by either field review or an analysis of ownership-wide management of the riparian zone. It may be that parts of the basin are already meeting the TMDL, and USFS and the State can concentrate their efforts on areas where natural potential shade is not being achieved. EPA recommends that the State develop additional information in support of changes in management actions or for any changes they wish to consider for the 2004 listing cycle.

USFS current standards and guides under the Northwest Forest Plan currently protect riparian areas from the effects of timber harvest on adjacent sediment and temperature characteristics. Thus, in theory, the Northwest Forest Plan already protects natural potential shade In this case, it may not be necessary to prove on a site specific basis that natural shade is protected.

For the Sediment TMDL, EPA specifically recommends that more instream sediment information be gathered throughout the basin. EPA also suggests that the State consider additional review and revision, if necessary, of the sediment source analysis, and consider using the information developed from it in setting priorities for any new sediment reduction programs in the watershed. This could be done in conjunction with USFS, to make use of work that has already been completed for the basin. EPA's analysis suggests that parts of the basin, particularly within USFS lands, may already be meeting the TMDL; if that is the case, no changes in current management may be needed on those lands. However, EPA emphasizes that those lands will only continue to meet sediment limits if future management practices and the intensity of management are not increased over the recent past. In addition, the State may wish to consider under what criteria delisting of USFS lands in the Middle Fork Eel–or other lands that are meeting standards–can take place, and work cooperatively with USFS experts on a monitoring plan. A monitoring plan should take into account number of samples, location of samples, sampling strategy and cost-effectiveness. USFS and the State can concentrate their efforts on those areas that still need reduction programs.

Because information available for the Middle Fork Eel basin suggests that lack of road maintenance in some cases could set the stage for catastrophic road failures if another large-scale flood (e.g., on the order of the 1964 flood) were to occur, EPA recommends that the Regional Board also consider measures to address necessary road maintenance. Regional Board staff have also indicated that road maintenance and upgrading will be a priority in some of the subwatersheds.

Any implementation and monitoring strategy should include a public participation process and appropriate recognition of other relevant watershed management processes, such as local source water protection programs, State programs under Section 319 of the Clean Water Act, or State continuing planning activities under Section 303(e) of the Clean Water Act.

EPA encourages the State and landowners to work together to fully develop an implementation and monitoring strategy that is appropriate for a watershed with a lower human caused disturbance than other watersheds.

CHAPTER 6: PUBLIC PARTICIPATION

EPA provided public notice of the draft Middle Fork Eel River Temperature and Sediment TMDLs by placing a notice in the Willits News and Santa Rosa Press Democrat, papers of general circulation in Mendocino and Trinity Counties. In addition, EPA sent a notice to those on the mailing list of the Upper Eel Watershed Forum, and participated in a public meeting that coincided with an Upper Eel Watershed Forum membership meeting, in order to make the meeting as convenient as possible to the greatest number of people in this sparsely-populated watershed.

The public meeting was held at 7 pm October 16 at the Masonic Hall in Covelo, California. EPA reviewed all written comments that were received during the public comment period, which ran from October 15-November 17, 2003. EPA has prepared a responsiveness summary that addresses all the comments that were received.

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APPENDICES

Appendix A: Temperature Modeling

available as a separate document

Appendix B: USFS Sediment Source Analysis

available as a separate document